# A Connecting Sea? Modelling Economic Cohesion in the Roman Adriatic

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## Abstract

This thesis focuses on modelling complex economic concepts in the Roman Adriatic. A quantitative focus is taken, and an effort is made to consider evidence from across the region, both terrestrial and maritime, from the offset. Section A considers the geographic and ecological evidence, taking a consciously non-archaeological approach in order to identify micro-regions within the wider region. This also introduces Circuit Theory (CT), which is central to modelling potential connectivity and ultimately economic cohesion in this thesis.

Section B is focused on the archaeological evidence, considering the urban population, wine and oil production and the transport infrastructure of the Adriatic. For each of these, the archaeological evidence is compared to the geographic and ecological evidence established in Section A. The CT data is used to identify areas and sites of particular significance, and through this, a complex economic system, operating on multiple scales begins to emerge; potential connectivity is at the centre of all of this.

In Section C, the distribution of *amphorae* and shipwrecks is considered. This expands on the production and connectivity outlined in Section B, and begins to more directly model the economic system in which the Roman Adriatic functioned through quantitative analysis.

This thesis demonstrates the importance of geography and potential mobility to ancient economies. A combined maritime and terrestrial approach is vital for any full understanding. Ultimately, this thesis demonstrates that the Roman Adriatic existed as a distinct economic system but one which was reliant on the wider Roman economy. Inter-regional trade was important and prevalent, extra-regional trade was organised in a more hierarchical system, with access to the wider economy likely conducted primarily through relatively few large sites in the north.

## Lay Summary

This thesis focuses on modelling economic concepts in the Roman Adriatic. A scientific approach is taken, in order to prove, in comparable terms, the hypotheses set out. The geography of the region is considered in detail before any of the archaeological remains themselves are directly engaged with.

The archaeological analysis begins with an assessment of the Roman Adriatic cities and their populations. This allows for the basic consumption needs of this population to be quantified, focusing on grain, wine and olive oil. The production of wine and oil in the Adriatic region is then considered, before the transport infrastructure is outlined; considering the roads, rivers and ports of the region. All of this is compared directly to the geographical reality of the region.

Finally, the Roman shipwrecks and distribution of wine and oil transport containers (*amphorae*), are discussed. This allows for a model of production, consumption, and exchange to be established. Ultimately, this thesis shows that geography, and maritime movement in particular, was central to the economic patterns that emerge in a region.

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All figures and appendices are produced or collated by the author, unless otherwise stated.

## Abbreviations

| | |
|---|---|
| ABM | Agent Based Model |
| cmcv | city mean current value |
| CT | Circuit Theory |
| DEM | Digital Elevation Model |
| EU | European Union |
| FTA | Free Trade Agreement |
| GIS | Geographic Information System |
| GMR | Geographic Micro-Region |
| ICEP | Illyrian Coastal Exploration Programme |
| imcv | individual mean current value |
| LCP | Least Cost Path |
| mmcv | monthly mean current value |
| MR | Micro-Region |
| NAO | North Atlantic Oscillation |
| OXREP | Oxford Roman Economy Project |
| sd | standard deviation |
| SMR | Soil Micro-Region |
| tmcv | total mean current value |
| wmcv | wreck mean current value |

# Introduction

The ancient economy has been discussed by scholars for decades, with a variety of regions, periods and approaches being engaged with in this complex field of research. These are all in the pursuit of better understanding the ancient world, and the way in which early economies were organised; the ways in which studies of the ancient economy can most effectively be approached are themselves subject to intense discussion. It is against this background of dynamic theoretical debate that the current research question is asked: how far can the Adriatic region be considered a cohesive economic whole during the early imperial period? In the current context, economic cohesion can be thought of as the extent to which parts of the wider region were reliant on exchange with one another, a lack of cohesion suggesting more self-reliance within the constituent parts of the region. In order to understand the level of economic cohesion, a number of complex concepts must be addressed and applied to this ancient context. These are outlined in Chapter 1below, before various aspects of the Roman Adriatic are analysed specifically, from the geographic and ecological landscape, through the archaeological, beginning with fixed point sites and finally looking at the distributions of portable remains. The main research questions are:

- How far was the economy of the Roman Adriatic a system distinct from the wider economy, or how reliant was the system on external exchange?

- Which areas of the Adriatic, if any, show likely evidence for economic specialisation?

- What can the use of Circuit Theory analysis reveal about ancient mobility and potential connectivity beyond more typical analyses?

The concepts within these research questions are addressed below, and the questions referenced throughout. All of this shows that the economy of the Roman Adriatic was a dynamic and complicated network, with exchange within the region, as well as beyond, acting to create a distinct system of production and trade, but one which was reliant on the wider network of the Mediterranean world. This system required economic specialisation of multiple scales and can be best understood through the wealth of quantitative data provided by Circuit Theory analysis, offering far deeper understanding of mobility and exchange than traditional Least Cost Analyses alone could provide.

# Chapter 1: Current State of Research

In this first Chapter, a discussion of the most relevant current literature surrounding the question of economic cohesion in the Adriatic is provided, and an outline of how the current work expands on this, through the application of new quantitative methodologies and a more integrative approach to what are often considered multiple disparate regions. Below, a discussion of some general trends in the scholarship focusing on the ancient economy is provided before a discussion of how modelling of ancient economies has been approached, and finally a discussion of specific scholarship considering the ancient Adriatic. This not only places the thesis within current research, but highlights how the work significantly advances this research.

## 1.1- The Ancient Economy

With such a long and prolific scholarly tradition, it would be impossible to fully discuss all of the scholarship on the Roman economy here; as such, only some of the more influential and pertinent works are examined. Following this, a discussion of wine and oil *amphorae* and the use of proxies in the Roman economy is provided. After this, two economic concepts are addressed in detail: economic specialisation and market integration.

At the centre of much of the debate surrounding the ancient economy is Finley's influential *The Ancient Economy*.[1] Despite being almost 50 years old, this work is still frequently referenced, and many current debates stem from Finley's work in some way.[2] This work sparked what is known as the Finley debate. There are essentially two sides to this, the 'primitivists' and 'modernists', both with conflicting concepts of how the Roman economy was organised. On the primitivist side, it is argued that the Roman economy was simple, unstable and loosely connected, directed by opportunity. On the other side, modernists argue for a much more integrated and complex, free market economy, guided by economic rationalism of some form.[3] The debate has taken different forms over the years and is rooted in helpful discussion. However, most scholars agree that the reality lies somewhere in between the extremes of primitivist and modernist, and that a black and white debate arguing for one or the other is largely unhelpful.[4] With purely qualitative methods applied to the debate, formal comparison of the opposing models is impossible, and so, the debate becomes entrenched, and ultimately

[1] Finley (1974).
[2] See Moss (1975) or more recently Greene (2000).
[3] Temin (2001), 3.
[4] Temin (2001), 31-32; Scheidel *et al.* (2008), 2-6; Bowman and Wilson (2009), 4, 7.

unproductive. Recent trends in the scholarship have seen more quantitative approaches being applied. These often borrow from the social sciences and apply computer learning, statistics and a more truly scientific method, to the archaeological data. Rather than simply arguing for one answer or another, discussions about how the questions should be addressed in order to arrive at a meaningful conclusion are becoming more common. Bowman and Wilson discuss at length the importance of applying quantitative approaches to the Roman economy and emphasise the need to acknowledge the inherent uncertainty in the archaeological data. Rather than seeking straightforward answers to what are extremely complicated questions, instead Bowman and Wilson advocate for identifying observable but more general trends in the ancient economy.[5] Indeed, Finley's argument that there was no useful quantifiable data for understanding the ancient economy was used as justification for the Oxford Roman Economy Project (OXREP), co-directed by Bowman and Wilson.[6] Finley was not wrong in 1974, but quantifiable data has become far more accessible since then, and processing rather than collecting more data has become more of an issue.[7] With more and more data being collected and collated, statistically relevant datasets can be examined and quantified with wide-reaching consequences for our understanding of how the Roman economy was organised. Even those who generally downplay how useful such data can be, such as Scheidel, have argued, similarly to Bowman and Wilson, that while the archaeological data cannot provide clear cut answers, the reluctance to approach questions regarding the quantification of ancient economies due to the meagre available data can now be challenged.[8] There is constructive discussion within the scholarship highlighting perceived issues with certain approaches, rather than solely with the conclusions.[9] The concepts discussed by these scholars of the ancient economy, particularly those focusing on the organisation and integration of the Roman economy, are drawn upon and advanced in this work. Beyond answering the question of economic cohesion in the Adriatic, the methodology used, outlined below, expands on these very current quantitative trends and offers a dynamic approach which can be applied to other complex questions, regions and periods.

### 1.1.1- Economic Specialisation

Now that the more general trends in the study of ancient economies have been addressed, the more specific economic theories, with which the current study is explicitly concerned, can be explored. Economic specialisation is a modern concept that is frequently applied, with little consideration for its

[5] Bowman and Wilson (2009), especially 5-9.
[6] Finley (1974), 23-27.
[7] See for example Kintigh (2006).
[8] Scheidel (2009), 46-47; Scheidel and Friesen (2009), 61-63.
[9] Wilson (2009).

inherent complexities, to the ancient world. A definition of economic specialisation in the current context is provided below, with reference to economic advantage and division of labour, before the issues with the limited scholarship surrounding ancient economic specialisation are discussed.

*1.1.1.1- What is Economic Specialisation?*

A key aim of my MScR research was to provide a clear definition of exactly what was meant by economic specialisation in a Roman context. This definition can be thought of very generally as one specific agent focusing on an economic/productive venture at the expense, but not to the complete exclusion, of other activities.[10] Importantly, this can be at any scale, with the agent representing an individual (craft specialisation), a region within a state (regional specialisation) or even multiple countries or nations (a form of globalisation). The current work is concerned mainly with regional specialisation which must fulfil four main criteria: economic advantage, production of a surplus, the exchange/trade of these surplus goods and a division of labour.[11] Of course, economic advantage and division of labour are modern economic concepts, and these require some brief discussion before being arbitrarily applied to ancient contexts.

Economic advantage is a situation in which it is more efficient for a specific agent to produce a certain commodity when compared to another. This can be due to local ecological conditions, traditions of production establishing localised skills or infrastructure, and a variety of other factors. The idea of an economic advantage can manifest itself in two ways; an absolute, or a comparative advantage. Either is suitable, and at least one is necessary, for economic specialisation. With an absolute advantage, one area produces a specific commodity more efficiently, or at less cost.[12] A comparative advantage is when, given finite resources and multiple commodities, focusing on a specific commodity decreases overall costs expended by agents, even if one agent has an absolute advantage for producing both commodities over the first. David Ricardo first introduced this concept in 1817, and other economic concepts developed from this and have been applied to ancient economies.[13] Consider an ancient Mediterranean context, where we might see a region ecologically predisposed to the cultivation of olives, with the infrastructure necessary for large pressing installations and access to the sea for efficient export. There would be an economic advantage for the production of olive oil in this region. Even if olive oil can be produced at less cost in a connected region,

[10] The general concept was originally discussed by Adam Smith and expanded upon by his successors and modern scholars, Smith (1776), especially 8-14; Marx (1867); Morgan (1877). See also Kerner (2010), 180.
[11] McLean (2016), 9-10.
[12] For a very helpful modern discussion of these concepts, see Markusen *et al.* (1995), 68-70.
[13] Ricardo (1817), 90-93; Brander and Spencer (1985); Krugman (1987), 134-137.

if this second region is itself more suited to the production of, for example, wheat, rather than oil, overall efficiency is increased through region one producing olive oil and region two producing wheat. In this example, region two has an absolute advantage over region one in olive oil and wheat production, but region two has a comparative advantage in olive oil production over region one. In this work, the concept of economic advantage is most explicitly addressed in Chapter 2, but the principles surrounding economic advantage and specialisation are important throughout.

A division of labour is required in order for economic advantage to be exploited. This is a term normally used for much smaller scale activity; for example, with its inception in Adam Smith's pin factory.[14] Each worker specialises on one specific task/aspect of producing the pin; this allows them to be much more efficient in this aspect of production. Other workers focus on other aspects, and again are more effective in this aspect, and an overall increase in efficiency is achieved. This can be applied to a much larger, regional scale. The production of a specific commodity, required/desired by the population at large (the focus of Chapter 4), can be concentrated in one region, while in another region, the focus is on producing another commodity. Both regions have access to both commodities through exchange (Chapter 7), but only have to produce one (Chapter 5). So, economic specialisation, in this context, can be viewed as the production of surplus goods, achieved through an economic advantage. With exchange/trade, this surplus can be exported, and with a division of labour, a different commodity can be imported. This requires some level of economic rationalism, organisational planning and, most pertinently, considerable economic cohesion. All of which results in an increase in *overall* efficiency. Of course, the reality is much more complicated than this example; with multiple regions interacting at once and with no region ever focusing on the sole production of one single commodity with absolutely no production of other essential goods. Nonetheless, this model can act as an informative tool for detecting the presence of specialisation within the Roman world, and through this how cohesive economic regions may have been.

#### *1.1.1.2- Current Scholarship*

Economic specialisation is a term that is frequently used in studies of the Roman economy. Yet, it has rarely been engaged with in an ancient context in a serious theoretical way. There are some studies, focused on the ancient near east, that offer dedicated discussions of specialisation, but these are concerned with individual/craft specialisation, rather than larger scale regional specialisation that is discussed in the current context.[15] Rice's DPhil thesis treats specialisation in a much more serious way

[14] Smith (1776), 1.1.9.
[15] Stein (1994); Wattenmaker (1994); Costin (1991); Kerner (2010).

than most publications.[16] The term is used throughout and while no formal definition is given, there are certain important features highlighted as being necessary for economic specialisation, such as a division of labour and a comparative advantage with integrated and interdependent markets leading to increased overall output.[17] This hints at a similar definition as is proposed in the current work. Rice argues convincingly for the presence of specialised production in two case study areas: in southern Turkey and southern France during the Roman period.[18] This argument is closely linked to surplus production and connectivity facilitating the exchange of goods. Foxhall argues that oil and wine production in the Roman world was highly specialised, and presents this in contrast to 'household production' in the Classical Greek world; which was not specialised in the same way.[19] The points made in these works are entirely valid; both are presented as convincing examples of economic specialisation and utilise archaeological data as proxies for economic activity. However, there is yet to be a formal definition of economic specialisation that can facilitate the comparison and quantification of different economic regions within the Empire.

Other scholars, similarly without offering a definition of specialisation, have argued that specialisation was not present in the Roman world. Erdkamp offers an in-depth treatment of the Roman grain market.[20] Through this he discusses how specialisation in olive or vine cultivation was not desirable for peasant farmers, due to deterrents such as the 'vagaries of the market' and 'lack of capital and small scale of their agricultural enterprises' increasing the inherent risk of specialisation.[21] This is specific to peasant farmers, but Erdkamp argues that increased 'market integration lowered the risks inherent in food market dependency' and allowed something more like specialisation to appear 'in some coastal regions of the Roman Mediterranean'.[22] This points to some factors as being necessary for specialisation in Erdkamp's understanding, such as economic rationalism and considerable initial investment. Even lacking a formal definition, some aspects of specialisation appear to be shared across the scholarship. However, Erdkamp concludes that the Roman grain trade, unlike the wine trade in some Italian regions, was not specialised.[23] The difference between grain and wine, according to Erdkamp, is that grain is more essential to survival, and more vulnerable to long-term storage. Therefore, the prices are more susceptible to wild fluctuation, while vines and olives, as cash crops, are more stable in price.[24] This stability is essential for long term specialisation. Erdkamp is quite

[16] Rice (2012).
[17] Rice (2012), especially 17-18.
[18] Rice (2012), 196-205, 272-278.
[19] Foxhall (2007), especially 132, 170.
[20] Erdkamp (2005).
[21] Erdkamp (2005), 78-79.
[22] Erdkamp (2005), 105.
[23] Erdkamp (2005), 167.
[24] Erdkamp (2005), 167-168.

convincing in his suggestion that the grain trade was not specialised. Other than an overreliance on the literary sources, this approach to questioning specialised grain exchange is generally helpful.[25] However, Erdkamp's treatment of specialised wine and oil is not as thorough. It has largely been, and continues to be, accepted that wine and oil was specialised without any concentrated effort to define or formally identify this specialisation. This is exactly the issue this work intends to address. How can the specialised wine and oil trade Erdkamp mentions be detected in a comparable and meaningful way? And what does the presence, or absence, of economic specialisation suggest about the economic cohesion of regions within the Roman world?

Some scholars have looked to the ecology of the Mediterranean in order to refute the possibility of specialisation. Witcher argues that there could be no economic advantage between Mediterranean regions due to similar ecological conditions and availability of natural resources.[26] Horden and Purcell argue the reverse, that the diverse and unpredictable nature of the Mediterranean made diversification and redistribution essential.[27] It should be noted that Witcher is speaking in very general terms, where the Mediterranean might actually be viewed as broadly similar, while Horden and Purcell discuss specific micro-regions that are clearly not similar. Both approaches can be valid, but considering micro-regions is necessary when discussing specialisation in a more meaningful and thorough way; it would be unhelpful to claim that the Roman Empire as a whole specialised (or did not) in the production and exchange of a specific commodity.[28] Nevertheless, all of these scholars touch on, or specifically highlight, some economic concepts that have been identified as essential for specialisation: economic advantage and a relatively stable and predictable economic situation, guided by economic rationalism. Whilst the assumptions and conclusions might be different, the approaches to specialisation are broadly similar, identifying or refuting specialisation without any real definition of what this is. Indeed, when Horden and Purcell argue that the diversity of the Adriatic prohibits any one region relying solely on a single commodity; what they describe is in fact monoculture, the production of one commodity at the complete exclusion of all others, and not specialisation.[29] Horden and Purcell directly refute Tchalenko's suggestion of olive oil monoculture in Syria.[30] Moeller argues for a monoculturistic wool trade in Pompeii, but this was quite successfully refuted by Jongman.[31] Monoculture does not equate to specialisation in the current definition. Though one product must be focused on at the expense of others, this need not be to the complete exclusion of others. It is

[25] See Erdkamp (2005), especially 110-111.
[26] Witcher (2017), 644.
[27] Horden and Purcell (2000), 274.
[28] The terminology surrounding regions and micro-regions is discussed in detail in Chapter 1.
[29] Horden and Purcell (2000), 274-275.
[30] Tchalenko (1953).
[31] Moeller (1976); Jongman (1988).

unrealistic to expect a region to exclusively produce oil while being reliant on imports for all of the region's additional requirements. Put simply, 'the economic benefits of specialisation do not hinge on complete specialisation in a single product'.[32] As is always the case, reality is far more intricately complex than any single model could, or indeed should, possibly be.

Specialisation is not a new or unfamiliar term in the scholarship of the ancient economy. Attempts to prove that aspects of the economy were not specialised have been largely accepted and attempts to identify monoculture have typically been refuted. Even with this, there is a general, but not formally proven, assumption that certain regions and commodities were specialised. Despite some common economic themes, such as economic stability, rationalism, advantage and market integration, there are no formal definitions, or real discussions of how to identify the presence of specialisation. The current work draws on these publications and, with a formal definition, aims to move beyond the assumptions that certain commodities were specialised, and demonstrate how discussions of ancient economic specialisation can be approached more meaningfully in order to identify specific regions, commodities and periods in which specialisation was more likely. The prevalence of specialisation in the scholarship highlights the importance of the concept, and it is hoped the current work will allow for new quantitative approaches to economic specialisation to reflect this importance.

### 1.1.2- Market Integration

Another economic concept often applied to the ancient world is market integration. In recent years, this has been approached in a more quantitative and theoretical way than economic specialisation has. The two concepts are closely linked, as even cursory discussions of specialisation acknowledge that it necessitates close market integration. As such, it is impossible to discuss economic specialisation. Concepts of economic cohesion and market integration are quite similar. The key difference in this work is of scale, with market integration being between smaller constituent parts of a wider region, while economic cohesion is the extent to which markets within the region allow the region to be considered an integrated or cohesive whole. Applying the concept of market integration to the current research context and utilising the most up to date quantitative approaches allows for a much better understanding of market integration in the Roman world, and the economic cohesion of the Adriatic region.

At the centre of the debate surrounding the extent to which the markets of the Roman economy were integrated are Bang and Temin. They argue for weak and strong market integration

[32] Personal correspondence with Candace Rice.

respectively. Bang argues that the Roman state directly controlled most long-distance trading and that the integration observed within the economy is due to this state intervention.[33] On the other hand, Temin argues that state involvement was limited in most trade, with the free market and close market integration driving these long distance exchanges in the Roman world.[34] Both offer qualitative models for market integration in the Roman world, and define these much more explicitly than most define economic specialisation. Temin approached market integration through the comparison of regional prices of wheat across the Empire.[35] Bang's comparison of the Mughal and Roman Empires argues that there were considerable, often political, barriers limiting the development of advanced trade networks.[36] These models have essentially become equivalents of the primitivist and modernist debate, despite Bang specifically arguing that he was in neither the primitivist nor modernist camps and criticising both sides.[37] Nevertheless, the question of market integration is an extremely interesting one, and holds great potential for increasing our understanding of how the economy of the Roman world was organised.[38] However, neither Bang nor Temin offered any truly quantitative approaches to the Roman economy. As such, there is no formal means of comparison between the two models, and we are once again stuck with an unquantifiable, entrenched debate. The approach to market integration in the current work builds upon criticisms of past approaches to quantifying and modelling the Roman economy.[39] However, it is unhelpful to attempt to answer the question of the Roman economy being highly integrated with a yes or no. The same is of course true for questioning economic cohesion, as the organisation of the economy varies with time and location. This is true even within regions, such as the Adriatic. Through the application of dynamic quantitative approaches that take into account the complexities of the Roman economy and the data available for understanding it, we can begin to discuss Roman market integration in a much more meaningful way.

Much like economic specialisation, market integration must be clearly and formally defined. Market integration is determined by prices of commodities, with integrated markets having prices that are not determined independently.[40] Temin utilised such a price-focused definition and used wheat prices across the Empire in an attempt to identify market integration; he argued that prices were determined in Rome, and prices elsewhere were these Roman prices compounded by transport

[33] Bang (2008).
[34] Temin (2013), 249.
[35] Temin (2013), 26-27.
[36] Bang (2008); Malmendier (2011).
[37] Bang (2008); Malmendier (2011), 3.
[38] See Silver (2009); Temin (2013); Malmendier (2011); Scheidel (2014); Velde (2014); Haas and Tol (2017); Wilson and Bowman (2018), for works discussing market integration, and especially Temin and Bang's models.
[39] Bowman and Wilson (2009), especially 213-269; Wilson and Bowman (2018), 1-17.
[40] Monke and Petzel (1984), 482.

costs.[41] Using prices to determine market integration is an entirely appropriate approach. However, there is a serious flaw with Temin's approach, in that he attempts to use actual prices, for which we have virtually no data in the Roman world.[42] Temin largely relies on written evidence, including epigraphy, but neglects the archaeological data. Rather than using actual prices, we must find a proxy for prices in this archaeological data and determine if these proxies are dependent on one another. If a pattern of distribution of commodities is similar across a region, we might suggest that the availability, or price of these commodities, are linked. If the prices are closely linked, or dependent on one another, it can be argued that these markets were highly integrated. The specific proxies used in this work are discussed in more detail below. With new statistical approaches, the similarities between regions and micro-regions can be quantitatively and formally tested and compared, rather than simply looking at distribution maps and essentially guessing whether or not they *look* similar.

### 1.1.3- Proxy Data

Some interesting debate surrounding how studies of the ancient economy should be approached have focused on the use of proxy evidence.[43] This proxy evidence is an extensive but intimidatingly complex series of disparate data sets. It has long been acknowledged that there is simply no appreciable quantity of direct data for the organisation of the Roman economy; there are no definitive statistics comparable to what we have for the economies of more recent societies.[44] Instead, scholars have turned to the archaeological proxies in order to understand economic activity. These proxies take various forms with some of the most common being 'shipwrecks, stature, lead and copper pollution, animal bone consumption'.[45] There are numerous potential issues with the way in which proxy data can be used, with chronological uncertainty, uncertainty biases and survivor biases to name but a few. As with much of the scholarship on the Roman economy, there is now a shift towards discussing how proxy data should and should not be used, identifying, accepting and working with the shortcomings inherent in the data.[46] The main issues with using proxies as evidence for economic activity in the Roman Empire is selecting insufficient or the wrong type of data for a given question, and in presenting

[41] Temin (2013), 26-27.
[42] Wilson (2009), 149.
[43]See especially Scheidel (2009); Wilson (2009).
[44] See Scheidel (2012), 2-3.
[45] Wilson (2009), 148.
[46] Scheidel (2009), 70; Wilson (2009). Both present different interpretations, but similarly advocate for more quantified use of the data.

the proxies used as complete and certain.[47] The current work builds upon these identified issues. Careful consideration has been given to the proxies used, and a number of different quantitative techniques for analysing these proxies are used and compared throughout.

#### *1.1.3.1- Wine and Oil Amphorae*

Wine and oil *amphorae* represent some of the most promising proxies for ancient economic activity. Wine and olive oil are two of the most important economic goods in the ancient Mediterranean world and were present at every level of society. The exchange of these commodities can be observed throughout the Mediterranean world, taking place at a local regional scale as well as long distance bulk trade. With widespread exchange at every level of society, such commodities are excellent for identifying market integration in the manner outlined above.[48] Moreover, wine and oil have been referred to as 'specialised' commodities, produced for specific markets.[49] These perishable goods are ideal for the current study, and fortunately, the durable ceramic vessels in which they were transported are reliable proxies for their exchange. The study of *amphorae* has a long history within studies of the ancient world. As such, typologies are often very well established, allowing for the origin, contents and chronologies of specific *amphorae* to be known with relative confidence. However, as with any proxy, there are issues with using *amphorae* as evidence for economic activity. Firstly, these are maritime transport vessels, and so their absence might not indicate that wine or oil was not reaching these sites, rather that they were not reaching the sites in *amphorae*.[50] The coastal nature of the current study largely negates this; although when considering sites beyond the Adriatic, such as Magdalensberg across the Alps, this must be accounted for. Skins, barrels and other perishable containers were likely used for transport overland and along rivers throughout much of antiquity.[51] Moreover, it is likely that they increasingly replaced heavy and relatively inefficient *amphorae* in later periods, even for maritime transport. Again, the time frame considered here, in the early Empire, helps to minimise the impact of this on the data considered. However, the use of barrels is particularly interesting given the current Adriatic context. Most examples of extant barrels come from the north-western provinces, and there is some evidence for such containers originating in north-western Europe.[52] However, it is also true that the wet, anaerobic conditions of north-western Europe are

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[47] Wilson (2009), 71-73, 77-78; (2014), 154.
[48] For some of the pioneering works in modern amphorae studies see Tchernia and Zevi (1972); Peacock (1974); Peacock and Williams (1991); Williams and Carreras (1995). Such works continue to be directly referenced in current publications, Sheenhan-Finn (2012); Monfort (2018).
[49] Mattingly (1988), 193; Tchernia (1993), 284; Erdkamp (2005), 167; Foxhall (2007), 132.
[50] There is a wide body of scholarship discussing alternate transport vessels such as barrels and skins, for example, Desbat (1991); Marliére (2002); Wilson (2009), 220-224.
[51] Bevan (2014), 392, 395.
[52] Bevan (2014), 395.

particularly well suited to preserving perishable wooden barrels. Similar conditions can be found in the lagoons of the northern Adriatic. Indeed, shipwrecks have been recovered in remarkably good condition from this area. Despite this, I am unaware of the presence of any such barrels.[53] While *amphorae* are the best suited proxies for the current study, great care is given to keep in mind that these were only one form of possible container.

## 1.2- Quantitative Modelling

The concept of modelling ancient economies is not a new one. Qualitative models have been proposed and discussed for almost as long as the Roman economy has been discussed. The primitivist and modernist models stemming from the Finley debate are arguably two of the most infamous models in studies of the Roman economy. The core issue with discussions between such models is their qualitative nature. That is, these models were established and 'tested' through discussion and persuasion, with no real possibility for formal comparisons between opposing models, or with the archaeological record itself. Recent scholarship has directly sought to overcome this through the application of multiple techniques. In this section, these techniques are briefly discussed, beginning with computational modelling and then moving on to the statistical modelling and GIS.

Agent based modelling (ABM), like many of the new quantitative approaches being applied to archaeology, has its roots in the social sciences, and especially ecology. This form of modelling allows programmes to simulate behaviour and interactions between different individuals (agents) based on variable inputs over multiple simulations in order to ascertain the probability of certain results. The potential for such a process in modelling past human behaviour should be clear. A particularly relevant example can be seen in Brughmans and Poblome's *MERCURY*.[54] This applies agent based computational modelling to the distribution of eastern Mediterranean ceramic wares, in order to show whether either of Bang or Temin's models could be possible given the actual archaeological distribution of these wares. The model has 'merchants' as agents, with computer learning applied to how these agents function.[55] The agents buy and sell different forms of ceramic ware over a series of steps, and the resulting distributions of these different wares can be compared to the archaeological record. Furthermore, the integration of the modelled market can be altered, by increasing or decreasing connections between different merchants and markets.[56] Through this, Brughmans and

[53] See for example the Comacchio wreck, Beltrame and Costa (2016).
[54] Brughmans and Poblome (2016a); (2016b). See also the 'Project MERCURY-MINERVA-SIMREC' website https://projectmercury.eu/ (accessed 07/06/19).
[55] Brughmans and Poblome (2016a); (2016b).
[56] Brughmans and Poblome (2016b), 400.

Poblome show that when the model had relatively high market integration, or many connections between the agents, the resultant distribution of ceramics most closely resembled the known archaeological distribution of the eastern Mediterranean ceramics.[57] Such an approach clearly shows the way in which discussions regarding the Roman economy can be conducted. With clear and formalised definitions, opposing models can be easily compared with the archaeological record, as well as one another, and discussions can develop and evolve based on these qualitative results, rather than becoming entrenched in endless debate. It is clear that such a quantitative approach has great potential for furthering our understanding of the Roman economy, and it is central to the current work.[58]

Statistical approaches to archaeology have similarly become more widespread recently, the main techniques to be applied being null hypothesis tests and the more general frequentist statistics, though Bayesian statistics show great potential.[59] Frequentist statistics work with pure probability which helps to remove some of the uncertainty and bias from certain discussions. Null hypothesis testing allows, for example, distributions of material culture to be compared against a random process or Poisson distribution; if these distributions can be shown to not be statistically similar, it can be said that something other than a random process is at work.[60] This obviously has considerable potential in archaeology and has been applied in different contexts.[61] Bayesian statistics have the potential to address further issues and Rubio-Campillo *et al.* recently applied these approaches to Dressel 20 *amphorae* stamps from *Monte Testaccio* in Rome.[62] This statistical analysis was used to suggest that the makeup of the Baetican olive oil industry followed the Pareto principle, and must have been organised as some form of free market.[63] The particularly useful aspect of Bayesian statistics is that the different possible models can be built into the formula, and the different models can be directly compared with one another and to the actual evidence. Other statistical approaches only allow random processes to be discounted, without direct comparison between different but potentially valid models. Statistical analysis is used throughout this work to analyse the data, primarily frequentist and null hypothesis testing, with a deep dive into the promising prospect of Bayesian statistics being beyond the scope of the current work.

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[57] Brughmans and Poblome (2016b), 403-404.
[58] Van Oyen (2017).
[59] See Rubio-Campillo (2016) for a discussion of Bayesian statistics in a historical setting.
[60] Rubio-Campillo (2016).
[61] For some examples of the varied contexts, see Buxeda i Garrigós *et al.* (2003) for statistical ceramic analysis; Baxter (2008) for an overview of the use of statistics in archaeology; Li *et al.* (2014) for an ancient Chinese context.
[62] Rubio-Campillo *et al.* (2017), 1244.
[63] Rubio-Campillo *et al.* (2017), 1248.

GIS has been applied to archaeology for decades now, with the application of techniques constantly evolving to suit the unique requirements and restraints of archaeology. We have been moving past simple distribution maps and charts, which, it can be argued, have ceased to be useful without additional analysis.[64] GIS can have much more nuanced and helpful applications, and allows for not only the presentation of data, but the analysis of data. GIS is a wide term and encompasses many different analytical approaches, but the most relevant is the ability to model landscape and movement through these landscapes. This is beginning to be applied much more meaningfully in archaeology, with higher resolution digital elevation models (DEM) and more sophisticated and customisable alternatives to least cost path (LCP) programmes becoming available. As such, networks in archaeology can be modelled in a much more sophisticated manner.[65] The potential of LCP for deepening our understanding of the movement of people, especially in the past, has been acknowledged and largely accepted. However, there are some limitations, such analyses require known points and can only produce outputs for paths between one origin and one destination, multiple origins and one destination or one origin and multiple destinations.[66] Discussions considering how to improve and how to most appropriately apply GIS techniques are relatively common.[67] Llobera provides an excellent discussion of how GIS and more scientific modelling can be used to understand archaeological landscapes. At the core of the paper is the belief that such techniques cannot produce absolute, certain representations of reality, but that they produce informative models that can be re-examined and re-adjusted to suit changing perceptions, technology and different contextual questions.[68] Similarly, Bevan discusses the potential of GIS modelling techniques, but argues for more careful testing of the models, and that 'hyper-real models' attempting to consider every aspect of the archaeological context being modelled are fundamentally unhelpful.[69] These are insightful theoretical works, and while they do consider some specific examples, they are explicitly concerned with theoretical discussion, rather than answering contextual archaeological questions. This approach directly ties in with discussions surrounding avoiding trying to provide simple, clear answers to complex questions, as noted above. Other studies have a more contextual focus, but none, to my knowledge, have applied such techniques to consider connections between coastal regions with an integrated terrestrial and maritime focus, and certainly not the Adriatic Sea. Modelling connectivity

[64] Scheidel (2014), 8-9
[65] See Canosa-Betes (2016).
[66] Canosa-Betes (2016), 416.
[67] See especially Brandt *et al.* (1992); Lock and Stančič (1995); Llobera (2000); Bevan (2011).
[68] Llobera (2000), 65-66.
[69] Bevan (2011), 384-385.

across the Adriatic and its coastal regions, is a key aim of the current study, and essential to answering how far we can consider the Adriatic to have been a cohesive economic whole.

In this study, the central focus on modelling movement goes beyond LCP, and looks to the application of Circuit Theory, a relatively new technique in archaeology. CT follows the basic electrical theory of the relationship between voltage, current and resistance.[70] The resistance value directly affects the ability of current to flow through the circuit. Software such as circuit scape have been used in other disciplines to model movement, using a cost surface map as resistance with the current flowing through this circuit representing relative movement or connectivity.[71] Fields such as ecology have been quick to adopt these and the application of this theory in archaeology has been minimal, particularly beyond prehistoric contexts.[72] As is often the case, Classical Archaeology has been slow to adopt similar new techniques, but the potential for circuit theory to deepen our understanding of connectivity beyond simple LCP networks is clear. This approach allows for connectivity across entire regions to be modelled, not just between select points, and generates numerical values for current flowing through the entire circuit (or across the cost surface map), revealing secondary or tertiary routes beyond only the path of least resistance shown in LCP networks. Moreover, depending on the context, different sources can be selected to generate current. Sources can be archaeological sites, cities, villas etc. Alternatively, in order to provide the basic connectivity of an area independent of the archaeology, the borders of the cost surface map can act as sources and destinations, providing numerical connectivity data without the bias of known archaeological sites. This allows us to identify regions of high or low potential connectivity within the landscapes being considered and by comparing these regions of connectivity with the location of archaeological sites we can begin to understand, in a comparable and quantitative way, whether or not archaeological sites are in areas of high potential connectivity and mobility. This becomes particularly interesting when we can compare what finds assemblages suggest about the connectivity of two sites with where circuit theory suggests highly connected areas between such sites are. The use of CT in the current model is expanded upon in Chapter 3 but with this approach, we can begin to build a picture of how connected the coastal regions were. Additionally, through integrating the Adriatic Sea itself, we can begin to determine how closely connected the opposite coasts may have been, in a formally comparable manner. Like all models, this is a simplification of reality, reliant on current and resistance as proxies for potential connectivity and

[70] Howey (2011); Thayn *et al.* (2016); McLean and Rubio-Campillo (2022), 4-8.
[71] McRae *et al.* (2013); (2016).
[72] Pelletier *et al.* (2014); Brodie *et al.* (2016); Ospiova *et al.* (2019). See Howey (2011); White (2015); Thayn *et al.* (2016); McLean and Rubio-Campillo (2022) for some archaeological examples.

cost of movement. Nevertheless, this provides insight into general trends and new ways to approach connectivity in the region, with a wealth of meaningful, quantifiable data.

Not only are there interesting examples of quantitative methods being used in archaeology, and specifically the archaeology of the Roman economy, there is a very current and vibrant scholarly debate surrounding how these techniques can be applied, what new techniques might be helpful, and how best to use these techniques for different questions regarding all manner of archaeological evidence. Quantitative and computational models have focused on how to apply these new methods as much as, if not more than, simply aiming to answer questions.[73] A particularly relevant discussion can be found in the constructive criticisms from Van Oyen directed at Brughmans and Poblome.[74] This received a direct response from Brughmans and Poblome, and both sides mainly focused on how such computational methods should or should not be applied, rather than refuting or defending the results themselves.[75] Van Oyen suggested that formalist approaches, such as computational modelling, could not effectively be applied in an attempt to settle the debate on modernist or primitivist models, as formalist approaches are inherently modernist.[76] Brughmans and Poblome responded convincingly by pointing out that formalist approaches use mathematics rather than verbal conceptual modelling to define hypotheses, and, as such, any theoretical concept can be formally expressed.[77] This is an important point, and one which is particularly relevant to archaeology. Using quantitative approaches reliant on mathematics helps to remove biases, as far as possible, and such biases are prevalent in archaeology. Again, this approach is taken throughout the current study.

There is a long tradition of discussing how quantitative approaches can be applied to archaeology, and there are very current discussions about how these techniques can be applied to the economy of the Roman Empire. The relatively large body of evidence available to those studying the Roman Empire means that it is particularly well suited to data processing, such as frequentist statistics, where large samples are necessary. Indeed, very large samples can help to lessen the impact uncertainties, according to the law of large numbers. For example, biases might allow for some sites to have an unusually high percentage of *amphorae* sherds, due to particularly good excavation or documentation, and other sites, excavated earlier, have less *amphorae* sherds, due to less scientific excavation and less detailed reports.[78] Such a situation would distort reality, but with a large enough

[73] For just some examples see Cowgill (1977); Hurst Thomas (1978); Shennan (1997); Aldenderfer (1998); Smith (2015).
[74] Van Oyen (2017).
[75] Brughmans and Poblome (2017).
[76] Van Oyen (2017), 1357-1358.
[77] Brughmans and Poblome (2017), 1364.
[78] See VanValkenburgh and Dufton (2020), for a discussion of big data in archaeology.

sample size of sites, both of these extremes should be included and the more standard sites, the average between the extremes, should closely model reality.

Market integration in the Roman economy has been approached using quantitative methods, as highlighted most relevantly in Brughmans and Poblome. However, economic specialisation has never been modelled in any quantitative method. Indeed, even qualitative approaches to economic specialisation in the Roman economy are very sparse. With the requirement of large scale production and exchange, and the survivability of wine and oil *amphorae*, I believe that specialised wine and oil production in the Adriatic region are some of the best situations in which new quantitative approaches can be meaningfully applied. There is a large body of evidence that has been studied, largely qualitatively, and in isolated locations. Without any real pre-existing definitions of economic specialisation in this ancient context, it is hoped that the definition above is clear and robust enough, so that models for economic cohesion and specialisation can be readily quantified and compared to one another and the archaeological record, using the formalist techniques outlined above.

Despite the huge increase in the application of quantitative methods in archaeology in general, and within the Roman economy more specifically, there has yet to be any targeted quantitative analysis of the economy of the Roman Adriatic. Certainly there are studies on the Roman Adriatic, studies discussing the organisation of the economy of the Roman Adriatic, and studies applying quantitative methods to the Roman economy that include parts of the Adriatic region. However, none have applied quantitative methods to the economy of the Roman Adriatic. The Adriatic during the Roman period is of particular interest economically. This is discussed in more detail in Chapter 2, but for now, an overview of the past scholarship on the Roman Adriatic can be offered.

## 1.3- The Adriatic Region

A general overview of current trends and techniques in the scholarship of the Roman economy has now been presented. With that we can begin to discuss more specific regional scholarship. The Adriatic region can be seen as a microcosm for the wider Roman world; both being centred around a sea which likely did more to connect the opposing coasts than to disconnect. There is huge potential for developing a more in-depth knowledge of how wider Roman and ancient economies were organised, through dedicated study of this region. As such, the economic importance of the region, particularly during the Roman Empire, should not be overlooked. There are numerous studies discussing the archaeology of the Adriatic region, which are not focused exclusively on the Roman period. There is a dedicated work looking at the potential of the Adriatic Sea to connect prehistoric peoples, as well as works analysing specialised potters and the early Greek colonisation of the region.[79] There are studies looking at changing trade patterns during and following the late antique period, into the medieval.[80] Additionally, there are modern economic studies of the Adriatic.[81] The concern of the current study is limited temporally to the early Roman Empire, but it is important to keep in mind, particularly in economic terms, that this region has a very active scholarly debate. Such studies provide excellent comparative potential; however, research in the region focusing on this specific period does have its issues, and desperately needs a new, more integrated approach. Some general issues with economic studies in the Italian and then Dalmatian Adriatic are highlighted, before more in-depth thematic discussions considering the production and exchange of oil and wine as well as trade and market integration and finally onto the limited discussions surrounding economic specialisation and the application of quantitative methods are analysed. It is outlined how the current work aims to address these issues, not only by adding to the scholarship of the region, but as a consequence, to our understanding of the wider Roman economy.

### 1.3.1- Italy

Studies of the economy of Roman Italy are numerous and varied. With Rome and the Italian peninsula at the heart of the Roman Empire, this region is often at the heart of debates surrounding the economy of the Empire. With the large body of scholarship concerning this, it would be unhelpful to provide an in-depth discussion of the Italian economy itself, what is instead provided here, is an overview of some of the more relevant and recent works discussing the economy of Roman Italy.

A particularly relevant work, *The Economic Integration of Roman Italy*, was published in 2017.[82] This contains a series of publications discussing in great detail the economy of Roman Italy, with market integration being a central concern. The approaches are much more archaeologically and scientifically minded than many earlier studies in the region, representative of a general trend in ancient economic studies.[83] *Amphorae* distributions are used to quantify integration, with quantities of *amphorae* being compared between sites and regions in attempts to define levels of integration.[84] This is similar to the current approach. Other proxies are used in a similar way, including the need of

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[79] For the prehistoric connectivity, see Forenbaher (2009); for the specialised potters see Spataro (2009) and for Greek colonisation Kirigin *et al.* (2009). For additional prehistoric and early Greek colonisation material, see Radić (2009a); Miše (2012).
[80] Lenzi (2003); Kingsley (2008); Reynolds (2010).
[81] Niavis *et al.* (2017).
[82] De Haas and Tol (2017).
[83] See for example Morley (1996).
[84] Pasquinucci and Menchelli (2017), 329; Tol (2017), 371-378.

fuel (wood and charcoal) in Rome, and the use of coins to track actual economic processes.[85] Some more theoretical sections are also provided, discussing the trajectory of studies in the ancient economy, and especially Roman Italy.[86] The most relevant section can be found in Van Limbergen *et al.* discussing viticulture in central-Adriatic Italy.[87] It is worth noting that in this more than 400 page book only 24 pages discuss the Adriatic in any detail. This is true in general of Italian economic studies, with the Tyrrhenian coast being far better studied than the Adriatic. Nonetheless, Van Limbergen *et al.* offer invaluable insight into the wine trade of the region; emphasising the importance of the demand for wine from urban centres, especially Rome. Frequent reference is made to the *amphorae* types present in the area in attempts to track economic integration and exchange within Italy. Notably, connections with the rest of the Adriatic are not considered. This too is representative of wider Italian economic studies. Adriatic Italy is discussed far less often than elsewhere, and connections with the eastern coast of the Adriatic are often not considered in the same detail.

This general theme, of gaps in the Adriatic as a study region, can be seen throughout the scholarship. The *Antichità Altoadriatiche* periodical, published regularly since its foundation in 1968, is an invaluable resource for historical and archaeological studies of the upper Adriatic. This considers a wide variety of topics, some relevant, within the Italian upper Adriatic as well as Istria.[88] This region of the Adriatic is inarguably the best discussed and understood in terms of the Roman economy, with scholars such as Carre and Mattioli discussing specific aspects of the economy of this northern region in detail.[89] Some recent attention has been given to the central Italian Adriatic, with Van Limbergen publishing multiple dedicated works analysing the wine trade in the area, especially between Rimini and Pescara.[90] There are some discussions of the southern Adriatic, particularly centred around Brindisi.[91] Although these are on the very edge of the study area considered. Generally, these studies rarely consider the eastern Adriatic and the possible connecting nature of the sea itself. This theme of isolated micro-regions within the Adriatic being viewed as case studies can be seen throughout Italian and Adriatic Italian economic studies. The current work aims at a much more outward looking approach when considering the promising evidence from the Italian Adriatic coast, with an emphasis on trade beyond, and especially across the Adriatic.

[85] For fuel, see Veal (2017) 388-406; for the use of coins, Crawford (2017), 407.
[86] Feinman (2017), 417-425; Attema (2017), 426-435.
[87] Van Limbergen *et al.* (2017), 342-366.
[88] See Rousse (2013), 123-140.
[89] These are discussed in detail below, but see Carre (1985); Pesavento Mattioli and Carre (2009).
[90] Van Limbergen (2011); (2016); (2018); (2019); Van Limbergen *et al.* (2017).
[91] Bezeczky (2010), 255; Reynolds (2010), 92-93 and especially Auriemma and Degrassi (2015).

### 1.3.2- Dalmatia

Scholarship discussing the economy of the Dalmatian coast of the Adriatic is quite distinct from that of the Italian coast. These discussions can be viewed as 'rather sparse', but are often much more focused on the Adriatic coastal regions than Italian studies are; as such, a relatively more comprehensive focused overview can be provided for the eastern Adriatic coast.[92] Wilkes, an authority on the province, published a significant work in 1969, titled *Dalmatia*. This has some discussion of the economy of the province, but, in this over 500 page book, only eight pages towards the end are dedicated to explicit discussion of the economy of the province.[93] Wilkes published a study concerned with the import of stamped bricks, largely from Aquileia, into the province. This alluded to the connections between the coasts.[94] However, a general trend can be observed in his works, which seem to downplay how economically prosperous or important the province was. The dated nature of this work is highlighted through the claim that Dalmatian wool was of too poor quality to be exported in any real quantity, but, as Glicksman argues, cheap bulk products were surely amongst those most widely exported.[95] Wilkes' contribution to the study of the province of Dalmatia is undeniable, but the contribution to economic studies is limited. Zaninović offers a similar account of the economy of Dalmatia, but arguably even less detailed, and with a similar lack of engagement with any archaeological evidence. [96] Both Wilkes and Zaninović highlight the importance of connections with the Italian coast to the economy of Dalmatia, but this is not discussed in any meaningful detail by either.[97] More recently, Škegro published a book dedicated to the economy of Dalmatia.[98] Glicksman points out that this work is quite shallow; not engaging with the evidence fully.[99] Although more up to date than the Wilkes or Zaninović, Škegro's book still does not offer a complete study of the economy of the province in any modern sense.

Glicksman's works have added much more considerably to our understanding of the economy of the eastern Adriatic. She has primarily focused on trade in the Roman province, especially in her 2005 work.[100] This considers the internal and external trade of Dalmatia. Focusing on the exchange of commodities, as opposed to a more blinkered view of simply what material culture was present in the

[92] Glicksman (2005), 190-191.
[93] Wilkes (1969), 407-415. See also Wilkes (1962).
[94] Wilkes (1979).
[95] Wilkes (1969), 409; Glicksman (2005).
[96] Glicksman (2005), 190; Zaninović (1977).
[97] Wilkes (1969), 408; Zaninović (1977).
[98] Škegro (1999).
[99] Glicksman (2005), 191.
[100] Glicksman (2005). Her 2009 DPhil thesis is concerned more generally with the economy of Dalmatia.

province (as is prevalent in earlier literature), is a much more helpful approach, which allows for a more complete discussion of the region and its economic cohesion. Importantly, Glicksman is explicit about attempting to compare the patterns of trade within and beyond Dalmatia with the wider Mediterranean world.[101] This is achieved to a considerable extent, and the nature of trade between the Italian and Dalmatian coasts of the Adriatic, with particular reference to Aquileia and its function as a possible *emporium*, is discussed in some detail.[102] Moreover, a diachronic account of the various regional imports that are present in Dalmatia is given.[103] This is always accompanied by a close discussion of the archaeological evidence, and with consideration given to the distortions and relative quantities of specific commodities, including *amphorae*. Glicksman's works are the first dedicated to the eastern Adriatic that approach the economy in a modern way, and have a more up to date conception of the ancient economy.

It must be kept in mind, that all of these works including Glicksman, are consciously focused on the province of Dalmatia, not the Adriatic. As such, the Italian evidence is rarely considered beyond Aquileia, and always with a focus on how it interacted with Dalmatia. Moreover, there are gaps in the scholarship along the Dalmatian coast. Due largely to excavation biases, the more southern areas, including some of the Montenegrin and Albanian coasts, are not discussed in equivalent detail to the Croatian evidence. Furthermore, many of these works discuss the interior of Dalmatia at some length. These are largely very informative discussions, but do shift focus away from the Adriatic itself, and the idea of an integrated Adriatic economy is rarely brought up. On the other hand, studies of Dalmatia can also be viewed as too wide-reaching in their scope. Few consider micro-regions within Dalmatia, and the ecological or economic variation between these.[104] Such approaches fail to consider the complexities of the Roman Empire, neither being a homogenous inter-connected network, nor a series of isolated regions acting independently. The second Chapter of this thesis focusses on defining and identifying micro-regions within the Adriatic and considering their ecological and economic connections with one another. This approach allows for both more intensive and extensive considerations of a regional economy within the wider Roman world.

It can be seen that there are numerous studies considering areas within the Adriatic case study. However, these are disparate and often disconnected. The current work can be viewed as a synthesis of the data already discussed, and brings together evidence from multiple countries and lingual and scholarly traditions. With a focus on the Adriatic itself, it is hoped that the economy of

[101] Glicksman (2005), 191-192.
[102] Glicksman (2005), 193-196.
[103] Glicksman (2005), 193-208.
[104] The difference between the fertile coast and mountainous interior are often mentioned, but not much else, for example, Glicksman (2009), 32.

each micro-region studied will be better understood within its wider context of the economy of the region and wider Roman world.

### 1.3.3- Adriatic Oil and Wine

Several studies have focused specifically on oil production in the Adriatic region. A lengthy book, *Olio e Pesce in Epoca Romana*, is concerned with the oil and fish product production in the upper and middle Italian Adriatic.[105] One of the most interesting sections of this book is provided by Busana *et al.*.[106] This assesses oil (as well as fish products) production through comparing literary sources with the archaeological evidence for oil production, in this case, almost exclusively pressing installations. This makes sense, as the study considers production, rather than trade in the region. Other sections of *Olio e Pesce* consider *amphorae* and trade more directly. Mazzocchin provides insight and an excellent database of funnel necked *amphorae* in the region.[107] Cipriano discusses the Dressel 6B oil *amphorae* in the region.[108] In this, Cipriano offers distributions of the *amphorae* beyond the Adriatic, with clear links to the Po Valley and into central Europe, highlighting how the region accessed markets beyond even the Mediterranean.[109] Both of these make reference to the stamps on the *amphorae* which helps to identify more precise groups of *amphorae*, as well as production points. Others discuss fish *amphorae* and, while this is not the type of *amphorae* with which the current work is concerned, the approaches to *amphorae* typologies in the region are relevant.[110] Botte examines the fabrics closely and creates groups within the assemblage based on this.[111] Mazzoli *et al.* follow a similar approach, and look at the archaeometry of the *amphorae* in the region and dividing these into groups based on statistical similarity.[112] The authors highlight that the results, while promising, did not allow for exact production points to be located, and suggest further work should be undertaken with the *amphorae* in the region.[113] Busana *et al.* are concerned with oil production while Mazzocchin and Cipriano study *amphorae* distributions and Botte and Mazzoli *et al.* use advanced archaeometrics and even some statistical approaches to group together *amphorae* types in attempts to pinpoint production points and find subsets within the assemblages. The results of these varied studies will be drawn upon throughout this work in an attempt to synthesise the existing data across the region.

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105 Pesavento Mattioli and Carre (2009),
106 Busana *et al.* (2009).
107 Mazzocchin (2013), 191-213.
108 Cipriano (2009).
109 Cipriano (2009), 178.
110 Botte (2009), 149-171; Carre *et al.* (2009), 215-238.
111 Capelli *et al.* (2009), 164-168.
112 Mazzoli *et al.* (2009), 239-250.
113 Mazzoli *et al.* (2009), 251-252.

However, none of these works are Adriatic-wide themselves. It is a specific aim of Busana *et al.* to transcend international or administrative boundaries, and consider more practical physiographic regions.[114] Indeed, scholars publishing in Italian, French and Spanish are all represented in the work. This is all excellent, and works towards considering the Adriatic as a more connected region. However, the authors are explicit in defining the upper and middle Adriatic as including the upper Italian Adriatic (*Emilia Romagna*, *Veneto e Friuli Venezia Giulia*), Istria and the middle Adriatic (*Marche*).[115] This leaves large gaps not only in some of the northern and all of the southern coastal regions of Italy, but does not consider any evidence from Dalmatia. Again, this is a common trend in Adriatic studies, with a clear divide between the scholarship of the eastern and western coasts, as well as Italian and Croatian scholarship itself.

There are also studies examining the wine production in Adriatic Italy, although these are somewhat less common than those for oil. Van Limbergen's work has been briefly mentioned, and it is his work in central Adriatic Italy that makes up the majority of dedicated studies on this topic. In these publications, he highlights the region's continued underappreciation for its economic importance.[116] Reference is made to evidence from the Dalmatian coast in a helpful manner, rarely seen in studies of the Italian Adriatic.[117] A detailed overview of the wine *amphorae* in the region is provided, with reference to their distributions.[118] In these discussions, Van Limbergen makes reference to 'pan-Adriatic' *amphorae* and highlights the difficulty in identifying precise production locations within the region.[119] He even compares the Adriatic Italian wine production and exchange to that on the Tyrrhenian coast.[120] The points made in Van Limbergen's analysis of the Italian central Adriatic wine trade are extremely interesting, and his fairly unique approach of viewing the Adriatic as a connected whole is helpful.

There are separate studies considering the production and exchange of oil and wine in Dalmatia. Wilkes noted the suitability of the region for oil and wine production briefly.[121] Two more recent works deal with the subject more meaningfully; Glicksman discussed olive and vine cultivation in the province, while Matijašić discussed oil and wine production.[122] Matijašić highlights the Dalmatian coast's suitability for vine and olive cultivation, as well as the particularly good sailing

[114] Busana *et al.* (2009), 35.
[115] Busana *et al.* (2009), 35.
[116] Van Limbergen (2018).
[117] Van Limbergen (2018), 201-202.
[118] Van Limbergen (2018), 202-213.
[119] Van Limbergen (2018), 213.
[120] Van Limbergen (2018), 219.
[121] Wilkes (1969), 408.
[122] Glicksman (2007); Matijašić (1993).

conditions in the area.[123] He highlights the well-known intense oil production in Istria with some 80 known sites with possible or confirmed oil production on the peninsula. This is contrasted with the less well preserved evidence in Dalmatia, with only 30 known sites at the time of Matijašić's writing, possibly due to less intense archaeological exploration in this region.[124] Matijašić does not believe there is much evidence for oil production beyond local needs in Dalmatia, and contrasts the clearly market orientated production in Istria.[125] Glicksman comes to a similar conclusion and cites the fairly meagre evidence for widespread wine or oil production across Dalmatia. Glicksman also believes that the evidence does not suggest major export that would have greatly impacted the wider Roman world.[126] A key aim of this work is to detect specialisation and model how it may have been organised. Even if there was not a specialised oil or wine trade from Dalmatia reaching the wider Roman world we might have specialised oil or wine being produced with target markets in the Adriatic itself. Or, Dalmatian products may have contributed to wider Adriatic exports, manifesting in a specialised exchange that pooled resources for wider export. Moreover, this limited volume of Dalmatian oil production need not suggest that it did not have a big impact on the local economy. Glicksman highlights the literary evidence (Apicius, *De Re Coquinaria*, 1.7) suggesting that Ligurian oil was valued as particularly high quality.[127] As such, Dalmatia may have produced high quality but low quantity oil, with high impact economically, but not necessarily archaeologically.[128] We can see a slight movement away from Wilkes downplaying the economic importance of the province, with acceptance that there was sophisticated economic activity, with some long range exchange of high value commodities. This can be taken further, if the *amphorae* distributions are analysed more thoroughly, and typologies established more firmly, it might show more considerable export of Dalmatian goods, where the evidence on the ground for its production might be as yet undiscovered. Of course, it may show the opposite, with a limited distribution beyond Dalmatia, and hence a limited scale of production in the province. In any case, the new, more quantitative approaches are applied to the case of Dalmatian wine and oil in an attempt to better understand the wider Adriatic economy.

The *amphorae* studies focusing on the transport of wine and oil across and beyond the Adriatic, though dated, are particularly helpful in understanding the manner in which these commodities were moved throughout the region. Cambi discusses in detail the different forms of Roman *amphorae* present in Dalmatia, and highlights that Lamboglia 2 had local imitations as well as

[123] Matijašić (1993), 247-248.
[124] Matijašić (1993), 248, 255.
[125] Matijašić (1993), 258-259.
[126] Glicksman (2007), 48.
[127] Glicksman (2007), 47
[128] Glicksman (2007), 48.

Italian imports.[129] Pointing to Lamboglia 2 varied fabrics suggesting the possibility of multiple production points.[130] While Aldini provides an in-depth analysis of so called *anfore foropopiliensi*, *amphorae* thought to be Adriatic in origin, with significant distributions around the region.[131] Brecciaroli focusses on the production of fish and wine *amphorae* in the central Italian Adriatic.[132] Cipriano and Carre discuss the production and typologies of coastal Adriatic *amphorae* in Italy.[133] There is a long history of *amphorae* studies in the region particularly for the Italian coast. While these works are excellent as reference points for the *amphorae* types in the Adriatic region, and will help to ground the current study, it is still a difficult process to identify specific production points for most Adriatic *amphorae*, as is discussed in more detail throughout. Indeed, *amphorae* from the Adriatic do not have robust typologies comparable to those found in Tyrrhenian or Baetican *amphorae*. The term 'Adriatic *amphorae*' has been used to describe a variety of vessels, including Lamboglia 2, *anfore foropopiliensi*, Dressel 6A and Dressel 6B.[134] There have been issues with the identification of many of these vessels. Lamboglia 2, for instance, were thought to have been exclusively Apulian oil vessels, but are now known to have been produced throughout the northern Adriatic and used mainly for wine.[135] These vessels are often assigned to vague production centres, such as the 'northern Adriatic', with no known differentiation between productions on the different coasts. However, some have suggested specific origins for certain *amphorae*, such as Lindhagen arguing Dalmatia was central to the production of Lamboglia 2.[136] Carre directly refutes Lindhagen's work, arguing that the Italian coast around Picenum was the centre for Lamboglia 2 production.[137] Both use qualitative approaches in attempts to disentangle the complicated *amphorae* forms from the Adriatic and, while Carre might be more convincing, nothing definitive has been shown either way, other than that there were production sites on the western Adriatic coast and that the *amphorae* are found across the whole northern Adriatic.

Moving towards something more directly comparable, some studies have applied more quantitative approaches to studying *amphorae* forms. Using statistical approaches, subtle differences within forms can be detected, which allows for clustering of sub-groups within the forms.[138] These

[129] Cambi (1989), 336.
[130] Cambi (1989), 311-313.
[131] Aldini (1978).
[132] Brecciaroli Taborelli (1984).
[133] Cipriano and Carre (1989).
[134] Carre and Pesavento Mattioli (2003); Van Limbergen (2011), 71-72; Auriemma and Degrassi (2015); Cipriano and Mazzocchin (2016).
[135] Van Limbergen (2018), 207-208
[136] Lindhagen (2013), 98.
[137] Carre *et al.* (2014).
[138] Gassner (2011), 3-7.

sub-groups may indicate different hands at work, and, importantly, different workshops. Despite general trends, there are some relatively well known *amphorae* types in the Adriatic. Istrian oil *amphorae*, for example, have a particularly in-depth scholarship surrounding them. Often discussions of Istrian *amphorae* focus on determining the provenance of the stamps on the vessels.[139] Utilising these stamps allows for much more precise production centres to be located, even individual workshops in some cases.[140] Studying the ratios in which these provenanced oil *amphorae* are present at different types of sites across the Adriatic would allow for us to better understand market integration as outlined above. Such precision is rare, but, if we add to these provenanced *amphorae*, the more ambiguous examples from the sub-groups detected through statistical approaches we can begin to establish quite an in-depth picture of how different groups of *amphorae* were distributed across the Adriatic. While it is beyond the scope of the current study to greatly expand on determining the provenance of these Adriatic *amphorae*, the quantitative approaches used by others will be used in analysing the likely origins of specific *amphorae* and cargoes. With this, the extent to which the region was economically integrated can begin to be understood through the study of these proxies.

There is considerable discussion surrounding wine and oil trade in the Adriatic, with some interesting techniques being applied to specific regions and case studies. The main aim of the current work, in this regard, is again to synthesise the evidence, and apply the most recent quantitative analyses to the disparate bodies of evidence in an attempt to unify studies of the Adriatic and determine how close economic connections between the two coasts really were. The production of wine and oil is mainly considered in Chapter 5, while their exchange primarily in Chapter 7.

### 1.3.4- Exchange and Market Integration

Some of the few areas of scholarship that commonly look beyond modern political boundaries are, unsurprisingly, maritime archaeology projects in the Adriatic. These almost always have a focus on trade, and some consideration of market integration. Recently, such maritime archaeological studies have become much more prevalent in the Adriatic. There is a series of projects dedicated to a more synthesised analysis of the archaeological remains along the eastern coast of the Adriatic. The Illyrian Coastal Exploration Programme (ICEP) aims at targeted analysis of the underwater remains along this coast, with the explicit intention of bringing together research from different modern countries, Croatia, Albania and Montenegro.[141] This approach is generally more inclusive than most of the works discussed thus far. Royal, part of ICEP, even provides some very interesting nuance to approaching the

[139] Tassaux (2001).
[140] Tassaux (2001).
[141] Royal (2015), 200

economic evidence in the area. He discusses the homogeneity and heterogeneity of cargo assemblages and their findspots, and notes that more heterogeneous wreck cargoes are generally closer to *emporia* sites and the homogenous cargoes are normally found closer to *amphorae* production sites. Royal argues that this may indicate that Croatian *amphorae* were sent to an *emporium* and from there sent further afield.[142] Royal also specifically considers wider connections, particularly between the Adriatic and the eastern Mediterranean.[143] This highlights concepts of integration, specialisation and considers and compares assemblages within the Adriatic region. As discussed above, these approaches are becoming more common in studies of the ancient economy and comparing distributions in order to model exchange and, ultimately, market integration and economic cohesion, is central to the current work; particularly in Chapter 7. However, the ICEP is specifically concerned with integrating different data sets of the eastern Adriatic and, although Royal's qualitative approaches to the assemblages are commendable, the application of statistical comparisons is not central in the project, though very clearly a component of it.[144] While the ICEP undertakes important research, the current work aims to take this further by combining the data with that of the western coast, and applying new quantitative techniques to understand distributions and exchange.

Another important maritime work considering the Adriatic can be found in Jurišić's *Ancient Shipwrecks of the Adriatic*.[145] This draws on earlier, unpublished works that focused on the underwater remains of the eastern Adriatic, as well as Parker's seminal work.[146] Jurišić offers detailed discussions of the *amphorae* forms found in the Adriatic at wreck sites, although does not discuss the forms produced at Adriatic sites in great detail.[147] He then offers a very detailed discussion of the maritime routes through the Adriatic at different periods, focusing on the early imperial.[148] Most relevantly, Jurišić produced an impressive catalogue of known wreck sites in the Adriatic, with a substantial number of maps and graphs detailing specific distributions not only of wrecks, but of the *amphorae* discussed. This work considers the entire Adriatic in an inclusive way that had not been attempted seriously before, and brings together evidence from all coastlines and wrecks across the sea. However, Jurišić did not draw many wide-reaching conclusions from the impressive data compiled and noted some general claims like the large volume of pottery imported into Dalmatia, and making some

142 Royal (2015), 205
143 Royal (2015), see also Bezeczky (2010).
144 See Royal (2017), especially 31-42, for some statistical analysis of amphorae dimensions and petrological analysis.
145 Jurišić (2000).
146 Jurišić (2000), 2; Parker (1992).
147 Jurišić (2000), 11-25.
148 Jurišić (2000), 47-55.

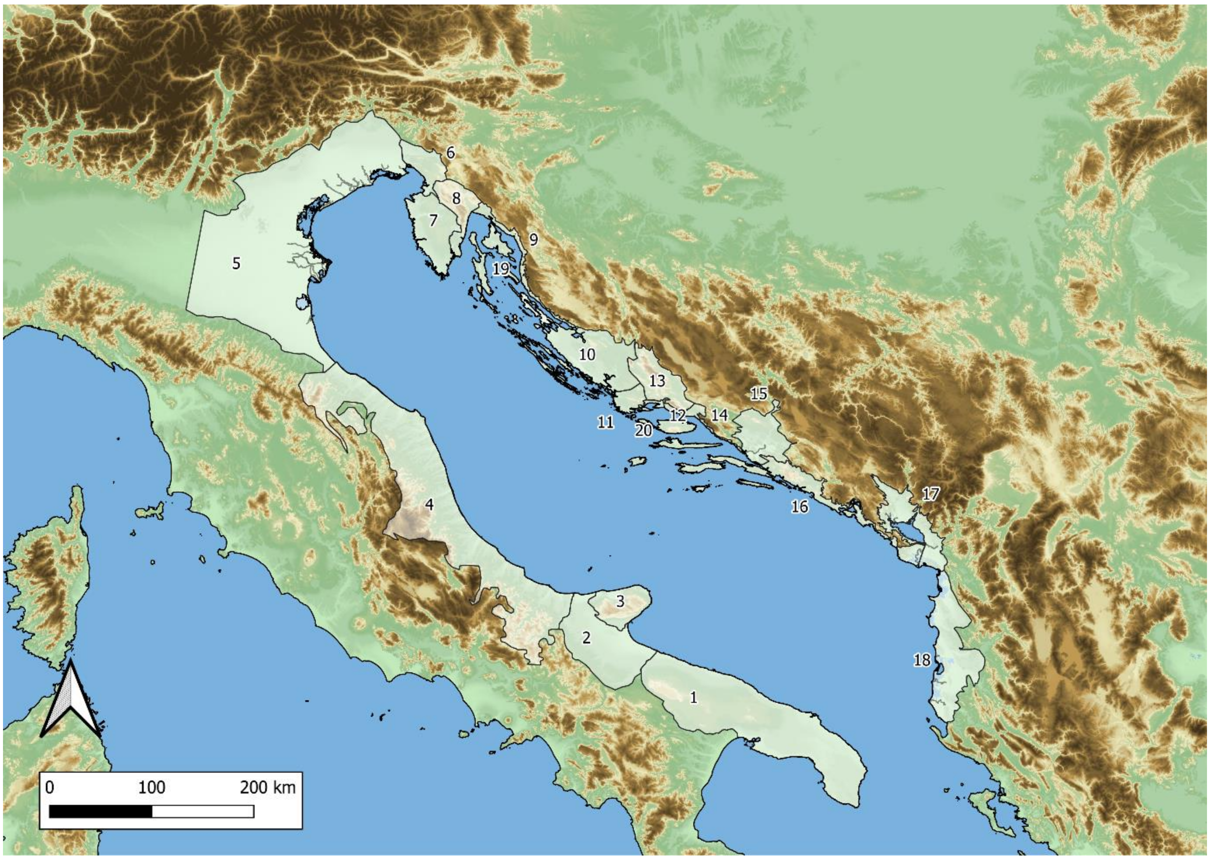
already apparent points such as the underwater evidence showing that there was more trade into Dalmatia than out of it.[149] It is difficult to imagine there was no cargo on return trips from Dalmatia, but we may assume that this cargo was perishable in nature, unlike the pottery being imported. Nevertheless, Jurišić's work is an excellent database, and the wide range of data compiled warrants closer and more targeted examination. This is discussed in detail in Chapter 7.

The works discussed in this section have all added considerably to how economic cohesion in the Adriatic region can be understood. While all have shortcomings of some form when considering the region-wide Adriatic economy, whether in scope or methodology. Ultimately, none offer an in-depth analysis of pan-Adriatic evidence and, considering both integration within the Adriatic, and integration beyond the region, allow for an understanding of the economic cohesion of the region. The current work draws on these excellent studies, and applies new quantitative techniques with a larger, more inclusive scope than has ever been previously attempted in the region.

There is an in-depth and vibrant scholarship discussing the economy of the Roman Adriatic. Significant progress has been made in recent years in understanding the organisation of the economy of the region which are largely based on wider studies. However, there are definite gaps in this scholarship. Most apparent is the lack of communication between studies of the eastern and western coasts with Italian and Croatian scholarship rarely engaging with one another in a meaningful way. Moreover, there are gaps in the study of both coasts. A definite bias can be seen; with studying the northern Italian Adriatic being more common the rest. Some recent work has looked at the central Italian Adriatic, but gaps remain. Similarly, there is a bias for the Croatian evidence on the eastern coast; with some recent projects aiming to consider evidence from Albania and Montenegro, as well as Croatia. This study aims at a synthesis of the disparate but significant research that has been undertaken across the region. Moreover, while there are constant references to specialisation in the oil and wine production at certain sites in the region, this has never been approached directly. The quantitative approaches that can be seen in some *amphorae* studies, as well as those looking at earlier time periods in the Adriatic, are applied to this synthesised data set, in an attempt to determine how integrated the possibly specialised markets of the Adriatic region were with one another, and ultimately, how far the region can be considered to have been a cohesive economic whole.

[149] Jurišić (2000), 58.

# Section A: The Physical Adriatic




This section takes a consciously non-archaeological approach. A discussion of how the geography and ecology of the region can be broken down into 20 distinct micro-regions is first offered. This is followed by an analysis of how this physical landscape may have affected mobility and potential connectivity between these micro-regions. These geographically derived features can then be compared to the archaeological data from Section B onwards.

# Chapter 2: The Adriatic 'Region'

'*The mouth is common to both; but this difference is to be observed, that the name Ionian is applied to the first part of the gulf only, and Adriatic to the interior sea up to the farthest end, but the name Adriatic is now applied to the whole sea.*'- Strabo, *Geographica*, 7.5.9.

The term 'Adriatic region' has been used multiple times above, but exactly what this Adriatic region is has not been addressed. In very simple terms, the Adriatic region is the area encompassing the Adriatic Sea, from the strait of Otranto to the gulf of Trieste (Fig. 2.1), and the associated coastal area. In the current context, the associated coastal areas are those inland which share the same continuous physical landscape as the connected coastal area, or those within around 200 km of the sea itself, even if the landscape is similar beyond this, whichever comes first. As is discussed below, a region can be far more complex than this, and having definite rigid boundaries often limits our understanding of the region itself. There is a tendency to generalise regions, regarding the region as mountainous, flat, fertile or dry for example.[150] Depending on the context of the study, this level of general detail can be sufficient, but with the current focus being on understanding complex economic specialisation and integration within and beyond the Adriatic region, such generalisations are unhelpful. In order to fully appreciate the complexity of economic cohesion in the Adriatic region, we must understand how the region manifests itself at different scales; are specific areas of the Adriatic more or less mountainous, flat, fertile or dry? By understanding the Adriatic region as a whole, as well as the diversity within the region, we can begin to meaningfully approach these complex issues of economic cohesion.

The aim of this chapter is to discuss the geographic and ecological Adriatic region in detail. First of all, the general term region is addressed, discussing in more detail exactly what this term means in the current context. The related concepts of regionalism and regionalisation are then briefly discussed in order to demonstrate which economic processes might lead to the creation of a cohesive region, combining concepts of physical (ecological/geographic) regions and economic regions. Following this, a discussion of what is meant by a micro-region, a constituent part of a wider region, is offered. Finally, the Adriatic region itself is discussed in detail, considering the specific geographies

[150] Horden and Purcell (2000), 12 and 56 highlight the issue of the Mediterranean (or smaller regions) being regarded as climatically homogenous. For some specifically Adriatic examples, see Bašić (2013), 31-35, highlighting three regions within Croatia, two being fertile and one being marshland; Radić (2009b), 13, discussing climate change affecting the Adriatic coast, with little discussion of how specific areas are affected differently.

and ecologies that can divide the Adriatic into these smaller constituent micro-regions. This chapter, and entire section, has a strictly physical, non-archaeological focus, with comparison of the physical Adriatic and the archaeological evidence being the primary focus of sections B and C.

## 2.1- Regions

### 2.1.1- What is a region?

Regions have been considered and discussed in a wide variety of contexts for a wide variety of reasons and as such, can be based on a number of factors. Some of the most common factors for defining a region involve 'geography, ethnicity and polity', though there are certainly many more.[151] Depending on which factors are used in defining a region will affect the actual limits of the region, and while geographic regions based on physical features generally require continuous connected limits (a mountain range for example), regions based on polity do not need to be entirely connected in this physical sense, and can contain entire geographic regions, be within geographic regions, or cross or be crossed by multiple such regions.[152] For example the modern European Union being a free trade region encompassing multiple political and geographic regions and being contained within the wider geographic region of Europe. Most modern economic discussions of regions make reference to groups of nation states or countries, located in close geographic proximity to one another, but regions can equally be contained entirely within a single country.[153] If we apply this to a Roman context, we can think of the different *geographic* regions that cross or are contained entirely within provincial boundaries.[154] In both cases, certain regions overlap with one another depending on the factors being addressed, geographic and economic regions are not necessarily the same, though the former can influence the latter. Essentially, a region can be thought of as an area that has relatively homogenous attributes, whether these attributes be physical geographic features, political control, the ethnic makeup of the people inhabiting the area, or any other number of attributes depends on what type of region is being defined. These different types of regions often affect one another, but rarely have the same limits; a country can have multiple ethnicities and physical landscapes within its borders. The type of region or regions that a regional study considers should depend on what questions are being asked in the specific study, though this is not always a straightforward process. The current

[151] Reger (2011), 371-372, see also, Deutsch *et al.* (1957); Russett (1967); Thompson (1973).
[152] Reger (2011), 371-374.
[153] Mansfield and Solingen (2010), 146.
[154] See Ando (2010) and Richardson (2008).

study is primarily concerned with the geographic region of the Adriatic, and how far that acted to create a cohesive economic region.

One particularly influential regional study that addresses the issues inherent within regionally based approaches is Horden and Purcell's *The Corrupting Sea*. Horden and Purcell discuss at length the concept of a Mediterranean region, or the validity of a Mediterranean history.[155] Here we can detect two distinct types of regions, a geographic, based on the limits of the Mediterranean Sea itself, and a historical or cultural region, based on a shared or connected history. Horden and Purcell make further distinctions between the history *in* a region, and history *of* a region.[156] History in a region can be based on physical attributes that connect the region, with the different histories within this geographic region being the focus. History of a region is based on historical or cultural attributes that connect areas within or beyond the shared physical attributes. Therefore, in order to understand a historical region, we must understand the different geographic regions which this historical region is part of. Reger has discussed at length how regional studies can be approached for the ancient Hellenistic world.[157] Importantly, he has explicitly discussed how considering the relationship between different types of regions can lead to a more 'robust' understanding of the regions themselves, whether these be geographic or economic.[158] This approach of considering the geographic as well as economic regions of the Adriatic is central to the current study. Reger offers definitions for how regions can be identified through geography, ethnicity and polity, and how these approaches affect our understanding of the economies.[159] Through these definitions we can understand the differences between the different types of regions and how each one may affect the other. The main types of regions include geographic, ethnic, political, ecological, economic and regions of connectivity. The most pertinent to this study are the geographic, ecological, economic and connectivity, but defining and considering ethnic and political regions can help us to understand all of these in more detail. A geographic region is based on the physical attributes of the area, whether this be elevation and slope, or proximity to the sea. If an area has a relatively homogenous elevation and slope, compared to adjacent areas, we can consider it to be a distinct geographic region. Similarly, an island, surrounded by the sea, might be considered to be a distinct geographic region, depending on the variation of the terrain within. An ethnic region can be defined by a shared ethnicity or sense of place/homeland amongst the people inhabiting an area.[160] This might also be considered a cultural region. A political

155 Horden and Purcell (2000).
156 Horden and Purcell (2000), 9.
157 See Reger (1994); (2007); (2011).
158 Reger (2011), 371.
159 Reger (2011), 373-378.
160 Reger (2011), 375.

region is based on the political control or administration of an area. A country could be considered as a political region, with a centralised administration. Of course, there are multiple levels to political administrations and so a country could in fact be divided into separate political regions based on local authorities, depending on how much power these authorities exercise, or indeed what questions are being asked. An ecological region, often defined by how the geography of the area impacts the suitability of the region for certain flora or fauna, of particular interest here, is the relative suitability for growing vines or olive trees. An economic region, related to ecology, is an area in which the inhabitants are engaged in relatively homogenous economic pursuits. A financial district of a city may be regarded as an economic region, or, more tangibly, a series of mining towns might be considered as a distinct economic region. Economic and ecological regions need not always line up as we might expect, as factors such as connectivity or polity can affect economic pursuits as much, or more than ecological factors.[161] Importantly, all of these definitions are dependent on *relative* homogeneity, a region must have more similar attributes between areas within the region, than it does with areas beyond the region. As such, the nature of all regions to which a single region is connected, affects the definition. Connections to other regions will directly influence the precise nature of the region, with, for example, economic pursuits being more or less favourable based on the ecology of connected regions. Indeed, two economic regions that have close interdependent trade connections can be considered as a single cohesive economic region, but have very different ecologies, allowing for diverse economic pursuits. As such, we must also consider regions of connectivity. These are defined by relatively low or high connectivity. This connectivity not only affects the other regions, but is itself affected by factors such as geography and polity. Through understanding how each of these different types of regions affect one another, we can begin to understand each specific region in a far more meaningful way. The geographic and economic regions, as well as the regions of connectivity in the Adriatic must all factor into how we approach the idea of the Adriatic as a cohesive economic whole. The geographic and connectivity micro-regions form the basis for understanding the economic regions or micro-regions in this study.

An issue with regional studies which can be seen in the definition of these regions, is in considering the appropriate scale of the study. The wider Adriatic region can be defined as above, based on physical attributes, the limits of, and distance from, the sea itself. However, within this geographic region we have numerous smaller geographic regions, or what can be considered as 'micro-regions' within the Adriatic, with areas of flatter terrain and variable climates across the Adriatic region. At a wider Mediterranean scale, the Adriatic may have relatively homogenous physical

[161] Horden and Purcell (2000), 64.

attributes compared to the rest of the Mediterranean, and can be considered as a single geographic region. However, if the region is considered at an Adriatic scale, we can see that there are clear differences within, which allow us to divide it into smaller geographic components. If we take it further down to an even more detailed scale, we would detect further differences within regions that are themselves within regions. Furthermore, on a global scale, the Mediterranean itself can be, and has been, viewed as having relatively homogenous physical attributes, as being a single region, of which the Adriatic, and its own regions' regions, are a part of. Again, depending on the questions being asked, we can limit the upper and lower end of this scale without drastically affecting the validity of the study, but this issue of scale should be of concern to any such regional study, as changing the scale can drastically affect the definitions of the regions. This study has the Adriatic region, as defined above, as the primary scale. Within this, we can see diverse geographic 'micro-regions'. Beyond the region, we can see extra-regional relationships with the wider Mediterranean and Roman worlds.

Through this detailed and dynamic approach, we can begin to answer how far we can consider the Adriatic to have been a cohesive economic whole, that is, an economic region within a defined geographic region. We can compare archaeological data between geographic micro-regions in order to understand the economic forces that may or may not have created economic regions and micro-regions within the geographic Adriatic region. How these micro-regions interact with one another on regional and inter-regional scales can tell us how cohesive the Adriatic may have been economically, with closer regional connections and more centralised inter-regional exchanges suggesting high levels of economic cohesion.

### 2.1.2- How are Cohesive Regions Created? Regionalisation and Regionalism

Once we understand the different types of regions outlined above and the scale we are considering, we can begin to identify how these non-geographic regions are created, and as such, we can more readily identify them in the archaeological record. The concepts of regionalism and regionalisation are central to understanding the process through which economic regions are created. Regionalisation and regionalism, like economic specialisation and market integration, are modern concepts, and similarly cannot be applied directly to the ancient world without careful consideration of what they mean in an ancient context. Both regionalisation and regionalism have been discussed in political and economic studies, but there is no definition for either that has been completely accepted by scholars; indeed, these are changeable and dynamic processes.[162] This makes modern studies complicated and

[162] Masnfield and Solingen (2010), 146; Middell (2012), 4.

applying these concepts to the ancient world even more problematic. It is, perhaps, simplest to consider definitions of these concepts in relation to one another.

Regionalisation and regionalism can be considered in terms of international relations. They are a political process and a political policy respectively, that both involve favouring a specific area over a wider whole.[163] With regionalisation, trade and investment within an area is more substantial than trade and investment beyond this area. This leads to marked economic differences within and beyond the area. These differences can lead to a distinct economic region forming, based on how the initial process of relatively high trade and investment affects any pre-existing political, ethnic or indeed economic regions. On the other hand, regionalism is marked by cooperation and coordination between areas, with close economic, political or cultural ties leading to the creation of a new region from these previously separate units.[164] Regionalisation can be seen as an inward looking societal process, while regionalism is an outward looking intentional policy.[165] So, with regionalisation we have a process of areas favouring close ties with certain other units, at the expense of others which leads to the creation of a region. With regionalism we have areas actively seeking out closer cooperation with one another that leads to the creation of a region. Indeed, regionalism can be seen as a policy that seeks regionalisation. With both of these, the 'areas' concerned are often based on polity, ethnicity, geography, connectivity or indeed the economy.

By applying these concepts to an ancient Adriatic context, we can identify what evidence and types of regions can best address the question of Adriatic economic cohesion. High economic cohesion can be thought of as very close ties within a region, with extra-regional exchange taking place in a more centralised, homogenous manner. If the cities of the Adriatic traded very closely with one another and pooled resources for more directed extra-regional trade, we can view this as a cohesive economic region, which came about through a process akin to regionalisation or, more difficult to detect given the need to identify intent, a policy of regionalism. In order to detect this process of regionalisation, we can look for proxies for the policies involved in the pursuit of regionalism. Modern regionalism is pursued through trade agreements, normally Free Trade Agreements (FTA) or Preferential Trade Agreements (PTA).[166] FTA's allow for much more efficient frictionless trade between countries, while PTA's produce similar results, but negatively affect third parties, in terms of trade.[167] Geographic regions that are joined by regions of high connectivity can be thought of as having a form of FTA, afforded by relatively low friction for movement between the regions. Similarly,

[163] Meadwell (1991).
[164] Haggard (1993), 48-49; Gamble and Payne (1996); Breslin and Higgott (2000); Ravenhill (2008).
[165] Pempel (2005), 19-20; Mansfield and Solingen (2010), 147.
[166] Mansfield and Solingen (2010), 147; Middell (2012), 2.
[167] Mansfield and Solingen (2010), 148.

economic regions that are dependent on the import of an economic commodity from another economic region, could be thought of as having a PTA. Trade with this region is favoured over others that do not export this sought after commodity. While these need not be direct policy, they would have a similar outcome to the policy of regionalism, and could represent a process of regionalisation, with the creation of cohesive economic regions. So, in order to detect a cohesive economic region in the ancient Adriatic, we need to understand the relationships between different geographic and economic micro-regions, as well as the regions of connectivity that link them. Central here is the interdependence of the economic region on the regions of connectivity and geography.

### 2.1.3- Micro-Regions

Throughout discussions of regions, reference has been made to smaller scale regions within a wider region. For the current study, these are referred to as 'micro-regions'. In simple terms, a micro-region can be considered as a smaller constituent part of a wider region. As has been outlined, depending on the scale, a region is not always a homogenous whole, rather a connected group of diverse micro-regions. These micro-regions can vary significantly in terms of ecology, geography or economy. As has been suggested, in order to understand the wider region, we must understand how these micro-regions interact with one another. Economic micro-regions can be linked to one another through interdependent trade that acts to create a single cohesive economic region. One example of this that is discussed by Horden and Purcell is the connection between dry farming and pastoralism. These two different agricultural practices suggest the presence of different economic micro-regions, as the land is exploited in different ways. However, different methods of exploiting the land can often be connected to one another economically, particularly with regard to economic specialisation. The diverse nature of ecological regions in the Mediterranean facilitates the diversification of agricultural practices, a reliance on dry farming can be drastically affected by subtle ecological changes year to year, causing whole crops to fail.[168] With diversification, and activities more resistant to variable conditions, such as pastoralism or transhumance, this uncertainty can be tackled.[169] So, whilst two micro-regions might have very different ecologies, one suited to pastoralism another to dry farming, the two could be closely linked through interdependence, with one being favoured under certain circumstances and the other under differing circumstances. This leads to economic interdependence between the two physical micro-regions: these physical micro-regions can then be considered as a cohesive economic region. Indeed, a single ecological micro-region, with similar conditions throughout, might not be exploited in the same way uniformly across the micro-region. There might

[168] Horden and Purcell (2000), 56-57.
[169] Horden and Purcell (2000), 69.

be similar potential for land use both inland and at the coast, but with close connections between the interior and coast, commodities can be produced at inland sites and bottled and shipped at coastal sites.[170] This could result in strips of economic micro-regions along an ecologically homogenous coastline, with closer economic connections between specific coastal and interior sites. If these economic micro-regions are then woven into a wider complex web through coastal connections, this can lead to a cohesive economic region covering multiple coastlines and associated interiors, covering great distances, while ecologically similar and closer sites are part of a separate economic system. Importantly, certain micro-regions will be closely tied to some others, but not necessarily all others, within the region. The link between physical and economic micro-regions, as well as how economic micro-regions are integrated with one another, is a complex matter. However, through understanding these complex relationships, we can begin to fully understand how far the Adriatic can be considered a cohesive economic region, and how this region interacted with the wider Roman world.

### 2.1.4- Past Conceptions of the Adriatic Region

The Adriatic has a long history and a rich body of diverse scholarship, as discussed in the introduction. However, few consider the entire Adriatic region as a whole, looking often to either the Italian or one of the modern Balkan nations' coasts, with little more than cursory discussions of what might connect these coasts, and create something approaching a cohesive whole. Indeed, the Adriatic is often neglected in discussions of the eastern or western Mediterranean, despite, or possibly due to, its central location between these two regions.[171] As such, in modern scholarship, there is no meaningful discussion of an Adriatic region of classical antiquity, even if the term 'Adriatic region' has been used before.[172] Scholarship discussing more recent history of the Adriatic has focused more on the concept of it being a distinct region, with close economic and cultural ties, while maintaining the obvious diversity within. Particularly the period during Venetian dominance of the Adriatic and the period following Napoleon's conquests of Italy and the Dalmatian coast, the concept of nationalism and nation states is prominent with the sources of the time, as well as being discussed in modern scholarship considering these historical periods of the region.[173] Indeed, the doges of Venice were explicit in proclaiming their domination of the Adriatic, viewing this control as a means to limit piracy and as beneficial to all Christendom.[174] Abulafia argued that the Adriatic is 'a miniature Mediterranean', and that 'the Adriatic has, since the early Middle Ages, brought the inhabitants of

[170] See Mattingly (1988) for an example of this with North African olive oil.
[171] Forenbaher (2009), foreword.
[172] See the introduction, and for example, Bezeckzy (2010); Ugolini (2021).
[173] Reill (2012); Phelps (2013), 713-714.
[174] de Vivo (2003), 161-162.

Italy face-to-face with Slavs, Albanians, and other Balkan peoples'.[175] Moreover, evidence for close trade connections between the Adriatic coasts of Italy and the Balkans have been used as indicators of peace, unity and stability across the region, with Hodges identifying multiple specific trade network regions within the wider Adriatic world. [176] As such, the concept of a unifying power bringing peace, stability and economic connectivity to the Adriatic, is not unique to the *pax Romana* experienced in the region during classical antiquity. Today, the Adriatic is a patchwork of some six sovereign nations in Italy, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro and Albania. Each with their own political and economic connections within this Adriatic region, as well as with the wider modern world, some within the EU, some not. The political and economic cohesion of the post-Roman Adriatic has been discussed amongst scholars of medieval to modern history, despite the acknowledged diversity inherent within the region. We can look to the Venetian control of the Adriatic as a more recent example of what may be considered a cohesive Adriatic region, but even in the scholarship investigating this period, there is limited explicit investigation of how economic cohesion may have manifested itself, and the control of the region was not complete, like it was during the Roman period.

Ancient sources also discuss the Adriatic and offer insight into how it may have been considered a distinct region during the Roman domination of the sea. Pliny and Strabo both make frequent references to the Adriatic in their respective works, using it as a geographic landmark to describe the location of various places and features within the wider Roman Empire.[177] Pliny does offer some suggestion of the Adriatic being a distinct entity through his differentiation between the Mediterranean and Adriatic (*Naturalis Historia*, 3.5, 3.2). This suggests that Pliny regarded the Adriatic as a distinct entity within the Roman world, at least to some extent.[178] Moreover, Pliny specifically highlights some particularly well regarded Adriatic products, including wines, peaches, fish and sand that was particularly suitable for marble polishing (*Naturalis Historia*, 9.20, 14.8, 15.11, 36.9). It is difficult to determine whether this is simply using the Adriatic as a geographic region to describe economic activities, or whether these are viewed as an economic region with distinct products. Nonetheless, with the varied array of Adriatic products, the diverse nature of this economic region is suggested, and some form of possible cohesion across the region is hinted at, whether it was economic, political, cultural or indeed imagined. This is much like the picture of a complex web of micro-regions producing different commodities in an inter-connected whole outlined above. However, even the specific references to Adriatic products mainly use the Adriatic as a landmark, to

[175] Hodges (2010), 107; Abulafia (2005), 67.
[176] Hodges (2010), 108-110, 112-113.
[177] For just some examples see Pliny, *Naturalis Historia*, 3.5, 4.11; Strabo *Geographica*, 7.5.1, 2.4.8, 5.1.2-3, 5.2.10
[178] The concept of these regions overlapping is discussed above.

identify exactly where these products are coming from, rather than Pliny describing a real economic region. Indeed, the idea of the Adriatic being a sea, a geographic landmark, rather than being thought of as a political or economic region is further suggested by Strabo. Strabo mentions the Pontic Sea (Black Sea), and the associated coastal area is described as the Pontic region (*Geographica*, 1.3.15). This suggests that, to Strabo at least, the area along the southern coast of the Black Sea was a cohesive region, connected in some form, by the sea. In contrast, the Adriatic is always referred to as a sea, or a gulf by Strabo, some geographic feature with different political or economic regions surrounding it, rather than as a distinct region itself. Certainly, the coastal Adriatic region is never explicitly described as having particularly strong internal economic or cultural connections. While discussion of the lands around the Adriatic do suggest that the region was diverse and produced commodities that were exported beyond the Adriatic itself, it does not seem that the ancient authors regarded it as a distinct region satisfying the definitions discussed above, other than perhaps a geographic one.

Strabo gives specific limits to the Adriatic Sea, highlighting that the Ceraunian Mountains (southern Albania) mark the limit between the Ionian and Adriatic Seas (*Geographica*, 7.5.8). This is notable for multiple reasons. First of all, that the sea was clearly regarded as a separate entity from the Ionian, and wider Mediterranean regions, in terms of a geographic feature. It is also notable that this divide is on the land, on the eastern coast of the sea. Strabo elaborates further, noting that the first, outer, section of this sea was known as the Ionian, while the 'inner sea' was known as the Adriatic. Furthermore, the entire body of water was apparently referred to as the Adriatic, with the Ionian being a division within the Adriatic, according to Strabo (*Geographica*, 7.5.9). Strabo here eludes to the complicated nature of regions, referencing seas within seas and the complicated process of dividing a geographic region into smaller constituent parts. Even though these are exactly the same as some of the concepts and issues discussed above, Strabo is still focused exclusively on the Adriatic as a geographic feature, a sea. Not a political, cultural or economic region that demonstrates any cohesion. Strabo does consider the coastal Adriatic, comparing the two coasts and highlighting that 'both seaboards in like manner are sunny and good for fruits, for the olive and the vine flourish there, except, perhaps, in places here or there that are utterly rugged' (*Geographica*, 7.5.10). In the same section (7.5.10), differences between the eastern and western coasts are discussed, as 'the whole Illyrian seaboard is exceedingly well supplied with harbours, not only on the continuous coast itself but also in the neighbouring islands, although the reverse is the case with that part of the Italian seaboard which lies opposite, since it is harbourless'. Moreover, the Po Delta is singled out as being particularly fertile and wealthy: 'For not only does the tilled land bring forth fruits in large quantities and of all sorts, but the forests have acorns in such quantities that Rome is fed mainly on the herds of swine that come from there.' (*Geographica*, 5.1.12). Again, all of this suggests some shared economic or ecological potential in the Adriatic region, while still showing the diversity within this region.

With an understanding of regions, their associated micro-regions and the historical concept of an Adriatic region, we can begin to breakdown the Adriatic into constituent parts. An ecological and geographic focus is taken, in the first instance, to establish what we may see as the physical micro-regions within the Adriatic. This provides dynamic hypothetical micro-regions that can showcase the diverse ecology and geography of the wider region. However, the historical, economic and especially archaeological reality is then assessed through close consideration of the archaeological evidence, in Sections B and C. Combining these different approaches in order to produce a dynamic map of micro-regions within the Adriatic region allows for a more helpful and informative model of the organisation of the Adriatic economy to be produced. Through this, we can begin to understand how far the Adriatic can be regarded as a cohesive economic whole, how the geography and ecology may have helped to form this economic region or micro-regions, and ultimately, begin to understand the organisation of the wider Roman economy in a more quantitative and comparable way than has been possible previously.

## 2.2- The Physical Adriatic Region

Now that what is meant by different types of regions has been outlined in detail, we can begin to look at the Adriatic at a regional scale, and consider how it can be broken down into micro-regions. Connectivity within and between these micro-regions will allow us to begin to understand how far the Adriatic region can be viewed as a cohesive economic whole. First of all, the possibility of the physical region having changed since antiquity is addressed. Following this, the basic geography of the Adriatic is considered, focusing on elevation and slope. The geology, and specifically the soil types, present around the Adriatic are then considered. This offers insight into how fertility may have varied within the region. The climate of these combined micro-regions is then considered and through this, a clearer picture of the different ecological micro-regions of the Adriatic, focusing on relative suitability for the cultivation of olives and vines, is possible. Through this, we can understand some possible geographic micro-regions, before going on to assess the potential regions of mobility and connectivity, and finally the archaeological evidence, in order to understand economic cohesion across the Adriatic.

### 2.2.1- Physical Change

Before the specific micro-regions of the Adriatic are examined, it is prudent to first discuss how the geography, geology and climate of the Adriatic region might have changed since antiquity. The data used are all largely modern, so, to what extent can we expect these to be the same for the early Empire? There have been several studies trying to determine the climate of the Mediterranean world during the Roman period.[179] These often come to similar conclusions, based on a variety of factors; that the Roman world experienced a change in general climate, with a trend towards warmer conditions from the 5th century BC into the 5th century AD.[180] As such, the 5th century BC can be viewed as colder than the present day, with the 5th century AD being warmer. This also suggests, that the period around 1st century BC, and much of the period considered here (1st century BC-3rd century AD) would have had a similar general climate to the present day, with presumably slightly warmer conditions towards the end of this period.[181] Scheidel and Harper argued that this change could have occurred earlier, and that from the 3rd century BC to the middle of the 2nd century AD was a relatively temperate and stable climatic period, with a dramatic cooling observable in the 6th century AD.[182] Beyond these general trends, the unpredictability of the Mediterranean climate has been discussed, particularly in relation to how climate changes may have affected ancient societies, and the fact that, due to the very diversity of the Mediterranean itself, different regions are affected in different ways by climate change.[183] The most pronounced difference in reaction to climate changes, can be seen between the eastern and western Mediterranean, with the Adriatic being part of the western Mediterranean in Scheidel and Harper's specific model.[184] In either case, we can assume that much of the Adriatic was affected by this Mediterranean wide climate change. Changes in the variety of factors that determine the climate across the Adriatic, including the North Atlantic Oscillation (NAO) and the pressure from the Azores and Persian winds, affect the Adriatic in the same way, with positive or negative NAO resulting in decreased or increased precipitation in the Adriatic and much of the western Mediterranean respectively.[185] Moreover, one of the biggest impacts on climate in the Adriatic is the wind tunnel created by the Apennine and Dinaric Alp ranges that separate the coasts from the interiors.[186] As is discussed below, the mountain ranges of the Adriatic have not changed in any significant way since antiquity, and although changes in the NAO and other weather systems affect different regions in different ways, the effect on the Adriatic region is relatively uniform.[187] As such,

[179] Garnsey (1988); (1998); (1999) (Scheidel (2018), 11.); Reale and Dirmeyer (2000); Harris (2013); Manning (2013); Moriondo *et al.* (2013). For a specific look at the changing range of olive cultivation see Oteros *et al.* (2014); Benito *et al.* (2015). For an overview of environmental history, see Scheidel and Harper (2018), especially 11-14.
[180] Reale and Dirmeyer (2000), 165; Fiorentino *et al.* (2010).
[181] Reale and Dirmeyer (2000), 165.
[182] Scheidel and Harper (2018), 25-26, 34.
[183] Scheidel and Harper (2018), 12-13.
[184] Scheidel and Harper (2018), 34-35.
[185] Pandžic´ and Likso (2005); Ulbrich *et al.* (2012), 329; Scheidel and Harper (2018), 15.
[186] Ulbrich *et al.* (2012), 329.
[187] Trouet *et al.* (2009), 79; Ulbrich *et al.* (2012), 329; Scheidel and Harper (2018), 15.

we can compare climatic differences between Adriatic micro-regions in the ancient world using modern data. We could say, for example, that micro-region A is warmer and wetter than micro-region B. With this, even if the climate of the micro-regions have changed since antiquity, if micro-region A is better suited to vine cultivation today than micro-region B, we could expect this to have been true for the period concerned, even if they were more or less well suited in antiquity when compared to the modern micro-regions. These issues with climate become much more pronounced when calculating agricultural output (discussed in Chapter 4) or more detailed concerns, but for the purposes of differentiating physical micro-regions, changing climate does not pose as significant a problem.

On the other hand, there has been little recent work on the soils of the ancient world.[188] Ancient sources occasionally mention particular soil types that are better suited to the cultivation of certain crops (Columella, *De Re Rustica*, 3.1 and 5.8; Cato, *De Agri Cultura*, 1.2-4), but rarely offer any insight into where these soils were present. However, we do know that the underlying geologies of the regions have remained unchanged since antiquity.[189] While underlying geology does not directly affect fertility or certain crop cultivation suitability, it does affect soil types.[190] Soil compositions can take a relatively long period of time to change significantly, on a scale of centuries, slower than that of climatic changes.[191] While there is a strong possibility that the soil types of the micro-regions studied do not exactly reflect the soil types found there in antiquity, the underlying geology and slow pace at which soil types change significantly, does mean that we might expect ancient soil types to be similar to their modern counterparts. For the current purposes, a general idea of modern soil types can be informative, but, like climate, cannot be entirely relied upon.

The basic geography of the Adriatic region has not changed in a significant way since long before antiquity. The mountains, plains and highlands all existed 2,000 years ago. While the coastlines have changed, (Pliny even mentions the sea receding quite drastically at points during antiquity, *Naturalis Historia*, 2.201) and the course of rivers have drifted, this is largely insignificant for the current purposes except in the Po and Neretva deltas.[192] These changes are discussed in more detail when the corresponding micro-regions are examined individually below, but for now, it is sufficient to highlight that the modern coastline around the Po delta extends considerably further into the Adriatic

[188] Huntington (1917); Scheidel and Harper (2018), 11-12. For the difficulties with soil types, see Goodchild (2009), especially 774-776. For an Anglo-Saxon England example, see Williamson (2013).
[189] See Babić *et al.* (2012) and Brunović *et al.* (2018) for the most recent geological Adriatic changes during the late glacial period.
[190] See Buol *et al.* (2011), 91-95; 102-113 for discussion of the formation of soils and their relationship with climate.
[191] Buol *et al.* (2011), 89-90.
[192] See Calzolari (2007) and Stefani (2017), on the Po; Mužinić (2007) and Romić *et al.* (2008), on the Neretva.

Sea than it did in antiquity, largely due to siltation, and that the branches of the Neretva delta have reduced from twelve to just three in recent years.[193] With these caveats, the basic geography of the Adriatic region can be taken to be largely the same since antiquity. Importantly, this basic geography can inform on the other factors. For example, distinguishing micro-regions might be tenuous based purely on soil differences, but if the basic geography also lines up with the soil types, we can be more confident that the micro-region had a different ecology from the surrounding micro-regions. As such, geographic differences are given precedence over soil and especially over climate differences, but all are used in order to understand the ancient Adriatic ecology and to form the potential micro-regions used throughout this study.

### 2.2.2- Basic Geography

The slope and elevation of a landscape has a profound effect on its agricultural potential. This also impacts mobility, connectivity and therefore economic cohesion. As such, it is helpful to consider the very basic geography of the region - i.e. where we can see different mountainous or lowland landscapes within the wider region. Three major mountain ranges can be found in the region. These are the Apennines running the length of much of Italy, the Alps, to the very north of the Adriatic, and the Dinaric Alps, stretching along the entirety of the eastern Adriatic coast (Fig. 2.2). Each of these ranges gives way to some form of lowland terrain towards the coast, with a flatter, lowland strip encircling much of the Adriatic. This varies in width considerably, with the eastern Adriatic having only very narrow bands of lowland coast in some areas, while the western Adriatic has generally more lowland before becoming mountainous in the interior. The plain of the Po, northern Italy, offers the largest continuous area of relative lowland in the region (and is the only area where the cut off of 200 km from the coast was necessary), but other lowland areas can be found in the area around modern day Zadar, central Croatia, the Neretva valley, southern Croatia, the Salento peninsula, the heel of Italy, and the low lying hills of central and western Istria, the large peninsula in the northern Adriatic. What can first be observed through this basic geography is the Adriatic region essentially being separated from other regions by these ranges. Other than the plain of the Po, the non-coastal study area is enclosed by mountainous landscapes. Moreover, the mountainous landscapes can act to cut off some of the areas within the region from one another, with only the Adriatic itself providing an efficient means of connecting micro-regions.[194] This may begin to suggest that the Adriatic can be

[193] Calzolari (2007) and Romić *et al.* (2008), 61-62.
[194] For discussions on the effect of these mountain ranges on the Adriatic, see Ulbrich *et al.* (2012), especially 330-331.

considered a distinct region, separated from the wider Roman world by mountain ranges, and closely connected within itself by efficient maritime movement afforded by the sea.

Through the digital elevation model (DEM) and slope map of the Adriatic (Figs. 2.2 and 2.3) we can divide the region into lowland, mountainous, hilly and flat areas, or geographic micro-regions (GMR). A GMR can be defined as a component of a wider region that has distinct geographic characteristics that separate it from the surrounding micro-regions. These characteristics are based on relative slope and/or elevation. The 22 Adriatic GMRs are summarised in Fig. 2.4 and Table 2.1. The basic geography of each of these is discussed in detail below.

**Table 2.1- Geographic Micro-Regions.**

*Elevation data from 'EU Copernicus Land Monitoring' website. Slope data a transformation of this elevation data using GDAL Slope function in QGIS.*

| GMR | Name | Basic Geography | Mean Elevation (m) | Mean Slope (°) |
|---|---|---|---|---|
| **1** | Salento Peninsula | Flat, lowland | 57.24 | 0.929 |
| **2** | Murgue Plateau | Flat, highland | 267.44 | 2.128 |
| **3** | Tavoliere delle Puglie | Plain | 120.02 | 1.517 |
| **4** | Gargano Promontory | Mountainous | 373.05 | 7.622 |
| **5** | Molise, Abruzzo and Marche | Hilly | 178.69 | 3.685 |
| **6** | Padan Plain | Plain | 31.95 | 0.844 |
| **7** | Gorizia Interior | Hilly | 130.13 | 5.861 |
| **8** | Gorizia Coast | Hilly | 316.58 | 5.966 |
| **9** | Trieste and Koper | Hilly | 87.73 | 7.57 |
| **10** | Central Istria | Hilly | 186.55 | 5.248 |
| **11** | Eastern Istria | Mountainous | 526.74 | 9.318 |
| **12** | Northern Dinaric Coast | Hilly | 268.46 | 12.112 |
| **13** | Zadar | Hilly | 174.49 | 3.95 |
| **14** | Split Coast | Hilly | 228.87 | 8.236 |
| **15** | Split Interior | Mountainous | 517.86 | 7.754 |
| **16** | Central Dinaric Coast | Hilly | 289.21 | 13.184 |
| **17** | Neretva Valley | Flat, lowland | 208.51 | 6.841 |
| **18** | Southern Dinaric Coast | Hilly | 293.29 | 12.278 |
| **19** | Mbishkodra plain | Plain | 146.19 | 7.149 |
| **20** | Albanian Coast | Flat, lowland | 62.95 | 3.906 |
| **21** | Northern Croatian Islands | Hilly | 102.91 | 7.27 |
| **22** | Southern Croatian Islands | Hilly | 179.84 | 10.33 |

GMR 1 can be found in the modern Italian region of Puglia, consisting of the low lying, relatively flat Salento peninsula. In contrast to this is GMR 2, which is separated from the Salento peninsula by the Messapic depression and dominated by the Murge plateau. This plateau is considerably hillier with a greater elevation than the lower lying GMRs that surround it. GMR 3 is more akin to GMR 1, consisting primarily of the *Tavoliere delle Puglie*. The *Tavoliere delle Puglie* is the second largest flat plain in Italy, with only the plain of the Po being larger, bordered by the mountainous Gargano promontory to the north-east. The Gargano promontory is itself GMR 4, and is characterised by mountainous terrain, far steeper and with greater elevation than the first three GMRs.

The *Tavolerie delle Puglie* and GMR 3 borders the modern Italian region of Molise to the north. Molise in turn borders Abruzzo which borders Marche, towards the north, before opening onto the Po valley. These three modern regions make up much of the Adriatic coast of Italy, and represent the large GMR 5. GMR 5 backs onto the Apennines towards the west, and slopes down towards the Adriatic coast, where they are characterised largely by sandy beaches (much like Strabo alludes to, *Geographica*, 7.5.10).[195] These hilly coastal areas are typified by the large number of rivers flowing through them, emptying into the Adriatic. The Fortore makes up the southernmost of these rivers, separating this hilly coastline from the flat *Tavoliere delle Puglie*.[196] After the Conca River, the hilly coastline begins to level out and opens onto the Po valley. GMR 5 is large and somewhat less distinct than the previous four. However, this hilly terrain with numerous rivers running from the Apennines into the Adriatic that is characteristic of GMR 5, keeps it distinct from the flat micro-regions to the north and south, as well as the mountainous Apennines to the west.[197]

Beyond the Conca River the Adriatic coast opens up as the Apennines curve westward and the hilly coast gives way to GMR 6, the expansive plain of the Po. This is the largest micro-region in the study area. Definitions of the extent of the Po valley vary, but using simple geography, a continuous flat plain can be observed stretching from the Conca River around the Adriatic coast up to the river Isonzo (Soča) where the coastal area around the Gulf of Trieste becomes more mountainous.[198] Again, this sixth micro-region is considerably larger and less distinct than the first four outlined. However, the coastal area of the plain of the Po and stretching up to the Gulf of Trieste can be differentiated from its adjoining micro-regions through its relative, uninterrupted flatness. Like GMR 5, GMR 6 is notable for the large number of rivers that flow through it, from the Apennines and Alps, into the Adriatic. Much of the western plain of the Po lies outside the scope of this current study, as being

[195] Fredi and Palmieri (2017), 58, 70.
[196] The rivers of the region are discussed in detail in Chapter 5, but as a reference, Fig. 5.2 details the main rivers.
[197] Fredi and Palmieri (2017), 67-71.
[198] Stefani (2017), 193-194.

more than 200 km from the Adriatic makes it difficult to argue that this area, despite relatively uniform geographic characteristics, is part of the Adriatic region. The area considered is bordered by the Apennines to the south; the Alps to the north; the beginning of the Dinaric Alps to the east; and the roughly 200 km limit to the west. There is some more variation in the plain of the Po, but much of this variation lies beyond what might be considered the Adriatic coastal region.[199]

Beyond the Isonzo the Adriatic coast becomes considerably more complicated in terms of geography. The former province of Gorizia (disbanded in 2017) in the modern Italian autonomous region of Friuli-Venezia Giulia rises onto the karst plateau that dominates much of the eastern Adriatic coast. Gorizia can be viewed as two distinct GMRs, 7 and 8; the low lying valley of the interior, bordered by the mountainous Dinaric Alps to the north, and the hillier coastal region. This hilly coastal region is bordered to the south by the low lying area around Italian Trieste and Slovenian Koper, and to the south-east the Ćićarija mountain range of Istria, and the rest of the Dinaric Alps. This lowland GMR 9 rises onto the hills of central Istria to the south then sharply up to the karst plateau and the beginning of the Ćićarija mountain range and the Dinaric Alps to the east.[200]

Istria itself can be divided into two distinct GMRs, 10 and 11. The relatively flat lowlands of the western and southern coast, including the low hills and valleys of central Istria, and the mountainous eastern coast. This mountainous coast continues for much of the eastern coast of the Adriatic, with the Dinaric Alps rising sharply into the interior.[201] These micro-regions are quite separate from the adjoining micro-regions surrounded on all sides by the Dinaric Alps or the Adriatic itself, and Istria is prominent throughout this study, particularly the western coast. Beyond the Istrian peninsula, the mountainous Ćićarija range gives way to a strip of hilly lowland bordered by the Adriatic Sea to the south and the Dinaric Alps to the north. This thin strip of hilly lowland narrows beyond Rijeka and continues along the coast until the Zadar County, where the lowland opens up and widens beyond the mountainous Dinaric Alps. GMR 12, the northern Dinaric coast, is characterised by this long and very narrow strip of lowland between the Adriatic and the sharply rising Dinarics of the interior. This basic geography makes up much of the Croatian and eastern Adriatic coast, including GMRs 12, 16 and 18.[202]

The peninsular area around Zadar County, GMR 13, can be differentiated from the surrounding micro-regions to the north-west and south-east by the much larger area between the sea and the Dinaric Alps. Additionally, while this area is not flat, it is less hilly than the surrounding coast. The Krka separates GMR 13 from the more mountainous interior of Split-Dalmatia County, GMR 15,

[199] Stefani (2017), 193.
[200] Cucchi and Finocchiaro (2017), 153-156.
[201] Faivre *et al.* (2011), 133-134.
[202] Kapusta and Wiluś (2017), 110-111.

and the flatter coastal area of Split, GMR 14. GMR 15 is dominated by the mountainous peaks of the Dinara and Svilaja ranges, separated from the Dinaric Alps proper by the Privija pass. The central Dinaric coast, GMR 16, beyond Split is somewhat less dominated by Dinaric Alps than the northern Dinaric coast but is still a relatively narrow strip of hilly lowland, bordered on the north-west by the mountainous Mali Kozjak and Mosor ranges, before opening onto the flat Neretva Valley.

The Neretva valley makes up GMR 17, and is among the flatter GMRs of the eastern Adriatic coast. The Neretva River flows from the Dinaric Alps down to the Adriatic where it empties through the Neretva delta.[203] Surrounding the low flat valley floor is an area of hillier terrain that rises into the Dinaric Alps. The southern Dinaric coast, GMR 18, then extends through Montenegro, includes the Bay of Kotor and continues into Albania before opening into Shkodër County and the Mbishkodra plain, GMR 19. The Mbishkodra plain is dominated by Lake Shkodër and is an area of relative flat lowland, encroaching on the mountainous Dinaric Alps. This flat lowland continues along much of the Albanian coast, although GMR 20 is generally lower lying, but slightly hillier than the Mbishkodra plain. This southern limit of the eastern Adriatic coast similarly backs up onto the Dinaric Alps and the connected Pindus range, but with much wider areas of flat coastal lowland as compared to the rest of the coast to the north.

In addition to the 20 mainland GMRs, the islands of the Adriatic, primarily in modern Croatia, can be considered as two distinct GMRs, 21 and 22. GMR 21 encompasses the northern most islands, and is dominated by relatively long, narrow islands, with fairly steep hills. In contrast, the islands to the south, are generally larger and less narrow but with steeper terrain. Of course, these groups of islands, as with many of the mainland GMRs, could be further subdivided, but the distinction between 22 GMRs is sufficient for understanding a regional Adriatic economy.

### 2.2.3- Soils

#### *2.2.3.1- Adriatic Soils*

Building on the basic geography, it is helpful to consider the soil types present throughout these Adriatic micro-regions, even if they cannot be relied upon entirely for ancient contexts. Through comparing the basic GMRs with soil types, we can begin to understand in more detail, the different potentials for certain crop cultivation in the Adriatic. Beyond this, we can build an ecological picture of the Adriatic that will help to answer how far we can consider the Adriatic to have been a cohesive

[203] Mužinić (2007), 127.

economic whole. Soil studies have a long history, and can inform not only on geography, but on agriculture.[204] As such, understanding the presence of different soil types can begin to point to which micro-regions of the Adriatic may have been better suited to particular agricultural pursuits.

Through comparing basic soil maps (Figs. 2.5 and 2.6 and Table 2.2), we can see some factors that seem to make the Adriatic a distinct entity. The coastal soil types are generally quite consistent, with the interior of both coasts generally showing a marked difference in soil taxonomy from coast to interior. These differences generally line up with the flatter coast and mountainous interior of the Adriatic. This is very apparent in Croatia, where limestone and dolomite derived materials dominate the coastal region, while alluvial, amongst other types of soils, are more common in the interior.[205] Much greater diversity between soil types is also apparent in the eastern interior. This is less evident in Italy, where cambisols (inceptisols USDA) are the dominant soil type on the Adriatic coast, but similarly are found across much of Italy (See Table 2.3 for a glossary of soil types). However, the volcanic andosols common on the Tyrrhenian coast of Italy are not to be found along its Adriatic coast. Moreover, it is clear that *terra rosa* is an prominent soil type across the Adriatic, though it is rarer on the eastern coast.[206] Soil types, particularly when combined with basic geography, do seem to suggest that the Adriatic is a distinct physical region. However, there are marked differences within this region, particularly between the coasts. With this general view of the region, we can begin to compare soil types with the GMRs and establish soil micro-regions (SMRs) based on a combination of both geography and soil.

*2.2.3.2- Adriatic Soils and Geographic micro-regions*

Through more detailed analyses of the soil types represented around the Adriatic coastal region, we can begin to create more informative physical micro-regions. As soil taxonomies are largely published separately for separate countries, it is necessary here to consider the Italian and eastern Adriatic SMRs separately. The different countries present on this eastern coast makes comparing soil types more complicated, but the Croatian publications are detailed enough to provide a good overview of soil types, with Albanian and Montenegrin sources filling in the rest.

At a glance it is interesting to note that many of the so-called soil regions of the Adriatic seem to line up closely with the GMRs outlined above. Costantini and Dazzi offer a map of the soil regions

[204] For specific discussion of the history of Italian, Croatian, Albanian and Mediterranean soil studies, see Costantini and Dazzi (2013); Bašić (2013); Zdruli (2005); Yaalon (1997) respectively.
[205] Bašić (2013), 30.
[206] Bašić (2013), 30-32; Costantini and Dazii (2013), 125. See Yaalon (1997), 165, for a discussion of the term *terra rossa*.

and systems of Italy (Figs. 2.7 and 2.8), based on their soil type map (Fig. 2.5). While 72.2 in Costantini and Dazzi covers most of both GMRs 1 and 2, the remainder of the GMRs line up very closely with the different soil regions.[207] This holds true when comparing it to the soil systems outlined in Costantini and Dazzi (Fig. 2.8).[208] Based on the soil types of the Adriatic, some slight changes have been made to the GMRs, resulting in the 20 SMRs of the Adriatic (Fig. 2.9 and Table 2.2).

**Table 2.2- Soil Micro-Regions.**

*Based on data from Costantini and Dazzi (2013), Bašić (2013), Zdruli (2003) and Yaalon (1995).*

| SMR | Name | Dominant Soil Types |
|---|---|---|
| **1** | Southern Apulia | Luvisols/Alfisols |
| **2** | Central Apulia | Calcisols/Inceptosols* |
| **3** | Gargano Promontory | Kastanozems/Mollisols |
| **4** | Molise, Abruzzo and Marche | Cambisols/Inceptisols |
| **4a** | Pescara | Cambisols Luvisols/Inceptisols Alfisols |
| **4b** | Ancona | Cambisols Calcisols Regosols/Inceptisols Entisols |
| **5** | Padan Plain | Cambisols/Inceptisols |
| **5a** | Po Delta | Fluvisols Umbrisols/Entisols |
| **5b** | Isonzo Delta | Cambisols Vertisols/Inceptisols Entisols |
| **6** | Trieste | Umbrisols/Mollisols |
| **7** | Istria | Limestone Dolomite/Terra Rossa |
| **8** | Eastern Istrian Coast | Limestone Dolomite |
| **9** | Northern Dinaric Coast | Limestone Dolomite (Some Terra Rossa) |
| **9a** | Northern Terra Rossa | Terra Rossa |
| **9b** | Southern Terra Rossa | Terra Rossa |
| **10** | Zadar | Limestone Dolomite** |
| **11** | Southern Šibenik-Knin | Limestone Dolomite |
| **12** | Split Coastal | Marl Limestone Flysh |
| **13** | Split Interior | Limestone Dolomite |
| **14** | Central Dinaric Coast | Marl Limestone Flysh |
| **15** | Neretva Valley | Alluvial |
| **16** | Southern Dinaric Coast | Limestone Dolomite |
| **17** | Lake Shkodër | Cambisols/Inceptisols |
| **18** | Albanian Coast | Fluvisols and Luvisols/Fluvisols and Alfisols |
| **19** | Northern Croatian Islands | Limestone Dolomite |
| **20** | Southern Croatian Islands | Limestone Dolomite |

** Also with some vertisols kastanozems phaeozems/vertisols mollisols entisols.*

*** Also with some alluvial soils and gravels.*

[207] Costantini and Dazzi (2013), 106-111.

[208] Costantini and Dazzi (2013), 110, 115-116. These soil systems are calculated through the frequency of certain soil types across Italy and retain a maximum of three of these soil types.

**Table 2.3- Glossary of Soil Types.**

*Based primarily on data from IUSS Working Group WRB (2015), as well as Costantini and Dazzi (2013), Bašić (2013), Zdruli (2003) and Yaalon (1995).*

| WRB Soil Type | Equivalent USDA | Characteristics | Common Crops |
|---|---|---|---|
| **Luvisol** | Alfisol | Suitable for a wide range of agricultural uses | Grains, sugar beets, fodder. Sloping terrain- orchards and grazing |
| **Cambisol** | Inceptisol | Good for agriculture, used intensively | Alluvial plain- food and oil crops. Sloping terrain- annual/perennial crops or grazing |
| **Calcisol** | Calcids | Limited suitability for agriculture, requires irrigation | When irrigated- Winter wheat and fodder |
| **Kastanozem** | Udoll/Mollisol | Potentially rich soils, limited by periodic lack of moisture | Small grains and vegetables |
| **Regosol** | Entisol | Limited agricultural potential, requires irrigation | Grazing |
| **Fluvisol** | Fluvent | Naturally fertile, situated near rivers | With water management- Dryland crops |
| **Umbrisol** | Entisol/ Inceptisol | Generally forested and on sloping terrain | Extensive grazing, potential for perennial crops |
| **Vertisol** | Vertisol | Require management for sustained agricultural production | Extensive grazing but often unused |
| **Andosol** | Andisol | High potential for agricultural production | Vegetable, wheat orchard and certain cash crops. Sloping terrain- forest |

SMR 1 combines GMRs 1 and 2, as these GMRs are both characterised by particularly fertile luvisol or alfisols. Alfisols are defined as such under USDA soil taxonomy.[209] Luvisols are roughly equivalent to these alfisols, in the World Reference Base for Soil Resources (WRB).[210] Important here, is the natural fertility of these soils. Typically used for grain production, on slopes they are better suited for pastoralism or tree growth.[211] Indeed, *terra rosa* is an alfisol/luvisol present in this micro-region, which is very well suited to olive tree or vine cultivation.[212] While geography is normally given precedence, it is also true that these two GMRs have more in common with one another than they do with GMR three, when considering geography and soil types together. As such, the ecology is likely to

[209] See Ditzler (2017), for an in-depth discussion of soil classification.

[210] See 'World Reference Base for Soil Resources' in Allaby (2013) and IUSS Working Group WRB (2015), especially 165.

[211] IUSS Working Group WRB (2015), 166.

[212] Costantini and Dazzi (2013), 124.

be broadly similar within GMRs 1 and 2, and different from GMR 3. Therefore, we can consider southern Puglia, GMRs 1 and 2, to be SMR 1.

SMR 2 has broadly the same extent as GMR 3, but with two clearly distinct groups of soil types. The south of SMR 2 is dominated by calcisols or inceptisols.[213] While the northern area, by the Gargano promontory and GMR 4, is considerably more diverse, with vertisols, kastanozems and phaeozems or vertisols, mollisols and entisols, making up the main soil groups (Figs. 2.5 and 2.10). Calcisols (WRB)/inceptisols (USDA) are considerably less fertile than the alfisols discussed above. While proper irrigation and fertilisation makes them suitable for some grain and fruit cultivation, they are generally better suited for pastoralism, especially on slopes, such as those around the edges of SMR 2.[214] Vertisols, on the other hand, are defined by their 'expansive clay', which causes considerable expansion and contraction when the soil is wet or dry respectively.[215] This can create fertile natural conditions particularly well suited to the grazing of cattle, but with irrigation, wheat can be grown effectively.[216] The thin strip of kastanozems/mollisols found the in the northern part of SMR 2 represents extremely fertile soils.[217] Entisols/phaeozems are similarly well suited to agriculture and pastoralism.[218] As such, while SMR 2 might at a glance seem to consist of two distinct SMRs, the reality is more complex. The majority of northern SMR 2 is best suited for pastoralism, and agriculture requires irrigation, much like the rest of SMR 2. While there are areas of northern SMR two that are well suited to agriculture, they are also particularly well suited for grazing and pastoralism. This combined with the basic geography, means that it is prudent here to have these seemingly two distinct soil regions, remain a single SMR 2. The Gargano promontory, GMR 4, is dominated by fertile kastanozems/mollisols. Given that its mountainous geography is completely different to the surrounding GMRs, it remains a distinct SMR 3, even though its land use might be related to the strip of similar soils to the south, in SMR 2.

GMR 5 can be seen to have a generally homogenous soil makeup, with cambisols/inceptisols being the dominant soil type. Cambisols, like calcisols (WRB), are generally equated to inceptisols (USDA).[219] As discussed, these soils are not particularly fertile and are better suited to pastoralism, though irrigation and fertilisation do make them suitable for certain crops. This hilly micro-region dominated by relatively infertile soils, can be considered SMR 4. However, there are two areas that

[213] Costantini and Dazzi (2013), 112.
[214] IUSS Working Group WRB (2015), 152.
[215] IUSS Working Group WRB (2015), 180.
[216] IUSS Working Group WRB (2015), 181.
[217] IUSS Working Group WRB (2015), 163.
[218] IUSS Working Group WRB (2015), 168.
[219] IUSS Working Group WRB (2015), 152.

appear to differ significantly; much of the area south-east of Pescara, and a large area around Ancona (see Fig. 2.5 or 2.10). The area south-east of Pescara has a band of luvisol, highly fertile soil, that when on hills are best suited to pastoralism, but otherwise are frequently used for grain cultivation. Indeed, these different soil horizons, do line up with some more harshly sloping terrain. Therefore, these pockets of luvisol within SMR 4 are still well suited to the pastoralism that the surrounding soil horizons are, but given the extra fertility, even better suited to vine cultivation, that favours a slope. As such, this should be considered as part of SMR four, but with some slight differences in soil types and general terrain. The regosols and calcisols/entisols that can be found around Ancona, are similarly suitable for intensive agriculture, given irrigation, but all are also most commonly used for pastoralism and grazing.[220] As such, while there are different soil horizons within SMR 4, they can all be considered as part of the same SMR, but with two slightly hillier and more fertile soil concentrations within.

This brings us to the plain of the Po, GMR 6. This micro-region is dominated by the inceptisols/cambisols found across SMR 4, but with much flatter terrain. The major difference is the high concentration of fluvisols along the banks of the Po itself. These fluvisols are highly fertile and with water control, are well suited to growing a variety of dry crops.[221] Given the flat nature of this micro-region, coupled with this high fertility, it is helpful to consider the fluvisol area immediately around the Po River itself to be within the wider micro-region, but with its own distinctly fertile characteristics, much like the different soil horizons in SMR 4. Another area, around the Isonzo delta, can be seen to have a concentration of gleysols. These soils are not hugely fertile and prone to waterlogging, but can be used for pastoralism and, if artificially drained, good arable land.[222] Again, while this delta region might be considered distinct from the wider SMR 5, given the suitability of pastoralism for all of this area as well as the largely uniform basic geography, we can consider it not to be distinct from the wider plain of the Po. So, we have SMR 5, with some slight variations in soil, but not geography, along the Po and Isonzo.

GMRs 7-9 are dominated by mollisols/umbrisols. These umbrisols, when on hilly terrain, such as is found here, are best suited to extensive grazing.[223] Although the elevation changes between these three geographic micro-regions, the similar soil horizons and slope suggests that they can all be considered as one soil micro-region, SMR 6.

Through all of this, we can begin to look at a slightly different picture for how the physical Adriatic micro-regions can be divided, with seven Italian SMRs. The soils of the eastern coast are

[220] IUSS Working Group WRB (2015), 152 and 172-173.
[221] IUSS Working Group WRB (2015), 158.
[222] IUSS Working Group WRB (2015), 159-160.
[223] IUSS Working Group WRB (2015), 179-180.

presented in a slightly different manner, due to the different data available, but the important thing is to be able to compare soil types within micro-regions, and while direct comparison of soil type in Italy and Croatia is not as straight forward, looking at the differences in soil types within both of these two countries allows us to build a picture of basic micro-regions within the Adriatic region that can be directly compared to one another, not on the basis of soil alone, but through a combination of geography, soil, climate and ultimately ecology.

*2.2.3.3- Eastern Coast*

The data available for the eastern coast focusses more on dominant parent materials for the soils.[224] This is somewhat different from the western coast where dominant soil groups themselves were the focused. However, it allows for a similar differentiation between micro-regions along the eastern coast, and allows us to understand in more detail the GMRs already outlined. SMRs 7 and 8 can be regarded as broadly the same as GMRs 10 and 11. The flat western coast and hillier interior of Istria are dominated by soils of limestone and dolomite, with a concentration of fertile *terra rossa* throughout.[225] Though the western coast is somewhat flatter than the interior of central Istria, this is only a small difference, and the similar soil types allow us to group these areas into a single micro-region, with a proliferation of fertile land throughout the hilly interior and flatter coast. The northern centre of Istria has patches of marl and limestone derived soils. These are similar in fertility and use to one another, and so we can consider this too, to be part of SMR 7.[226] The eastern coast of Istria has a very similar makeup of dominant parent materials, being dolomite and limestone, but with markedly fewer concentrations of *terra rossa*. This coupled with the contrasting mountainous nature of the eastern coast of Istria means that it should be considered as a distinct micro-region, SMR 8.

The northern Dinaric coast has a similar soil makeup to that of much of Istria, with dominant parent materials being dolomite and limestone, with some patches of *terra rossa.* Indeed, two distinct concentrations of *terra rossa* can be identified, as well as a strip of marl and limestone. These concentrations of *terra rossa* line up very closely with alternatively flatter and steeper terrain within GMR 12. While the variations in terrain and concentrations of *terra rosa* could be enough to distinguish these as distinct SMRs, the proximity of these micro-regions to one another, and the fact that all lie within GMR 12, it is again more helpful to consider these all as a single micro-region, SMR 9, albeit with some patches of more suitable agricultural land within.

224 Bašić (2013).
225 Faivre *et al.* (2010), 133-134.
226 Drohan *et al.* (2006), 108.

The flat area around Zadar, GMR 13 clearly has a different soil makeup from the surrounding soil regions. While still displaying a high concentration of limestone and dolomite derived soils, like much of the eastern Adriatic coast, there is also a blend of alluvials and marl throughout. These alluvials are particularly fertile, and given the relatively flat expanse of this micro-region, SMR 10 can be viewed as one particularly well suited to agricultural production.[227] As the flat coastal region shrinks again beyond Zadar, we can then see an area dominated again by dolomite and limestone derived materials. This is differentiated from the coast around Split by the presence of marl. While this hasn't been enough to differentiate other micro-regions, combined with the lower lying and flatter nature of the coastal area around Split, we can assign these as SMRs 11 and 12. This marl limestone around Split stretches along the central Dinaric coast to the Neretva valley, and given the much hillier nature of this central Dinaric coast, even with a similar soil makeup to that of SMR 12, we can consider this to be a separate micro-region, SMR 14. The interior of Split is dominated again by dolomite and limestone, but with a considerable concentration of alluvial loams and gravels throughout its various valleys. This, coupled with the far hillier nature of the interior, as compared to the flat marl coast, allows this to be a distinct SMR 13. The Neretva river valley, GMR 17, is characterised by much flatter and more open terrain than the surrounding coast and mountainous Dinaric Alps. Similarly, the soils are different, largely, again, due to the river itself.[228] Instead of the limestone and dolomite derived materials across much of the rest of the coast, we can find a concentration of alluvium derived materials in the flat expanse of the Neretva valley. Again, this micro-region would be considerably more agriculturally productive than the surrounding areas, given the fertility of alluvial soils and the flatness of the land.[229] As such, this can be considered SMR 15.

Beyond the Neretva valley we return to the limestone and dolomite that dominates the majority of the eastern Adriatic coast. This corresponds to the narrow strip of lowland coast that is GMR 18 and becomes SMR 16. Beyond SMR 16, we need to access soil data from Montenegro and Albania. Accessing such data from Montenegro can be complicated, as it is still in the process of being digitised.[230] However, there are some more detailed and accessible soil maps for Albania (Fig. 2.11).[231] GMR 19, the Mbishkodra plain, is dominated by cambisols. Whereas the rest of the Albanian coast switches between fluvisols, along the rivers Drin, Mat, Ishmi and Seman, and luvisols beyond these basins. All of these soil types are very fertile.[232] Given the minor differences in agricultural potential

[227] IUSS Working Group WRB (2015), 157-158.
[228] Mužinić (2007), 127-128.
[229] IUSS Working Group WRB (2015), 157-158.
[230] Salković (2018).
[231] Zdruli (2005).
[232] IUSS Working Group WRB (2015), 157-158 and 166.

of these soil types, it is prudent here to keep the distinction between GMRs 19 and 20, with the cambisols of the Mbishkodra plain and the luvisol/fluvisol dominated coast of Albania, focusing on the geography rather than minor soil differences. Thus, SMRs 17 and 18 correspond closely to these GMRs.

While the geography of the Croatian islands can be divided into two distinct GMRs, the soil horizons are broadly the same across all of these islands. They are dominated by limestone and dolomite, with some few patches of marl, much like most of the eastern coast. It would be possible to consider all of the islands and SMR 19 alone. However, with the clearly distinct geography and position within the wider region, it is more helpful to consider these again as two separate micro-regions, SMRs 19 and 20.

As the soil types largely line up with the geography of the Adriatic, the GMRs and SMRs are fairly similar, but through accounting for some differences, this creates a more detailed map of the physical micro-regions of the Adriatic, again with a total of twenty two micro-regions, based on a combination of GMRs and SMRs. These SMRs become the physical micro-regions that we can now discuss the climate and ecology of, and will remain the basis for the micro-regions (MR) discussed throughout the rest of this thesis.

### 2.2.4- Climate

Now that we have considered the basic geography and different soils of the Adriatic, we can begin to look at the climate of the Adriatic. Through considering the general climate of these micro-regions, we can begin to formulate a more detailed picture of which areas of the Adriatic are better suited to the cultivation of which crops, and through this, begin to understand any wider region economic systems and cohesion. It should again be emphasised that the data used here are largely modern, and so should not be relied on as directly equitable to the Roman period. However, different modern climates between micro-regions can helpfully inform on what may have been similar differences between these micro-regions during the early Roman Empire.

The term 'Mediterranean climate' is often used, referring to what might be considered a unifying climate across the entire Mediterranean coast.[233] This so-called Mediterranean climate is defined by warm, wet Winters and dry, hot Summers.[234] While such conditions are certainly present in the Mediterranean, assuming that the entire coastal region shares a single climate is, of course, an over simplification. One of the most widely used climate classification systems was established in the

[233] See Lionello (2012); Benito *et al.* (2015).
[234] Lionello *et al.* (2012), xxxix-xl.

19th century by Wladimir Köppen, based on temperature and plant life in specific regions.[235] Under this Köppen climate system, a Mediterranean climate is categorised as Csa/Csb (Table 2.4). And looking at (Fig. 2.12) it is clear that not much of the Mediterranean has what might be regarded as a typical Mediterranean climate. There is considerable variation in the climate across the Mediterranean. Certainly, it is not the case that the Mediterranean is a homogenous climatic region.[236] Most pertinent here is the fact that the Adriatic region can, in many ways, be viewed as a distinct entity within this diverse Mediterranean climate. The Adriatic coastal region is largely a Cfa climate (humid sub-tropical with no dry season) with an interior Cfb climate (maritime temperature), though there are pockets of Csa (Mediterranean climate) within the Adriatic. Some areas of the Mediterranean have similar climate categorisations, such as the coastal region from Catalonia into southern France, or the Chalkidiki peninsula in northern Greece. However, the Adriatic is the largest continuous coastal region with this climate categorisation, and is notable as being an enclosed coastal region, with the surrounding regions having markedly different climate categorisations. Other than the coastal region around Catalonia, there is nowhere else in the coastal Mediterranean with this distinct climatic makeup. Even Tyrrhenian Italy has a more typically 'Mediterranean climate'. So, again, we can see a distinct Adriatic region within the Mediterranean when we consider general climatic trends. However, with closer analysis of the Adriatic itself, this distinct region, like the rest of the Mediterranean, is by no means a homogenous one.

The southern-most part of the Italian Adriatic, Puglia, is the most Mediterranean of the micro-regions found in the Adriatic. With the majority of it being part of this hot, dry Summer climate definition, including Lecce, Brindisi and Bari. MR 1 can be almost entirely categorised as Mediterranean climate (Csa). Further north, into MR 2, the climate becomes a more humid subtropical one, particularly around Barletta and Foggia. This climate becomes considerably colder in the mountainous MR 3. The differences in climate line up very closely with the differences between the identified SMRs.

As we move north along the Italian Adriatic coast, we come to MR 4. The climate here is broadly similar to that of the adjoining MR 2, being humid and subtropical. This is the case along this entire coastal strip of MR 4, with the hillier interior of the micro-region having a cooler maritime climate.[237] This again, lines up well with both the GMRs and SMRs, with this area being defined by a long strip of hilly interior sloping down to a warmer, flatter coastal strip. The different soil

[235] Köppen (1918).
[236] Lionello *et al.* (2012), xxxix.
[237] Gentilucci *et al.* (2018), 2.

concentrations within SMR 4, around Pescara and Ancona, share this climate with the rest of the micro-region.

**Table 2.4- Climate of the Adriatic micro-regions.**

*All climatic data is taken from the climate-data website https://en.climate-data.org/ (accessed 05/06/19) unless otherwise stated.*

| MR | Name | Climate |
|---|---|---|
| **1** | Southern Apulia | Csa |
| **2** | Central Apulia | Cfa |
| **3** | Gargano Promontory | Cfb |
| **4** | Molise, Abruzzo and Marche | Cfa (Cfb towards hilly interior) |
| **4a** | Pescara | Cfa (Cfb towards hilly interior) |
| **4b** | Ancona | Cfa (Cfb towards hilly interior) |
| **5** | Padan Plain | Cfa (Cfb towards Apennines Dfb towards Alps) |
| **5a** | Po Delta | Cfa |
| **5b** | Isonzo Delta | Cfa |
| **6** | Trieste | Cfa (Cfb) |
| **7** | Istria | Cfa (Cfb in some isolated central pockets) |
| **8** | Eastern Istrian Coast | Cfa |
| **9** | Northern Dinaric Coast | Cfa |
| **9a** | Northern Terra Rossa | Cfa and Cfb |
| **9b** | Southern Terra Rossa | Cfa and Cfb |
| **10** | Zadar | Cfa (Cfb towards interior) |
| **11** | Southern Šibenik-Knin | Cfa (Cfb towards interior) |
| **12** | Split Coastal | Csa |
| **13** | Split Interior | Cfa |
| **14** | Central Dinaric Coast | Csa |
| **15** | Neretva Valley | Csa (Cfa towards upper Neretva) |
| **16** | Southern Dinaric Coast | Csa |
| **17** | Lake Shkodër | Cfa |
| **18** | Albanian Coast | Csa |
| **19** | Northern Croatian Islands | Cfa |
| **20** | Southern Croatian Islands | Csa |

| **Key** | |
|---|---|
| Csa | Mediterranean |
| Cfa | Humid Subtropical |
| Cfb | Maritime/Oceanic |
| Dfb | Warm Humid Continental |

MR 5 has a fairly uniform climate, almost wholly dominated by humid subtropical climate (Cfa). There are some pockets of more maritime climate zones on the edges towards the Apennines and humid continental climate zones closer to the Alps. However, this micro-region is almost entirely humid subtropical. While the soils of the Po and Isonzo deltas are markedly more fertile than that around the rest of SMR 5, the similar geography and climate allow these all to be considered part of the wider MR 5.

The area around Trieste, MR 6, has a similar broadly humid subtropical climate to that of the previous northern Adriatic micro-regions outlined, again, with the climate becoming cooler and more maritime towards the Alps. The different terrain of the Gorizia coast and interior both share similar climates and soils, and as such, we can still consider the hillier coast from the eastern bank of the Isonzo down to Trieste, to be a single micro-region.

Istria is dominated by this same humid subtropical climate. This is true for the entire coast of the peninsula and the overwhelming majority of central Istria.[238] There are a few select areas of maritime climate in the hillier central northern parts of Istria and the mountainous Ćićarija range in the east. Virtually all of the northern Dinaric coast can be considered similarly humid subtropical. It quickly becomes a more maritime climate towards the Dinaric Alps themselves, but the coastal region is dominated by a warmer humid climate. The humid subtropical climate, with some patches of maritime climate towards the Dinaric interior, continues throughout MR 11. The area around Zadar is again almost entirely dominated by this humid climate. Similarly, MR 13 continues this humid subtropical climate, with fewer cooler areas combined with relative flatness and distance from the Dinaric Alps. As we move around the Adriatic into the lower lying strip around Split and the associated coast, the climate becomes somewhat warmer. Here, we find a more Mediterranean climate, with a hot dry Summer, like that found in MR 1. This gives further credence to this coastal area around Split, MR 12, being a distinct micro-region within the Adriatic. Moreover, the interior of the Adriatic region around Split, MR 13, is markedly different in terms of climate, as the immediate interior around Split, being slightly higher land than the coast itself, is also somewhat cooler, with a humid subtropical rather than fully Mediterranean climate.

This coastal Mediterranean climate (Csa) continues along the central Dinaric coast, through MR 14. Around the Neretva valley delta the Mediterranean climate persists. Indeed, this hot climate is found well into the interior of the Neretva valley.[239] Just beyond the modern border of Bosnia and Herzegovina, the climate becomes slightly cooler again, becoming the humid subtropical climate found along much of the northern Adriatic coast. This slight change in climate, coupled with the very slightly flatter terrain of the lower Neretva, might encourage us to divide MR 15 into to two separate micro-regions, between the upper and lower Neretva. However, given that the terrain is broadly the

[238] Faivre *et al.* (2010).
[239] Mužinić (2007), 127.

same, and there are more similarities between the upper and lower Neretva than between either of these and the surrounding micro-regions, it is more helpful to consider these slight differences between the interior and coastal parts of MR 15 as just that, slight variations within a wider distinct micro-region. The southern Dinaric coast continues with this Mediterranean climate. Indeed, this is the case along the entire length of the Albanian Adriatic coast. MRs 14 and 16 share similar Mediterranean climates, but with hilly and flat geographies respectively. The intervening micro-region nineteen, around Lake Shkodër, is a flat micro-region with a cooler humid, subtropical climate, distinct from the Mediterranean climate of the surrounding micro-regions. The climate of the islands of GMRs 21 and 22 further emphasise the distinct character of these two groups of islands. The northern islands, SMR 19, have overwhelmingly humid subtropical climates (Cfa), while the southern islands of SMR 20 are significantly warmer, with much more typically Mediterranean climates (Csa). Again, it is clear that the Croatian islands of the Adriatic can be divided into two distinct groups.

With this, we now have modern climate information for the twenty distinct physical micro-regions. As has been highlighted throughout, there are similarities between many of these, and slight variations within the majority. This reinforces the point made above, that regions and micro-regions are essentially theoretical constructs and that having definitive borders between such micro-regions is, at its core, unhelpful. The micro-regions outlined here give us a general view of the variety and similarity within the wider Adriatic region and allow us to begin to think about how economic specialisation and cohesion might manifest themselves within such a physically diverse region.

### 2.2.5- Ecologies

We have now identified GMRs, based on terrain and basic geography, combined this with different soil types to identify SMRs, and finally considered the varying climates across these Adriatic micro-regions. With all of this, we can begin to discuss how each of these different MRs may be more or less suitable for the cultivation or certain crops, particularly olive trees or vines. Through this, we can begin to understand how specific MRs of the Adriatic may have interacted, to create an environment conducive to economic specialisation and cohesion. Before we discuss the specific ecologies, it is helpful here to outline to what extent we can actually determine the ecologies, or agricultural potential. There have been numerous attempts to do just this, often focusing on the scale of potential output, utilising complicated demographic estimates.[240] As has been briefly discussed, calculating climate changes and the result this would have on the cultivation of certain crops has also been attempted. These often rely on a variety of assumptions, in the absence of solid data, such as pollen

[240] See for example, Frier (2000); Čuka (2002); Goodchild (2009); Lionelli (2012); Bosi *et al.* (2019).

analysis or preserved organic materials.[241] Again, it is difficult to determine exact ecologies of the ancient world with any certainty, but with the data discussed above, we can gain an insight into the *relative* productive potential for the micro-regions of the Adriatic.[242]

To enhance our understanding of ancient ecologies, we can look to the written sources. The ancient agronomists offer considerable insight into what conditions they believe were best suited to the cultivation of certain crops. Columella describes vines as being very resilient, though needing more care than olives do (3.1 and 5.8). According to Columella, vines prosper in most climates, which are not excessively cold or hot, and can be grown well on flat plains, but do better on gently sloping hills (3.1). While apparently well suited to all moderate climates, they do better in slightly warmer rather than cooler climates as well as drier rather than wetter (3.1). Columella specifically claims olive trees are very resilient and hardy, but that they do not thrive under very hot or very cold conditions (5.8). In hot regions, they do better on the north side of a hill, while in cooler regions they are better planted on the southern slope of the hill (5.8). Cato argues for a general preference for southern slopes in agriculture (1.2-4). This, presumably, is in order to keep the trees from becoming overly cold or overly hot, with north facing slopes being colder than southern facing slopes generally (See Table 2.5 for aspect data for each micro-region).[243] Moreover, they are better suited to gentle slopes rather than either very flat or very mountainous terrain (5.8). On this point, Columella specifically highlights the Sabine hills of Italy as particularly well suited to olive tree cultivation. The olive tree, according to Columella, also does well in looser soils with underlying gravel, as well as denser soils only if they are moist and fertile (5.8). This is all particularly interesting, as it shows that we may be able to utilise the geographic terrain of the Adriatic, which is much more reliable for an ancient context, to understand which areas might be better suited to olive or vine cultivation.[244] Nevertheless, it should be kept in mind that the ancient sources do not represent infallible accounts of how ancient agriculture was actually organised in reality. These authors present their own idealised view from their personal experience, often restricted to central Italy and Rome, not necessarily representative of the Adriatic region. As such, while these sources are undoubtedly helpful, they cannot be relied upon exclusively to understand ancient agriculture and ecology.

Beyond ancient sources, we can also use modern comparative data as an indicator of vine or olive cultivation in the Adriatic region. Certainly, the modern range of the olive covers the entire study region, with the mountain ranges of the Dinaric Alps, Apennines and Alps acting as barriers (Fig.

[241] Dermody *et al.* (2012); Bosi *et al.* (2019), 2.
[242] Agricultural suitability is considered and quantified in more detail in Chapter 3, based on the trends outlined in this chapter.
[243] Goodchild (2009), 775-776.
[244] See Goodchild (2009) for an example of this having been used for ancient wheat cultivation.

2.13).[245] Olives are generally restricted to these relatively warm and wet climates (C in the Köppen climate classification).[246] Currently Italy is one of the world's leading producers of olive oil, accounting for some 14.5%, with the majority of this coming from the southern regions, and especially Puglia (Fig. 2.14).[247] In addition to Puglia being Italy's most important olive oil producer, the agricultural potential of the area is further attested by the region also being the main wheat producer in the country.[248] Importantly, while a Mediterranean climate is generally well suited for olive cultivation, it is not uniformly so, but varies throughout the year and phase of olive growth, dependent on the geographic location of the tree itself.[249] Although the production of olive oil in Croatia is not on the same scale as in Italy, it is an important part of the country's economy, and the suitability of coastal Croatia and its islands for the cultivation of olives has been noted.[250] The climate of the entire study area, therefore, is well suited to olive cultivation. In order to understand the varied suitability within the region, slope and aspect, and to a lesser extent, climate and soil data is used.

**Table 2.5- Aspect of the Adriatic micro-regions.**

*Aspect data was derived by transforming the elevation data from the Copernicus Land Monitoring Service using the GDAL Aspect tool in QGIS. Aspect is here expressed as a percentage of cells within the raster that have slopes facing one of the four cardinal directions.*

| MR | Name | N | E | S | W |
|---|---|---|---|---|---|
| 1 | Southern Apulia | 24.30 | 19.32 | 33.88 | 22.50 |
| 2 | Central Apulia | 19.70 | 9.12 | 47.18 | 24.00 |
| 3 | Gargano Promontory | 20.69 | 20.11 | 31.59 | 27.61 |
| 4 | Molise, Abruzzo and Marche | 38.98 | 34.68 | 15.54 | 10.79 |
| 5 | Padan Plain | 10.40 | 12.46 | 66.93 | 10.21 |
| 6 | Trieste | 29.61 | 14.56 | 34.67 | 21.15 |
| 7 | Istria | 21.94 | 27.80 | 28.10 | 22.17 |
| 8 | Eastern Istrian Coast | 19.99 | 18.99 | 31.01 | 30.01 |
| 9 | Northern Dinaric Coast | 21.21 | 25.66 | 26.25 | 26.88 |
| 10 | Zadar | 33.50 | 25.32 | 22.05 | 19.13 |
| 11 | Southern Šibenik-Knin | 22.83 | 17.85 | 30.28 | 29.04 |
| 12 | Split Coastal | 23.99 | 18.38 | 32.56 | 25.07 |
| 13 | Split Interior | 25.83 | 17.50 | 32.71 | 23.95 |
| 14 | Central Dinaric Coast | 26.12 | 14.65 | 31.26 | 27.97 |
| 15 | Neretva Valley | 9.21 | 8.19 | 38.99 | 43.61 |
| 16 | Southern Dinaric Coast | 33.64 | 18.60 | 29.59 | 18.18 |
| 17 | Lake Shkodër | 20.92 | 26.48 | 26.30 | 26.30 |

[245] Caudullo *et al.* (2017), 665.
[246] Ćuka (2002), 101.
[247] Fontanazza (2005), 14. See 'International Olive Council' website https://www.internationaloliveoil.org/ (accessed 29/04/19).
[248] USDA (2018).
[249] See Osteros *et al.* (2014).
[250] Ćuka (2002), 98.

| | | | | | |
|---|---|---|---|---|---|
| **18** | Albanian Coast | 28.25 | 29.49 | 22.04 | 20.22 |
| **19** | Northern Croatian Islands | 29.75 | 19.07 | 29.75 | 21.44 |
| **20** | Southern Croatian Islands | 22.81 | 20.93 | 23.73 | 32.53 |

In terms of wine, Italy is similarly one of the world's largest producers, in part due to the favourable physical conditions afforded by the country's geography, soils and climate.[251] Much of Croatia is well suited to modern wine production and is also a major producer worldwide.[252] There is a considerable diversity in the cultivation of vines across Croatia, from the continental productions, to the coastal, the latter being more similar to Italian wines, and the unique grape varieties found on the Croatian islands.[253] The entire Adriatic region considered is highly suitable for the cultivation of both olives and vines. Southern Italy is particularly well suited to olive cultivation and the entire country is a world leader in wine production. Croatia is somewhat more diverse in terms of vine and olive cultivation potential, with very distinct geographic wine regions, but the entire coast is well suited to vine and olive cultivation. This should be kept in mind throughout, while some areas may have been given over to one form of production or the other, mixed cultivation would surely have been widespread, indeed, there is evidence for this specifically in an ancient Adriatic setting in the form of *arbustae*.[254] Nevertheless, the following approach allows for the micro-regions to be readily compared based on reliable geographic factors. With these general ecological trends outlined, we can now begin to assess the individual micro-regions for their potential for vine and olive cultivation, using the ancient sources, modern comparative data and of course, the physical characteristics of the micro-regions themselves (See Table 2.6).

In MR 1, we have fertile luvisols and alfisols, with a Mediterranean Csa climate. Luvisols and alfisols are extremely fertile and well suited to agricultural production. Being quite dense but fertile and moist, they are well suited to olive cultivation, particularly on sloping terrain.[255] The Mediterranean climate found here is also well suited to the cultivation of wheat, olives and vines. Given the hotter climate in MR 1, we should expect a preference for north facing hills, going by Columella's recommendation (5.8). However, only a quarter of slopes in the micro-region are northward facing. Moreover, the micro-region is generally flat, with only a few thin strips of gently sloping land. Vines do better on flatter terrain than olives do, but are likewise especially well suited to gentle slopes. Moreover, warmer climates, like what is found in this southernmost micro-region, are

[251] 'Food and Agriculture Organization of the United Nations' website https://www.fao.org/home/en (accessed 01/05/19).
[252] 'Food and Agriculture Organization of the United Nations' website https://www.fao.org/home/en (accessed 01/05/19).
[253] 'vinopedia.hr' website https://sommelier.hr/ (accessed 01/05/19).
[254] Van Limbergen (2016); (2022).
[255] IUSS Working Group WRB (2015), 166.

slightly better for vines than cooler climates. Additionally, there is evidence that southern Italy was less well suited to olive cultivation during the Roman period than the preceding and subsequent periods, due to the more humid conditions.[256] Again, these humid conditions are better suited for vine cultivation. While olives could and certainly are grown here in significant quantity, it could be argued that vines are better suited for this micro-region, based purely on the physical characteristics of the ancient Adriatic. Additionally, the flat terrain is also well suited to grain cultivation (Columella, 2.9.3). As such, we can view MR 1 as well suited to oil, grain or wine production, but favouring vines given the physical characteristics of the micro-region.

**Table 2.6- Vine and olive tree suitability of the Adriatic micro-regions.**

*The suitability here is derived from a combination of the factors assessed throughout this Chapter. These should be taken as general trends, and not indications that the entirety of any micro-region was or was not well suited for cultivation of a particular crop. More general agricultural suitability is quantified and analysed in Chapter 4.*

| MR | Name | Best Suited | Olive Suitability | Vine Suitability |
|---|---|---|---|---|
| **1** | Southern Apulia | Vines | High | High |
| **2** | Central Apulia | Pastoralism | Mid | Mid |
| **3** | Gargano Promontory | Pastoralism | Low | Low |
| **4** | Molise, Abruzzo and Marche | Vines/Olives | High | High |
| **4a** | Pescara | Vines | Very High | Very High |
| **4b** | Ancona | Vines/Olives | High | High |
| **5** | Padan Plain | Grains | Mid | Mid-High |
| **5a** | Po Delta | Grains | Mid | Mid |
| **5b** | Isonzo Delta | Grains | Mid | Mid |
| **6** | Trieste | Pastoralism | High | High |
| **7** | Istria | Olives | Very High | Very High |
| **8** | Eastern Istrian Coast | Pastoralism | Low-Mid | Low-Mid |
| **9** | Northern Dinaric Coast | Pastoralism | Low-Mid | Low-Mid |
| **9a** | Northern Terra Rossa | Pastoralism | Mid-High | Mid-High |
| **9b** | Southern Terra Rossa | Pastoralism | Low-Mid | Low-Mid |
| **10** | Zadar | Grains | High | High |
| **11** | Southern Šibenik-Knin | Pastoralism | Mid | Mid |
| **12** | Split Coastal | Vines/Olives | High | High |
| **13** | Split Interior | Pastoralism | Mid | Mid |
| **14** | Central Dinaric Coast | Pastoralism | Mid | Mid |
| **15** | Neretva Valley | Fruit | Mid-High | Mid-High |
| **16** | Southern Dinaric Coast | Pastoralism | Mid | Mid |
| **17** | Lake Shkodër | Grains | High | Mid-High |
| **18** | Albanian Coast | Vines | High | Very High |
| **19** | Northern Croatian Islands | Pastoralism | Mid | Mid |
| **20** | Southern Croatian Islands | Vines/Olives | Mid-High | Mid-High |

256 Moriondo *et al.* (2013), 825.

MR 2 is characterised by flatter lower lying terrain than the surrounding micro-regions. It is also slightly cooler and wetter than MR 1, with a humid, subtropical (Cfa) climate. Here we find a mix of soils, none of which are quite as fertile as those in MR 1, and all better suited to pastoralism, especially on the gentle slopes found around the edges of MR 2.[257] There are some north facing slopes in this micro-region, but the majority are south or east. As such, while there is nothing to suggest that vines or olives could not be cultivated in this micro-region, it seems better suited to pastoralism, particularly with the more suitable micro-region one so close.

The Gargano promontory, MR 3, is considerably more mountainous than the surrounding micro-regions. There are some fairly steep slopes and a higher concentration of hills. The climate is also slightly cooler and wetter, making it less suitable for vine or olive cultivation. That being said, there are a good number of north facing slopes, creating some suitable terrain for olive cultivation. In this micro-region, it seems unlikely that there would be intense vine cultivation, and while olive cultivation would certainly possible, this would also likely be on a smaller scale, given the cooler wetter and mountainous environment. The Gargano promontory is one of the only areas within Puglia (MRs 1-3) without any major modern wineries, and the modern production of wine in this micro-region is on a far lesser scale than the surrounding micro-regions.[258] MR 3 can be viewed as less suitable for vine or olive cultivation than the surrounding micro-regions, though with many north facing slopes, olive cultivation could certainly have been undertaken.

With MR 4 we have much hillier terrain than the surrounding micro-regions. The climate is humid subtropical, and with the large concentration of gentle slopes, many of which are north facing, along the many river valleys, we can find very suitable land for olive and vine cultivation. These northern facing slopes are particularly good for olive trees. The cambisols/inceptisols of this micro-region are extremely fertile and quite loose, very suitable for olive cultivation.[259] The area would also be well suited for vine cultivation, with the wetter, warmer conditions and plenty of gentle slopes. The area around Pescara, with the inclusion of luvisols/alfisols, makes the area even better suited to olive and particularly vine production, especially given the slightly gentler slopes, few of which are north facing. We can therefore, suggest that the area around Pescara, within MR 4, is well suited for olive and vine cultivation, but especially for vine, more so than any of the previous micro-regions discussed thus far. Overall, the gently sloping nature of the entire micro-region makes it highly suitable for vine and olive cultivation, more so than for grain cultivation, which requires flatter terrain.

[257] IUSS Working Group WRB (2015), 152.
[258] 'Wine Searcher' website https://www.wine-searcher.com/regions-puglia (accessed 01/05/19).
[259] IUSS Working Group WRB (2015), 153.

This brings us to the plain of the Po, MR 5. This is very flat land compared to everything discussed thus far, and while this plain could certainly be used for the cultivation of olives and vines, the ideal slopes described by Columella cannot be found here in any concentration. Modern olive cultivation here is far less intense than the rest of the country to the south, but wine production in Veneto is considerable.[260] While the fluvial soils along the course of the Po itself are extremely fertile, the damper, more humid conditions are not best suited to vines or olives.[261] Indeed, the comparative lack of hills in this micro-region make it particularly well suited to the cultivation of grains and use as arable land (Columella, 2.9, 1.2.4). Olives and especially vines, could certainly be grown in this micro-region, but with the flat, extremely fertile terrain, intensive crop rotation farming is even more suitable in MR 5, especially as compared to the previously discussed micro-regions.

MR 6, Trieste, is considerably hillier than MR 5, but less mountainous than the nearby eastern Istrian coast of MR 8. This micro-region, while having very little flat land, generally has gently sloping terrain, with harsher slopes to the south of the micro-region, these gentler slopes are ideally suited for vine or olive cultivation. However, the umbrisols/mollisols in this micro-region are better suited to grazing, especially when on sloping ground. This area is certainly well suited to olive or vine cultivation, but arguably more suited to pastoralism.

In western/central Istria, MR 7, we have hilly terrain, similar to MR 6, but with gentler slopes. There are high concentrations of fertile *terra rossa* soil in this humid subtropical micro-region. All of this means the micro-region is very well suited to olive or vine cultivation. While the terrain is also suited to pastoralism, the predominance of gentle slopes suggests olive or vine cultivation would be more suitable. There are a large number of north facing slopes, suggesting that this area is particularly well suited for olive cultivation. Moreover, Istria is a distinct modern wine region in Croatia, suggesting its particular suitability to the cultivation of vines.[262] This micro-region is better suited for olive or vine cultivation than any other agricultural pursuit, but seems particularly suitable for olive cultivation.

The eastern coast of Istria, MR 8, is considerably more mountainous than the rest of the Istrian peninsula. It also lacks the concentrations of fertile *terra rossa*. This strip along the eastern coast could be used for vine or olive cultivation, but the steepness of the slopes means it is less well suited than MR 7. The limestone and dolomite derived soils are relatively fertile, but given the almost mountainous terrain, this micro-region is not as well suited to cultivation of vines or olives as many of the other micro-regions already discussed.

[260] Moret *et al.* (1994).
[261] Moriondo *et al.* (2013), 825.
[262] Lukić and Horvat (2017), 95-96.

MR 9, the northern Dinaric coast, is generally hilly with quite steep slopes. This micro-region is not particularly well suited to vine or olive cultivation, much like MR 8, especially given the lack of north facing slopes. However, there is a slightly flatter, *terra rossa* rich area within this wider micro-region. This area is still hilly, but with considerably gentler slopes than the rest of the surrounding micro-region, combined with the concentration of fertile *terra rossa*, we could argue that this strip of land was better suited to vine or olive cultivation than the rest of the northern Dinaric coast. Indeed, while there is another concentration of *terra rossa* to the south, this is on more harshly sloping terrain, above the mean slope for MR 9. As such, we can argue that the majority of MR 9 was not particularly well suited to vine or olive cultivation. We might expect this hilly terrain to be best suited to pastoralism over vine or olive cultivation.

The area around Zadar is considerably flatter than most of the eastern Adriatic coast, but with the majority of MR 10 consisting of very gently sloping hills. Moreover, the presence of alluvially derived soils in this micro-region means that it is better suited to vine and olive cultivation than the preceding northern Dinaric coast, even than the *terra rossa* rich areas of MR 9. Some of the interior of this micro-region gets slightly colder, with a more marine climate, less well suited to vine or olive cultivation. It could be argued, especially given the predominance of flat terrain with some very gentle slopes, that grain cultivation might be better suited in this micro-region. MR 10 can be viewed as very well suited for vine or olive cultivation, but arguably better suited to grain cultivation.

MR 11 is hillier, but slightly warmer (with less areas of a marine climate) than MR 10. MR 13 is similar to this, but considerably more mountainous. The steeper slopes of MRs 10 and especially 13, make them less well suited for vine or olive cultivation, but certainly do not make either a poor area for the cultivation of these crops. Nonetheless, both MRs 11 and 13 can be viewed as more suitable for pastoralism than for olive or vine cultivation. The adjoining MR 12 becomes slightly warmer, with a drier, more Mediterranean climate than the rest of the eastern Adriatic coast to the north. MR 12 is also considerably flatter than the surrounding coast and dominated by marl derived soils. These are similar to dolomite and limestone, in terms of the fertility of the resultant soils.[263] Being drier and much flatter, but still with gentle slopes, makes this micro-region very well suited to the cultivation of olives or vines. Although grains could be cultivated here, the slopes are slightly hillier, and are likely better suited to vines or olive trees.

The central Dinaric coast, MR 14, has a similar terrain and soil makeup to that of the northern Dinaric coast MR 9. However, it is slightly warmer and drier, with a Mediterranean climate. This means we can view this micro-region as slightly better suited for vine or olive cultivation than the northern

[263] Drohan *et al.* (2006), 108.

Dinaric coast, but still not particularly well suited, given the steep slopes, few of which are north facing. The Neretva valley, MR 15, is much flatter than the surrounding micro regions, with some gentle slopes. The climate is generally warmer and drier than the northern Adriatic, being a Mediterranean climate, and is dominated by fertile alluvial soils. This micro-region is quite well suited to vine or olive cultivation, but with the very flat and fertile alluvial conditions, it could be argued that the micro-region is better suited to grain cultivation, rather than olive trees which prefer more of a slope and slightly drier conditions. Today, the valley is more known for its fruit other than grapes or olives, particularly mandarins.[264] Nevertheless, olive trees and vines could certainly be cultivated in MR 15, and is relatively better suited to the cultivation of these crops than the surrounding micro-regions.

MR 16, the southern Dinaric coast is similar to the northern and central Dinaric coasts in terms of terrain, being very hilly with steep slopes rising up to the nearby Dinaric Alps. The climate is drier and warmer than in the northern Dinaric coast, and so, like MR 14, this micro-region is slightly better suited to vine or olive cultivation than the northern Dinaric coast, but not particularly well suited, particularly in comparison to the two adjoining micro-regions.

The southern Dinaric coast opens up onto the much flatter Mbishkodra plain, and associated Lake Shkodër. MR 17 is similar to the Neretva valley, being generally flat, but with more slopes than can be found in the Neretva valley. Moreover, it is slightly cooler and more humid than the Neretva valley, with some of the interior areas having a more subtropical rather than Mediterranean climate. This micro-region is better suited to vine or olive cultivation than the southern Dinaric coast, and indeed, some of the oldest olive trees in the world are found along the coast of Lake Shkodër and the Montenegrin Adriatic.[265] However, much like the Neretva valley, MR 17 would likely be better suited to the cultivation of other fruits or grains, given the very gentle slopes and especially the slightly wetter conditions.

The final mainland micro-region, MR 18 the Albanian coast, is a relatively flat micro-region, with several hilly areas, that generally have gentle slopes. The climate is similar to the opposing coast, being a relatively hot and dry Mediterranean climate. With these dry conditions with flat to gently sloping hills, this micro-region is very well suited to the cultivation of vines, and olives, given the large number of north facing slopes. Albania has a considerable modern wine production, particularly along these moderately sloping hilly coastal areas.[266] As such, we can consider MR 18 to be best suited for vine cultivation, but still highly suitable for the cultivation of olives.

[264] Zovko *et al.* (2018), 61.
[265] Lazović *et al.* (2016), 117.
[266] Zhllma *et al.* (2012), 322.

The islands micro-regions of MRs 19 and 20 differ somewhat in their ecology and agricultural potential. MR 20 is slightly more hilly than MR 19, but neither are especially mountainous or with steep slopes. The dolomite derived soils of both are quite fertile, and while the climates of both MRs are well suited to vine or olive cultivation, the Mediterranean climate of MR 20 is more so. As such, we can view both islands micro-regions as well suited for vine or olive cultivation, but MR 20 more so, with MR 19 likely being better suited to pastoralism.

With these 20 micro-regions we have a diverse ecological potential, based on the geography, and to a lesser extent, the climate and soils of the micro-regions (Table 2.6). It is clear that there are different levels of suitability for growing olives and vines across the Adriatic region, though all micro-regions have conditions where the cultivation of both is possible. It should again be noted that the suitability is based largely on ancient sources for terrain preference, and modern climate, soil and slope data. Moreover, the potential for certain crop cultivation is based purely on the physical Adriatic, and does not necessarily mean that any of these areas produced the crops they were most suited for in antiquity. This is discussed at length, with reference to the archaeological record, in Chapter 5 and quantified more definitively in Chapter 4. However, what we now have, is a general idea of which physical micro-regions are likely better suited for the cultivation of olives or vines than others. With these micro-regions, we can begin to look to the potential mobility and connectivity across the region and micro-regions.

# Chapter 3: Circuit Theory and Modelling Combined Terrestrial and Maritime Mobility

'*All the products of the world can be brought by water to the city in which you live, and all your people in turn can convey or send whatever their own fields produce to any country they like*'- Cicero, *De Republica*, 2.7-2.9.

Now that we have discussed the physical properties of the Adriatic region and divided it into micro-regions, we can begin to model mobility and potential connectivity across the region.[267] As has been the case for this section thus far, an explicitly non-archaeological approach is taken in the first instance, looking to how the physical properties of the Adriatic affect connectivity, before this is compared with the archaeological record from Section B onwards. Past approaches to modelling mobility are outlined, before these, and more innovate methods, are applied to the Adriatic. Following this, the results of the model are analysed in brief, before being compared to the archaeological record in subsequent chapters.

## 3.1- Mobility Studies

Understanding the mobility and potential connectivity of archaeological landscapes is vital to understanding exchange across, and ultimately the economic systems of, such past landscapes. The process of modelling past mobility has greatly benefited from advances in quantitative computational methodologies. Geographical Information Systems (GIS) are one of the main tools used for modelling past mobility.[268] Before applying such methods to the Adriatic, it is important to understand the benefits and shortcomings of the various methods that have been, and continue to be, applied to this area of research.

[267] Some of the research and conclusions outlined in this chapter have been published under McLean and Rubio-Campillo (2022).
[268] Conolly and Lake (2006); Bevan and Lake (2013).

### 3.1.1- Least Cost Path Analysis

The most commonly used approach in modelling mobility across past landscapes is Least Cost Path (LCP) analysis.[269] LCP requires a cost surface map, usually derived from a Digital Elevation Model (DEM) or slope. This surface can then be used to calculate the optimal path between two given points. Understanding this optimal route has significant potential for deepening our understanding of mobility across the landscape. Through comparison with the archaeological data, we can even begin to understand whether the LCP was exploited or not.[270] Nevertheless, LCP does not represent an infallible method for understanding mobility, and such analysis comes with inherent limitations. Of greatest concern is that only a single optimal route is defined using LCP. If this route is blocked, basic LCP analysis cannot offer insight into available alternative routes. Moreover, LCP requires set points to be defined, and the optimal route between these two points is identified. These points are typically archaeological sites, and so, their inclusion can exacerbate the archaeological bias of analysis. Various methods have been use in attempts to overcome these issues, using pairwise LCP, using grids or perimeters of points, but even these approaches are limited to the single optimal route. [271] These issues are certainly not new and have been extensively discussed, but they are yet to be entirely overcome.[272]

### 3.1.2- Circuit Theory: Beyond Least Cost Paths

Circuit Theory (CT) represents a particularly promising method for overcoming some of the limitations of LCP. Not only are set pairs of points not required inputs for CT analysis, but whole regions of potential mobility, rather than just single optimal routes, can be revealed. Furthermore, the volume of quantitative data produced through CT analysis is significant. At its core, the theory is based on Ohm's Law. This outlines the electrical relationship between current $I$, resistance $R$ and voltage $V$ under the formula $V = IR$. In this system, the flow of current ($I$) across a circuit, is dictated by the resistance ($R$) values across the circuit, with higher resistance resulting in lower current. The circuit has a source of current and each cell within it, a specific resistance value. In this analysis of relative

[269] For just some examples, see Carballo and Pluckhahn (2007); Doyle and Garrison (2012); Hazell and Brodie (2012); Llobera *et al.* (2011); White (2015); Gustas and Supernant (2017); Martínez Tuñón *et al.* (2018); Rosenswig and Martínez Tuñón (2020). For a more novel approach to terrestrial transport costs, see Franconi and Green (2019), 69-72.
[270] Rosenswig and Martínez Tuñón (2020).
[271] Murrieta-Flores (2012); Yubero-Gómez *et al.* (2015).
[272] For more in-depth discussions of some of these issues see Herzog (2014); Seifried and Gardner (2019). And for innovative approaches to combating such issues, Güimil-Fariña and Parcero-Oubiña (2015); Verhagen *et al.* (2019).

mobility and potential connectivity, voltage (*V*) is largely irrelevant. Fig. 3.1 offers a basic workflow for CT which can be compared to LCP in Fig. 3.2. CT has been used extensively in ecological studies, but is yet to be applied widely in archaeological studies.[273] An archaeological landscape can be thought of as an electrical circuit for this model, the source being a point or area of archaeological interest, such as an urban centre, and the resistance values provided by cost surface maps, based on slope, much like with traditional LCP analysis. Current then flows from the source across the circuit, and analysis of the resultant 'circuit' can give insight into potential mobility (see Fig. 3.3 for an example output of the Istrian peninsula). Comparing these quantitative data to archaeological evidence begins to provide insight into connectivity, settlement patterns and a variety of more complex aspects of the archaeological environment.

The most striking advantage CT has over LCP analyses is the ability to produce huge quantities of comparable quantitative data for entire regions, at relatively low computational costs. While LCP can be run thousands of times between thousands of pairs of points to generate large amounts of data across a region, this quickly becomes very demanding computationally and will inevitably result in overlaps as well as blank spots, given that it is only single optimal routes being generated, even between thousands of points. CT on the other hand, produces set values for every cell in the region, whether they lie along optimal routes or not. Archaeological sites can then be compared to these data, for example, the mean value of CT outputs within urban centres. This is expanded upon below in Chapter 4, but it is helpful here to outline three important terms, which demonstrate the depth of data produced through relatively low cost CT models.[274] The terms relate to the mean current values within certain boundaries of the CT outputs. The total mean current value (tmcv) simply reflects the mean current value of the entire output raster (there 48 different rasters representing 48 different scenarios, which are discussed below). The individual mean current value (imcv) is the mean value of individual urban centres, within specified radii of the centre. In the current study, there is a single imcv for every city, with each being the mean across all 48 scenarios. The city mean current value (cmcv) represents the mean value within all urban centres radii for each scenario. This provides a tmcv which can be compared against the cmcv of every scenario as well as against the imcv of every city. This

Nevertheless, CT is not without it's own limitations. For one, reading the outputs are not as intuitively easy to grasp as a single LCP, though with some basic explanation, can be readily understood. It is tempting to see CT as showing the level of connectivity across a landscape. However,

[273] For some ecological examples, see Pelletier *et al.* (2014); Brodie *et al.* (2016); Osipova *et al.* (2019). And for some of the rarer specifically archaeological studies, Howey (2011); White (2015); Thayn *et al.* (2016); McLean and Rubio-Campillo (2022); Rubio-Campillo *et al.* (2022).
[274] For similar use of means also utilising probability and viewsheds, see Rubio-Campillo *et al.* (2022).

these are ultimately quantifications of *potential* mobility. This potential may not have been utilised, indeed, explanations as to why potential mobility was or was not exploited leads to particularly interesting models. Moreover, areas with high current values are not necessarily the areas with the lowest absolute movement costs, the CT outputs are not just cost-surfaces. Current, or potential mobility, must be understood in *relative* terms. Compare the uniformly flat southern area of Istria in Fig. 3.4 to the far more varied CT output in the same area of Fig. 3.3. Narrow mountain passes, which may have quite high movement costs, have much lower relative costs compared to the sheer cliffs surrounding them, so we would expect high current values in such an area, acting as a funnel point. On the other hand, flat open plains have relatively uniform movement costs, and so we would not expect this a funnel point resulting in particularly high current values. In this sense, CT gives a much clearer picture of the overall region, although, if a specific route is being sought, traditional LCP may still be the more appropriate tool. It should also be kept in mind that though this CT model I base don real costs in time, the output is in current (amps). Again, it is relative values that are important here. The exact amperage will depend on the value used in the source (1 amp was used in all iterations of this model), and so there is no real way to gauge whether isolated exact current values suggest high or low potential mobility. Instead, we can compare relative values within the model, such as cmcv against tmcv or comparing different the cmcv between scenarios. While there is some more nuance to interpreting the results of CT required over LCP analyses, the information provided through CT analysis is a significant step forward, building upon the more limited data produced through LCP analyses, though this is not to suggest that CT should outright replace LCP or that they cannot be used fruitfully together in some situations (compare the LCP overlaying the CT output in Fig. 3.5).

### 3.1.3- Maritime Mobility

Maritime mobility is often neglected at the expense of terrestrial mobility in archaeological studies. Modelling maritime mobility is more complicated than for terrestrial, but, as is shown, the former had a significant impact on the latter. The difficulty with understanding maritime mobility comes in part, from the reliance on LCP. Most LCP analysis is reliant on DEM and slope data, which are not available for seascapes. While LCP remains dominant, there is no widely applicable standard for modelling maritime or terrestrial movement, and certainly not for an approach combining the two.[275]

Leidwanger has specifically sought to address many of the issues with modelling maritime mobility in the ancient world.[276] The disconnect between historians' and prehistorians' approaches to

[275] For some compelling approaches discussed below, see Leidwanger (2020); Leidwanger and Knappett (2018); Gustas and Supernant (2017); Indruszewski and Barton (2008); Jarriel (2018); Safadi and Sturt (2019).
[276] See for example, Leidwanger (2013); (2014); 2017); (2020); Leidwanger and Knappett (2018).

modelling this maritime connectivity has been highlighted, with historians traditionally drawing on more technical details and using information regarding sailing technology and harbours, that is simply not available to prehistorians. As such, those studying maritime mobility in prehistoric contexts must rely on more environmental factors.[277] These are essentially methodological issues, and Leigwanger and Knappett are indeed explicit in stating that the fundamental issues for approaching maritime connectivity are of methodology.[278] They call for the more widespread use of network analysis and more quantitative approaches.[279] Furthermore, Leigwanger and Knappett argue that environmental and ecological factors can transcend major societal, political or cultural shifts and that the changing scale of maritime connectivity must be considered in future studies.[280] These thoughts on the future of modelling ancient maritime connectivity are outlined in the opening chapter of their 2018 volume, which includes works by various scholars attempting to apply some of these approaches to specific ancient Mediterranean contexts.[281] These approaches have yet to be widely applied to the Roman period, but the quantitative focus forms the basis of the current CT approach.

Some archaeologists, particularly those studying prehistory, have attempted to model ancient connectivity across the sea through utilising different data in order to generate meaningful cost surface maps. Canadian scholars Gustas and Supernant model the connectivity across the prehistoric landscape of the Pacific coast of Canada.[282] They use traditional LCP network analysis, and in fact utilise slope data to generate a cost surface map. It was determined that the slope of the coast affected how easily a boat could make landfall here, and so a steeper slope was given a higher cost value in order to model the difficulty of landing a boat here. Moreover, cultural factors were added into the model, with a preference for shallow waters in sight of land, over deeper ocean sailing.[283] This begins to tackle the issues with modelling mobility and connectivity across the sea, but perpetuates the same issues with LCP network analysis and with a reliance on cultural factors, we return to essentially qualitative approaches and biases within our incomplete knowledge. Moreover, while the reliance on terrestrial slope for maritime connectivity can offer insight into possible landing sites, it does little to meaningfully model dynamic costs of travelling across the sea, and explicitly does not consider wind patterns.[284]

[277] Leidwanger and Knappett (2018), 4.
[278] Leidwanger and Knappett (2018), 7.
[279] Leidwanger and Knappett (2018), 8-9.
[280] Leidwanger and Knappett (2018), 10-11.
[281] Leidwanger and Knappett (2018).
[282] Gustas and Supernant (2017).
[283] Gustas and Supernant (2017), 46.
[284] Gustas and Supernant (2017), 40.

Such approaches largely ignore the single most important factor in sea travel. Wind patterns affect the cost of travelling over the sea more than any other factor, whether they be cultural or practical issues with landing the ship along a steep coast.[285] Even rowing vessels feel the effects of wind patterns, as they are the main influence over circulation and flow patterns in the Adriatic.[286] Modelling wind patterns is a complicated process even when applied to modern contexts, and as always, this becomes more complex when applied to the ancient world.[287] There have been numerous discussions on exactly how wind patterns would have affected ancient sailing speeds and journey times, but it is largely agreed that the specific location within the Mediterranean as well as the season, would have had a major impact on these patterns, and thus, the sailing times.[288] Even with these caveats, scholars have attempted to model maritime mobility based on wind patterns through utilising, as is the case with CT, software never initially intended for use in archaeological contexts. Software primarily used for modelling the spread of wildfires (an anisotropic spreading routine available in GRASS 6 GIS) was used to better understand a historical ancient Scandinavian voyage across the Baltic Sea.[289] The wildfire software already had the functionality to incorporate wind speed and direction, and so could be applied to the Baltic Sea to create a dynamic cost surface, based on seasonal wind patterns, for the specific voyage being modelled.[290] The wind data was taken from a Baltic voyage undertaken by a historical replica ship, the *Ottar*.[291] LCP analysis was then performed, using two separate inputs for direction and intensity of the wind, in order to understand the most likely route this specific voyage would have taken.[292] This is certainly a step in the right direction, and begins to model maritime mobility in a more meaningful way, through utilisation of modern wind patterns and their effect on sailing. However, the software requires inputs such as the type of vegetation, and was only used for one specific voyage that had a start and end point, with a presumed direction of travel and that had been, very helpfully, tested through the use of a historical replica ship.[293] As such, this approach cannot be used to understand the general mobility or connectivity of a region, but the incorporation of wind patterns into the model is an important step in the right direction.

[285] Papageorgiou (2008), 201; Leidwanger (2013), 3302-3303; Jarriel (2018), 57.
[286] Book *et al.* (2007), 1.
[287] See Pandžić and Likso (2005); Book *et al.* (2007); (2009); Cushman-Roisin *et al.* (2007), 1-2, for some discussion of attempts to model modern Adriatic wind patterns and flow.
[288] See Bilić (2012); Arcenas (2015).
[289] Indruszewski and Barton (2008), 59.
[290] Indruszewski and Barton (2008), 61-62.
[291] Indruszewski and Barton (2008), 60-61; Englert and Ossowski (2009).
[292] Indruszewski and Barton (2008), 62.
[293] Englert and Ossowski (2009).

An analysis of connectivity in the Bronze Age Cycladic Islands has produced an arguably more meaningful model for ancient maritime connectivity. Jarriel created a cost surface map based on wind speed and direction for each season, and allowed for multi-directional movement across this surface.[294] This generated results in which moving in a certain direction was more efficient during certain seasons, and so a map of connectivity could be created to visualise how connected certain islands would have been in certain seasons.[295] Moreover, Jarriel is specifically concerned with local scales of connectivity, which she believes have not been considered in the same detail that regional connectivity has been.[296] Indeed, Jarriel utilises average modern seasonal wind data to create the relevant cost surface maps.[297] This focus on environmental factors, with dynamic seasonal cost surface maps and a focus on a more thorough understanding of different scales of travel, is very similar to the approach outlined below. Certainly, Jarriel's methodology provides some of the most promising approaches to modelling ancient maritime connectivity. However, although it aims to better understand a relatively neglected scale of connectivity, it does not directly compare this with wider scales of connectivity within the model. Furthermore, despite using a dynamic cost surface map, it is still reliant on what is essentially LCP analysis, and lacks the detail necessary, in the connectivity maps, for the current purposes, as it gives sailing times as values of only one, two or more than two days. Nevertheless many of the approaches used by Jarriel are used and adapted for the current study.

All of these cases are focused on maritime mobility, but a full integration of seascapes and terrestrial landscapes is seldom seen in any archaeological-based model, and the issues associated with LCP outlined above remain.[298] Such reliance on LCP limits the extent to which the challenges of modelling maritime mobility can be effectively addressed.

## 3.2- Materials and Methods

Before the basic results can be interpreted, it is helpful to outline the exact materials and methodology used for the application of CT to the Adriatic. The use of Circuitscape software is detailed before the terrestrial approach is outlined, followed by the more complex maritime method.

### 3.2.1- Circuitscape

[294] Jarriel (2018), 60.
[295] Jarriel (2018) 63-69.
[296] Jarriel (2018), 54.
[297] Jarriel (2018), 58.
[298] See Scheidel (2015) for a rare combined terrestrial and maritime approach.

The software used for running the CT model is Circuitscape.[299] The project's website and these publications offer lengthy bibliographies for the use of Circuitscape in varied disciplines, but none are archaeological, despite some works, highlighted above, not included in the bibliographies applying CT to archaeological contexts. Different inputs and scenarios can be used in Circuitscape. The most pertinent combination is raster inputs with the 'advanced' scenario. This allows for the direction of current to be controlled. It requires a source, ground and resistance map, all of which must be in Esri Grid format and of the same size and resolution.[300] Each cell in the resistance grid has a value corresponding to a cost/resistance value, and each is connected, by default, to eight adjacent cells, from which average resistance values are calculated. Current can then be generated at the source, and flows across the grid towards the ground. The relationship between current and resistance dictates the manner in which current flows and therefore, the output of the model. If, for example, the eastern border of the grid is used as the source, and the western border the ground, the output models how current would flow from east to west. By then comparing the location of known archaeological sites with the current values in the output grid we can determine if the archaeological sites are located in regions of high potential mobility or not.

### 3.2.2- Terrestrial Mobility

The materials used for CT, like with LCP, are cost surfaces and specific points/sources between which current flows. In the present analysis, the sources are relatively straight forward, being the northern, southern, eastern and western borders of the study region, though these can be specific points in the landscape is desired. These are all weighted equally, though Circuitscape has the functionality to implement weighting. Additionally, these sources and grounds could be anywhere across the grid, in the north-east and south-west for example, depending on the direction of movement being researched. The cost surface maps themselves are somewhat more complicated. The terrestrial surfaces are based on the DEM available from the Copernicus Land Monitoring Service and slope can be calculated from this, producing the rasters used in Figs. 2.2 and 2.3 respectively. Using a common equation $s = 0.033i + -1.357$, movement speed can be calculated based on how the incline of a slope ($i$) affects movement speed ($s$).[301] Slopes in excess of 42° generate negative speed values, and so are, reasonably, deemed impassable. This function does not require direction of travel to be accounted for, and so was chosen over others. However, this is not the only suitable way to calculate movement cost, and terrestrial direction of travel can be accounted for by using more complex functions if

[299] McRae *et al.* (2013); (2016).
[300] For basic examples of this, see McRae *et al.* (2013).
[301] Bosina and Weidmann (2017).

required. Transforming the result of this function into time, using the time, distance, speed equation ($s=d/t$) with the raster resolution of 250 m being taken as the distance ($d$). This provides a cost surface map for the terrestrial Adriatic region as seen in Fig. 3.6. With a resolution of 250 m, the numerical values of each cell represent the time taken, in seconds, to cross 250 m at the given incline. The number of uncertainties involved in the model, given the ancient context and large scale, mean that a resolution of 250 m is more than sufficient, with tests using a 100 m resolution producing similar outputs at much higher computational costs. Additionally, while movement down a gentle slope is more efficient than movement up the same slope, this becomes increasingly negligible and even reverses as the incline of the slope increases.[302] This, combined with the scale of the current study region, means that direction of travel does not have a significant impact on terrestrial mobility, particularly when compared to its effect on maritime mobility.

With these sources and cost surfaces prepared, Circuitscape can be called in Julia and the CT analysis run. By comparing the Istrian LCP output with the Circuitscape outputs, it is immediately apparent that considerably more information is provided through employing circuit theory.[303] Several new highly connected routes can be observed, and, even more interestingly, regions of high connectivity are revealed. Rather than simply showing the most efficient routes between sites, CT reveals a split between the north and south of the Istrian peninsula in terms of mobility and potential connectivity (this remains the case when different combinations of sources are used). What circuit theory immediately reveals, is a clear representation of regions of potential connectivity within the Adriatic. In Istria, these regions do not line up exactly with the micro-regions outlined based on ecological factors. This already offers some insight into the possible economic cohesion and role of specialisation in the Adriatic. If we have two micro-regions with different potentials for agricultural production, but similar potentials for potential connectivity, we can expect closer economic ties within this 'connectivity micro-region', with exchange of commodities within the micro-region and beyond being closely linked, even indicative of strong economic cohesion. On the other hand, if two very similar ecological micro-regions are part of different connectivity micro-regions, we should again expect these to interact with the wider region differently, with a micro-region with higher potential connectivity values having closer links with the wider region, even if the ecological potential is broadly similar. Through this approach, we can begin to understand to what extent the physical Adriatic allows for high levels of economic cohesion and specialisation. By comparing these results with the archaeological record we can understand how this manifested itself during the early Empire. What is

[302] Hunter *et al.* (2010); Meeder *et al.* (2017); Bosina and Weidmann (2017).
[303] It should be noted that while regionwide CT analysis was possible, similar scale analysis for LCP proved prohibitively costly computationally. As such, the smaller scale Istrian example utilising random source points is used for comparison.

particularly interesting, is when the archaeological record does not line up with what the CT results suggest. In such instances, we must answer these questions of potential connectivity and cohesion through different explanations beyond the purely environmental or ecological. If sites in the Adriatic region show archaeological evidence for close connectivity despite having low natural potential connectivity, something more significant must be at play, and this is where the current approach fully moves beyond more traditional methodologies.

Beyond providing more detail than is possible with LCP analysis, CT also allows for much more meaningful comparisons of scale. If we continue with the example of Istria, we can begin to understand how potential connectivity changes with scale in the Adriatic. When Istria is considered in isolation, we can see two quite distinct connectivity micro-regions. However, if we take this to the Adriatic level (Fig. 3.7), this virtually disappears. Istria is quite uniformly, a poorly connected area. This can largely be attributed to the nature of the sources, with no source in Istria, flow of current across the peninsula, which is essentially a dead-end without sea travel, is virtually non-existent. However, even if we add a source in Istria, the picture of potential connectivity in Istria is quite different at this wider scale (Fig. 3.8). We can see the entire central area of the peninsula having relatively high current values, with some of the coastal areas much lower. This disparity between scales can be ascribed to the relative potential connectivity of the Adriatic and its micro-regions. While the southern and northern parts of Istria have different current values, these different levels are actually more similar than they are different when compared to current values across the entire Adriatic. With the importance of regions and scale in the current study, being able to quantitatively demonstrate such differences within the Adriatic is vitally important, and something that cannot be achieved with traditional LCP analysis.

### 3.2.3- Maritime Mobility

Generating a cost surface map for the sea itself, vital to fully understand mobility and exchange in the Adriatic, is a considerably more complicated undertaking. Wind patterns had the greatest single effect on sailing times, and so a cost surface map based on these patterns is used. Ancient wind patterns are largely inaccessible, and so modern patterns were drawn upon. It is important to justify the use of modern wind data for an ancient context. Modern wind data have been used in ancient sailing contexts for more than half a century, though initially with considerable caveats due to a lack of certainty in asserting that ancient wind patterns were the same as modern.[304] Murray explicitly sought to address this uncertainty by comparing, in detail, wind patterns recorded for the 4th century BC

[304] Mohler (1948); Labaree (1957), 32; Hodge (1975); Murray (1987), 140.

Greek world by Aristotle and his student Theophrastus (*Meteorologica* and *De Ventis*) to data collected for the modern city of Athens.[305] Murray concludes that 'the winds of classical antiquity were essentially the same as they are today' based on this comparison.[306] Murray's argument is convincing, pointing out the majority of ancient observations line up closely with modern data, and only begin to differ when the data is collected from beyond the immediate scope of the eastern Mediterranean. This, Murray argues, is largely due to less reliable data available to Aristotle and Theophrastus, based in Athens, for these more distant locations, and do not differ enough to suggest that the Western Mediterranean had significantly different wind patterns in antiquity than those observed today.[307] Furthermore, Murray argues that this makes sense, given the huge atmospheric changes that would be necessary to drastically alter wind patterns in the Mediterranean.[308] Murray's argument for similar ancient and modern wind patterns has largely been accepted, and is still cited in more modern scholarship.[309] As is the case with current scholarship using modern wind data, this study assumes that wind patterns were broadly similar in antiquity as they are today. However, it should be further emphasised that the results produced through the use of modern data are not meant to represent the absolute reality of ancient mobility across the Adriatic at one specific point in time. Rather, it is the intention to offer a model for how this mobility would likely have manifested itself *generally* across the ancient Adriatic. Offering a model for comparative analysis, rather than anything representing an ancient reality.

ERA5 hourly Datasets from the Copernicus Project were retrieved, which contain both u and v components of wind at 10 m.[310] The coordinates for the extent of the Adriatic used are a latitudinal and longitudinal range of 39.5-46.0° and 12.0-20.0° respectively. These components were taken hourly from 1979 through to 2020, before being averaged for every month. Using Pythagorean Theorem, the u and v components were transformed into wind speed (m/s) (eg.- *ws <- sqrt(*$u^2 + v^2$*)*) and using the atan2 function in the R package 'raster', into wind direction in degrees (*wd <- 180 + (180/pi) atan2(u, v)*). The resolution of available wind data is limited to 0.25°/25 km, so in order to be functional with the terrestrial cost surface, the wind data was translated into 250 m resolution rasters, though each pixel in a given 25 km$^2$ area will all have the same value. Again, due to the uncertainties inherent in calculating the impact of modern wind patterns on speeds of ancient sailing vessels, this resolution does not meaningfully affect the viability of the model.

305 Murray (1987), 141-142.
306 Murray (1987), 159.
307 Murray (1987), 159.
308 Murray (1987), 156.
309 See for example, McGrail (2001), 89; Simmons (2014), 52-53; Alberti (2017), 514.
310 Hersbach *et al.* (2020).

In order to transform wind patterns into time, the effect of wind speed and direction on ancient sailing vessels has to be assessed. There have been numerous discussions focusing on possible sailing speeds of ancient vessels, and how prevailing conditions would affect this.[311] It is beyond the scope of the current study to greatly expand on the work already undertaken in this area, but the values for sailing speeds used in this study (primarily derived from the ORBIS project, Bilić and the pioneering work of Beresford, following on from the early scholarship of Casson)[312] are not meant to represent infallible real sailing speeds, rather simply provide comparable averages which can be readily adjusted over multiple iterations of the model. A combination of wind speed and direction ranges provide the sailing speed values. Six ranges are used for wind speed as defined in Table 3.1 and sixteen for wind direction (Table 3.2). These ranges were each assigned a numerical value which could then be used in calculating sailing speeds across the entire Adriatic. The calculations required to generate values for sailing speeds are based on all possible combinations of the ranges of wind patterns, with a strong wind in the direction of sailing providing a relatively high sailing speed as compared to a weaker wind against the sailing direction for example. Higher and lower resultant sailing speeds were tested, but produced unrealistic results, with the slower resulting in much of the sea being impossible to sail across for most of the year. In reality, techniques such as tacking would have allowed ancient sailors to make slow, but steady progress even under unfavourable conditions.[313] Reference grids for the resultant sailing speeds can be found in Appendix A (All Appendices are hosted online here) including those with slower and faster sailing speeds. The main complication in generating meaningful results through this step is factoring in directionality, which can be difficult with some GIS methodologies, and further complicated by the fact that Circuitscape does not have built in capabilities for directional cost surface maps. Of course, sailing with and against the same wind patterns would produce very different sailing speeds, and so direction of travel is essential in understanding maritime connectivity. As such, four separate raster maps were created for each month, one for each of the cardinal directions of travel, with the output values dependent on the relative direction of the wind to the direction of travel. This follows on from the work of Pelletier *et al.*, who discuss possible approaches to modelling directionality with Circuitscape.[314] Petellier *et al.* divided a cost surface raster into a grid and generated current from east-west, west-east, north-south and south-north across each of the squares within these grids before combining all of the results to produce a CT output influenced by the direction of travel.[315] They point out that using more detailed

[311] Arnaud (2005), 15-22; Bilić (2012); Leidwanger (2013), 3304; Beresford (2013); Arcenas (2015).
[312] Casson (1950), 145; (1995); Bilić (2012), 82-84; Arcenas (2015).
[313] Casson (1995); Beresford (2013).
[314] Pelletier *et al.* (2014).
[315] Pelletier *et al.* (2014).

directional data, such as an eight point rose, for the direction of travel did little to improve the accuracy of their model of connectivity, and so, the four cardinal directions were deemed sufficient for current purposes.[316] Petellier *et al.* worked with high resolution (30 m) data over a relatively small area (24,300 km$^2$).[317] As the current study uses relatively low resolution data (0.25 degrees of longitude from ERA5, but covering an area of more than 140,000 km$^2$) and, more importantly, is modelling connectivity for a period some two millennia ago, this increased resolution would do little to improve the results of the current model. Again, by the very nature of this study, the model is necessarily a generalisation and not a representation of an absolute reality. Therefore, for each of the monthly wind rasters, four new cost surface maps were created, for sailing north, east, south or west. By assessing all possible combinations of wind speed and direction ranges, a set of possible sailing speeds were created for each of these sailing directions for every month. By simply transforming these sailing speed rasters into sailing times and combining them with the terrestrial cost surface maps, 48 individual cost surface maps are created, for sailing in each of the four cardinal directions every month of the year. With that, we have sources and resistance maps with which to run our CT analysis, calling Circuitscape through Julia.

**Table 3.1- Wind Speed Ranges.**

*The wind speed ranges used in calculating sailing speed and ultimately movement costs across the Adriatic. While speeds are given in knots, m/s were used for the calculations.*

| Range | Wind Speed (knots) | Beaufort |
|---|---|---|
| **1** | 0-1 | Calm |
| **2** | 1-3 | Light Air |
| **3** | 3-6 | Light Breeze |
| **4** | 6-10 | Gentle Breeze |
| **5** | 10-16 | Moderate Breeze |
| **6** | >16 | Strong Breeze and Above |

**Table 3.2- Wind Direction Ranges.**

*The wind directions ranges used in calculating sailing speed and ultimately movement costs across the Adriatic.*

[316] Pelletier *et al.* (2014), 5.
[317] Pelletier *et al.* (2014), 2.

| Range | Wind Direction(Degrees) | Cardinal |
|---|---|---|
| **1** | 348.75-11.25 | N |
| **2** | 11.25-33.75 | NNE |
| **3** | 33.75-56.25 | NE |
| **4** | 56.25-78.75 | ENE |
| **5** | 78.75-101.25 | E |
| **6** | 101.25-123.75 | ESE |
| **7** | 123.75-146.75 | SE |
| **8** | 146.75-168.75 | SSE |
| **9** | 168.75-191.25 | S |
| **10** | 191.25-213.75 | SSW |
| **11** | 213.75-236.25 | SW |
| **12** | 236.25-258.75 | WSW |
| **13** | 258.75-281.25 | W |
| **14** | 281.25-303.75 | WNW |
| **15** | 303.75-326.25 | NW |
| **16** | 326.25-348.75 | NNW |

## 3.3- Results

The CT outputs allow us to begin to understand how the presence of the Adriatic Sea may have affected the mobility and potential connectivity across the region. The results of every scenario can be found in Appendix B.[318] If we look at sailing north in January (Fig. 3.9) as an example, and compare it to the terrestrial connectivity maps (eg. Figs. 3.7 and 3.8), it is immediately apparent that the addition of the sea, with dynamic costs, affects mobility across the land as well as sea. The peninsulas and islands, which seemed largely disconnected without the sea, are shown to be highly connected micro-regions within the Adriatic. Similarly, the flat expanse of the northern Adriatic, consistently has the highest current values with the terrestrial models, whatever the source. This is far less pronounced with the inclusion of the sea, though the north, and especially the north-east, remains an area of particularly high current values. The importance of the sea for understanding connectivity is clear, impacting connectivity across the entire Adriatic region, whilst considering the terrestrial landscape in isolation gives an incomplete and potentially misleading picture.

The CT analysis clearly shows that the time of the year and direction of travel have a significant effect on mobility. The impact of sailing direction is very pronounced when comparing journeys sailing east or west with journeys travelling north or south (see, for example, January in Fig. 3.9, August in

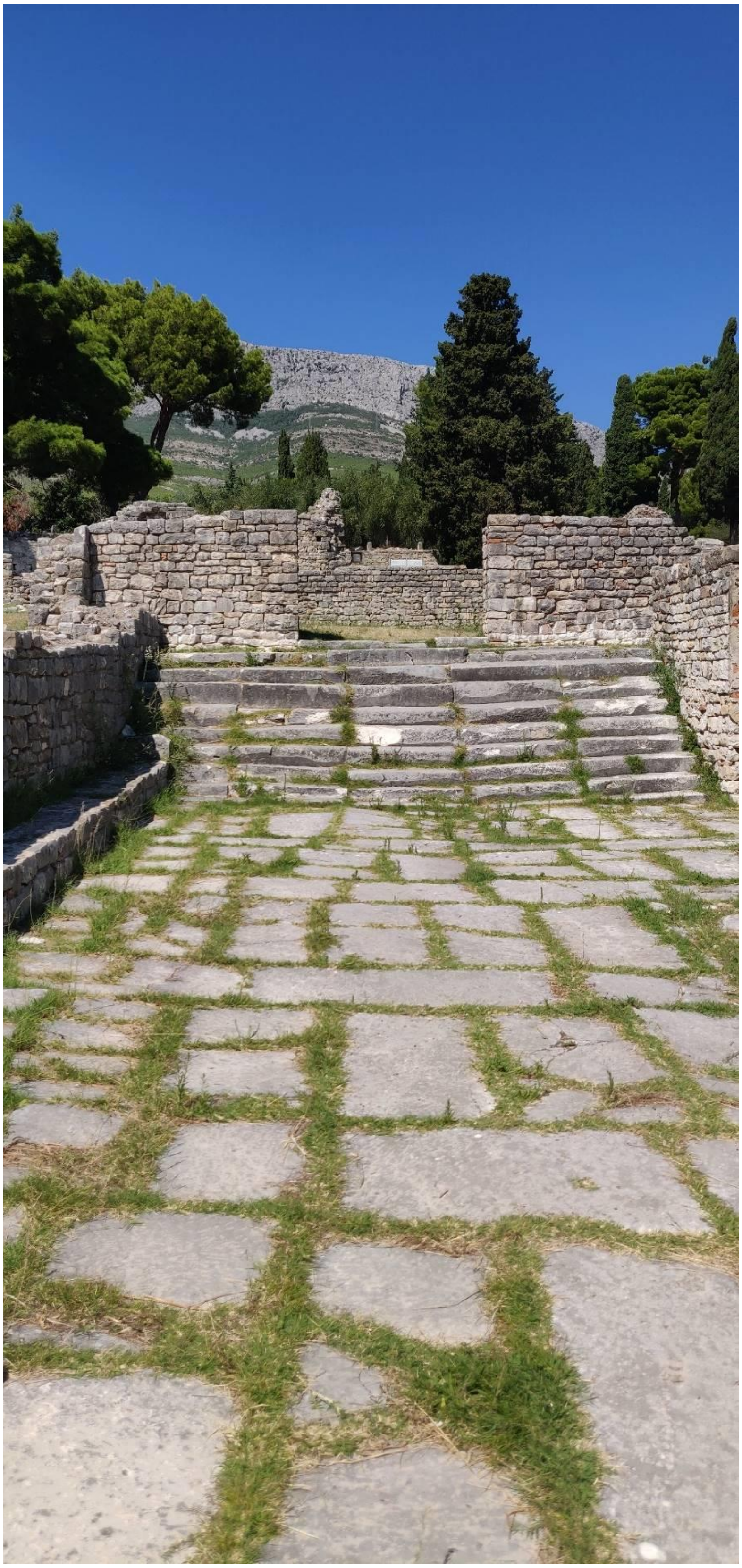
[318] This is a large and cumbersome amount of data, so only the most pertinent scenarios and results are discussed in detail here, but the source data is all readily available at https://figshare.com/account/projects/131855/articles/19123343?file=33981830.

Fig. 3.10 and April in Fig. 3.11). In January, maritime movement north (Fig. 3.9) appears less efficient than travelling south (Fig. 3.10) (when comparing the numerical value of the current generated). This may be due to the nature of the source and ground points used, as these have a consistent and significant impact on the CT outputs. Interestingly, this is reversed for terrestrial movement, with higher current values travelling north than south. This is likely due to the relative costs, sailing north is expensive, so terrestrial movement is more suitable, while sailing south is less costly, and terrestrial movement is therefore less suitable. Movement east (Fig. 3.11) or west (Fig. 3.12) is somewhat different, there being clear funnel points for lower cost movement, mainly in the north, both in the landscapes and seascapes. When considering movement east, the northern Adriatic has considerably higher current values than the south. For movement west in January, the current values are considerably lower than for other directions. However, the north east still has relatively high current, though so too does the south west, suggesting that the high potential mobility of the northern Adriatic is less pronounced for movement west than east. This is largely true for every month and begins to point to something that may be considered a cyclical form of movement around the Adriatic; with movement west primarily in the south; movement north along the eastern coast; movement east along the northern coast; and movement south along the western. This is over simplified, and based on only some observations. However, this will be built upon throughout the study, and a more robust model for movement and exchange proposed.

Differences can also be observed between seasonal current values. If we take sailing north as an example, coastal sailing is relatively favourable in January (Fig. 3.9), with the deeper open waters having lower current values. Additionally, there is no marked difference in current between some terrestrial and maritime areas, with much of the terrestrial landscape actually having higher current values. On the other hand, for travelling the same route in August (Fig. 3.13), maritime movement is clearly preferable, though movement across southern Italy seems relatively efficient. Comparing sailing north in April (Fig. 3.14), the maritime current values are less uniform than in January or August, with the eastern coast having significantly higher current values. Importantly, though the terrestrial cost surface is the same for every scenario, changing the maritime cost surfaces significantly impacts the potential mobility across the terrestrial landscape in every case.

As should be apparent, there are a huge variety of combinations for comparative analysis afforded by just these 48 outputs. Far more information is afforded through the outlined approach than would be possible through only using LCP analysis, and the use of environmental and ecological factors at this initial stage, allows for more directly comparable quantitative analysis of the results. It should also be kept in mind that the only change between all of these maps is the average wind patterns for the month or the direction of travel (with the same wind patterns). The same data are used for all maps despite the clear differences between many of them. Without considering maritime connectivity in such a way, we cannot truly understand how far the ancient Adriatic may be considered to have been a cohesive economic whole. While comparing the basic CT outputs can offer some insight into patterns of mobility and potential exchange, the underlying quantitative data is more useful when compared to the archaeological remains. The CT results outlined in this chapter will be referenced throughout the rest of the work, as they are compared to the archaeological record, and a clearer picture of economic cohesion across the Adriatic region is formed.

# Section B: The Archaeological Adriatic



Now that the physical Adriatic has been discussed at length, we can begin to incorporate more of the archaeological evidence from the Adriatic region. In this section, the Adriatic region as a whole is considered thematically, and with reference to the micro-regions and circuit theory (CT) analysis outlined in Section A. The sites and infrastructure of the Adriatic are the focus, before the more portable remains are investigated in Section C. Patterns of urbanism, consumption and settlement patterns are first assessed. Following this, the archaeological evidence for wine and oil production is then considered and finally the infrastructure of the region. Through all of this, a relatively complete picture of the economic reality of the entire Adriatic region can begin to be established, before modelling patterns of exchange can allow us to answer the question as to how far the Adriatic region can be considered a cohesive economic whole.

# Chapter 4: Urbanism, Consumption and Settlement Patterns

'*It is not without good reason that gods and men chose this place to build our city… All these advantages shape this most favoured of sites into a city destined for glory*.'- Livy, A*b urbe condita Libri*, 5.54.4

In this chapter, a brief outline past scholarship and a discussion of what is meant by 'urbanism' is provided. This has a focus on current methodologies used for quantifying urbanism and the urban population of the ancient world. These methodologies are then applied directly to the urban population of the Adriatic region itself, before the expected resource requirements of this urban population and the ability of the micro-regions to provide for this are analysed, focusing on grain, wine and oil. The expected size of the rural population is then discussed, with reference to the relationship between city and hinterland and how far we can expect the resources needed by the urban population to have been supplied by the rural. Finally, the CT analysis is compared to the distribution and population hierarchy of the region, quantifying how far potential connectivity may have affected these patterns of urbanism. Ultimately, this chapter discusses whether or not there existed in the Adriatic region, the manpower, arable land and mobility to produce and exchange a specialised surplus of wine and/or oil.

## 4.1 Quantifying Urbanism

In the current discussion, urbanism can be understood as the existence of urban centres and the presence of an urban population, and urbanisation as an increase in the number, size or population of these centres.[319] The very existence of cities has often been viewed as a defining characteristic of the ancient world and a vital component of the ancient agricultural economy, which cannot be overlooked in any economic studies.[320] As such, there have been a number of studies specifically concerned with these concepts in the context of the ancient world.[321] Despite all of this scholarly attention, there are

[319] Hanson (2016), 24. Urban centre, city, or town are all terms essentially denoting a settlement with urban characteristics, and are used interchangeably in the current work. For a more in-depth discussion of this terminology, see Hanson (2016), 18-24.
[320] Jones (1940), 299; Ward-Perkins (1974), 8; Finley (1977), 305; Hanson (2016), 3-4.
[321] Hanson provides, perhaps, the most comprehensive overview of these discussions, Hanson (2016), 1-5. See also, Finley (1973); (1977); Moeller (1976); Hopkins (1978); (1980); Leveau and Goudineau (1983); Fulford (1987); Bairoch (1988); Jongman (1988); Engels (1990); Wilson (2002); Gates (2003); Scheidel (2007); De Ligt (2012); Erdkamp (2012).

no definitive figures for the populations or levels of urbanism across the ancient world, though certain ranges are generally agreed upon. This uncertainty is largely due to a lack of evidence. As with analysing any aspect of the economy, the level of detail available in later periods simply does not exist for the Roman world. Some ancient sources can be drawn upon to identify where certain cities were, and some even provide vague insights into the size of specific cities. However, these sources are often problematic and occasionally contradictory, some cities are left out by certain writers, while others are seemingly given inflated importance depending on the source itself.[322] Of course, the archaeological record can be used to provide a greater understanding of the reality of urbanism in the ancient world. Certain sites, like Pompeii can provide a more detailed understanding of urban life in the Roman world.[323] Other cities remain bustling urban centres into the present day, and so any comparable remains have long since been lost.[324] Nonetheless, scholars have attempted to produce figures for the total urban populations of the Roman world, for specific cities, and for general levels of urbanism across the Empire. These are based on a combination of literary sources and archaeological remains, and a general consensus for many of these has been arrived at. The widely accepted total population of the Roman Empire ranges from 59-72 million, with the level of urbanism between 10 and 15%, resulting in estimates for the total urban population ranging from 7 to 9 million.[325]

The population of specific cities has also been discussed. It is generally accepted that the largest cities of the Empire, were Rome, Alexandria, Antioch, Carthage and Ephesus, in rough descending order.[326] These figures are derived through various techniques, but generally rely on three main pieces of information; how much space was inhabited, the number of dwellings in this space and the number of people in each of these dwellings.[327] Hanson applies this to the largest number of Roman cities yet included in a single study and has produced very reasonable population estimates for some 64% of the cities in his database of 1,388 total sites, resulting in 885 cities with population figures based on reliable archaeological information.[328] Vermeulen produced a similarly detailed database for urban centres in Central Adriatic Italy.[329] Even with some missing size estimates, this provides sufficient data to extrapolate for the sites where such accurate information is missing, and Hanson used this to arrive at an estimate for a total urban population between 10.6 and 17.2 million.[330] As Hanson points out, this is considerably higher than previously accepted, and highlights,

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[322] Hanson (2016), 51-53.
[323] Raper (1977); Jongman (1988).
[324] For the particular issues with this in Central Adriatic Italy, see Vermeulen (2019), 190-193.
[325] Erdkamp (2012), 243; Scheidel (2007), 78; Hanson (2016), 69.
[326] Hanson (2016), 51-54.
[327] De Ligt (2012); Hanson (2016), 61; Vermeulen (2019), 201.
[328] Hanson (2016), 59.
[329] Vermeulen (2019), especially 203.
[330] Hanson (2016), 69-70.

as Lo Cascio had argued previously, that the convincing evidence for the urban population does not line up with the generally accepted total population and level of urbanism, either an urbanism level of 10% is too low, or the total population was considerably higher than 59-72 million.[331] Hanson argues that a higher total population is more likely than an urbanism level of over 10%, as this is largely in line with more complete evidence for the 17th-18th centuries.[332] Using these figures, population densities for urban centres have been used, generally around 90-130 p/ha.[333] More recent approaches have drawn upon active field survey and filling in the gaps in the record by analysing private architecture.[334] As urbanism is not the sole focus of this thesis, such impressive but time intensive methods are beyond the current scope. Nevertheless, a general scheme for population density, based on site size, can be found in Table 4.1. The methodology and basic figures used below are broadly in line with those outlined by various scholars actively researching urbanism, and the methodologies are applied in a broader sense to the Adriatic region, in order to better understand the demography and level of urbanism.

**Table 4.1- Urban Population Densities.**

*After Hanson (2016).*

| Size (ha) | Density (p/ha) |
|---|---|
| <50 | 100 |
| 50-100 | 150 |
| 100-150 | 200 |

## 4.2 Adriatic Urbanism

In order to understand how urbanism in the Adriatic manifested itself in a meaningful way, it is necessary to understand the location and population of the cities. Figure 4.1 provides an overview of the locations of the cities, while Appendix C offers more detail on these cities. In order to fully understand urbanism in the Adriatic region, the distribution of the cities themselves is first discussed, before a more detailed breakdown of the populations is provided, and finally, a brief analysis of the hierarchy of the urban system.

[331] Lo Cascio (2009), 97; Hanson (2016), 72.
[332] Hanson (2016), 72.
[333] De Ligt (2012); Hanson (2016), 61; Vermeulen (2019), 201; Van Limbergen and Vermeulen (2020).
[334] See especially Van Limbergen and Vermeulen (2020).

### 4.2.1- Cities of the Adriatic

There are a total of 169 Adriatic urban centres identified in this study. Of these, a total of 95, just over 56%, have reasonably well accepted estimates for their size. These 169 cities are dispersed across the entire region, but with some apparent clusters and trends from a very basic overview of the sites. On the eastern coast, cities are generally spread out across the thin strip of coastal land between the Dinaric Alps and the Adriatic, other than the larger area of flatter land around MRs 10-13, where cities cluster more than anywhere else on this coast. This is generally also true of the Italian coast, with most cities spreading out fairly evenly between the Adriatic and the Apennines, other than the large cluster in the north of MR 4, which seems to have a larger portion of cities than elsewhere in the region. To look at this in more detail, we can consider the Italian and Dalmatian[335] coasts separately, using the Roman borders between *Italia* (MRs 1-7) and *Dalmatia* (MRs 8-20). The majority, 112, are in *Italia*, with only 57 being in *Dalmatia*. This seems to confirm a general consensus that Roman Italy was one of the most urbanised areas of the Empire.[336] However, it is also true that the area covered by *Italia* is far larger than that by *Dalmatia*, 61,639 $km^2$ to 23,062 $km^2$. This gives a site density of 1.8 cities/1,000 $km^2$ for Italia, and 2.5 cities/1,000 $km^2$ for Dalmatia. These are very similar, with *Dalmatia* actually appearing to be slightly more urbanised. However, as has been noted, these figures include even those cities for which there are no reliable estimates for their sizes. If these are removed, of the remaining 95, only 14 are on the Dalmatian coast, with 81 on the Italian coast. This gives site densities of 0.61 cities/1,000 $km^2$ and 1.31 cities/1,000 $km^2$ respectively. This is a much more notable difference, but is possibly a reflection of archaeological biases rather than the real situation. With Italian sites generally being better understood and more commonly surveyed/excavated than those on the modern Balkan coast, we would expect proportionally more Italian cities to have known sizes. This should be kept in mind throughout, though a conscious effort has been made to consider the Adriatic without modern national boundaries, these boundaries do affect the evidence available. So while there do seem to be different patterns of urbanism across the two coasts, the level of urbanism in the Adriatic region, based purely on the presence of cities, does not appear to have differed drastically between these coasts.

It should be noted, that the general trends between the Italian and Dalmatian coasts do not reflect the realities of the provinces themselves. *Italia* includes the entire Italian peninsula, not just the Adriatic coast, while the province of *Dalmatia* had proportionally more land in the interior than it did on the coast. On one hand, *Italia* as a whole shows a greater density of cities that its Adriatic coast

[335] For current purposes, *Dalmatia* includes the Adriatic portion of the province of *Macedonia*.
[336] Scheidel (2007), 78; Erdkamp (2012), 244; Hanson (2016), 68.

alone, with 337 in total according to Hanson's database. Notably, much of *Italia* is coastal, be it the Tyrrhenian or Adriatic. The coastal area of *Dalmatia* has the majority of the provinces' cities, with the combined total of Hanson's Dalmatian and Macedonian cities coming to a total of 75. So, while it certainly does remain the case that Italy was considerably more urbanised than Dalmatia, by considering the Adriatic region itself, this trend does not seem to persist in such a pronounced manner. Access to the sea, it can be tentatively suggested, may have had some a more pronounced effect on levels of urbanism than provincial administrative differences.

The main database used for the urban centres is Hanson's OXREP cities database.[337] This is an extremely useful set of data, but it is not without it's faults. There have been some criticisms of inaccuracies in the positioning and naming of sites in the database.[338] Most of these are fairly obvious when looking at the data (eg. Hanson confusing Pollentia and Potentia/Spanish or Ligurian sites of the same name) and so the Adriatic inaccuracies were easily corrected, particularly with the use of additional sources.[339] Furthermore, some sites seems to have been excluded, particularly those of smaller size or which have been less well excavated. Indeed, beyond the Adriatic region, specialists in other regions have noted inaccuracies and omissions at these more targeted scales.[340] Nevertheless, the large scale of Hanson's data, as well as the current regional study, means that wider trends should not be significantly impacted by the possible exclusion of some of the smaller sites. Similarly, the lack of intensive investigation of individual sites, while a valid criticism for determining accurate individual population estimates, is of less concern when considering the larger, region wide population. While the data is far from perfect, additional sources have been used wherever possible and the wider conclusions drawn in this study are not significantly affected by the imperfect data.

### 4.2.2- Urban Populations

Looking at the location of cities alone offers some insight into levels of urbanism, but to fully understand Adriatic urbanism, the total urban population must be analysed. Certain population thresholds have been suggested as requirements for a site to be considered urban. These vary between periods, but are generally between 1,000 and 5,000 for the ancient world.[341] Applying these thresholds has a significant impact on the urban landscape of the Adriatic region. The population figures for individual cities are based on the area covered by the site, as outlined in Table 4.1. Sites

[337] Hanson (2016).
[338] Pfuntner (2017); Donev *et al.* (2017).
[339] Especially De Ligt (2012) and, to a lesser extent, Wilkes (1969).
[340] Pfuntner (2017).
[341] Chandler (1974); Bairoch (1988); Scheidel (2007), 80; Lo Cascio (2009); Erdkamp (2012), 244; Hanson (2016), 12.

with unknown sizes are assumed to have relatively small populations of 1,000. This is a fairly simplistic approach, but is helpful for the large scale nature of this study. Nevertheless, these estimates should not be taken as exact values, rather as figures to extrapolate wider conclusions from. The large scale nature of the data means that analysing every individual site in detail is beyond the scope of the study. While the area covered by the sites can be taken as a rough indicator for the population size, there are complications to this which must be highlighted. For example, the extent to which a cities area is occupied by uninhabited public buildings varies, but can be substantial.[342] Some sites may cover a large area, but act as a gathering place for the wider landscape, with few permanent residents and many public buildings used by the urban as well as wider rural populations. For this reason, the population estimates might be slightly inflated, though mitigations for this are outlined below. Nevertheless, this extensive approach allows general trends to be relatively confidently drawn from relatively brief analysis of the individual sites themselves.

Of the 169 cities, 157 have populations of 1,000 or over (including those with unknown sizes), while only 13 have populations greater than 5,000. Breaking this down further, 103 Italian cities have populations meeting the 1,000 inhabitant threshold, to 54 Dalmatian. Additionally, 11 Italian cities have populations of 5,000 or larger, to Dalmatia's 2. This can again be broken down into site density to better understand the data. For a threshold of 1,000 this gives 1.7 cities/1,000 km$^2$ in *Italia* and 2.3cites/1,000 km$^2$ for *Dalmatia*. Again broadly similar. With a 5,000 inhabitant threshold, the densities are 0.24 cities/1,000 km$^2$ and 0.1 cities/1,000 km$^2$ for *Italia* and *Dalmatia* respectively. This is a far more significant difference than has been observed thus far. However, it could simply be the case that the relative lack of certain data from the eastern coast is impacting this. Of the 14 Dalmatian cities of known sizes, 2 (or around 15%) meet the 5,000 inhabitant threshold, while 10 (77%) meet the 1,000 inhabitant threshold. This is broadly comparable, though less so with the lower threshold, to *Italia* with 15 (19%) and 72 (89%) for the two thresholds, though *Italia* does still seem to be slightly more densely populated. Furthermore, it is unlikely that the cities without known sizes were as big as the largest cities. As such, this does begin to shed light on another notable trend in the urbanism of the Adriatic region. The difference in actual urban population between the two coasts.

Using these values, estimates for the Adriatic urban population are as low as 169,550 and as high as 590,187, depending on the method used to account for the cities of unknown sizes (Table 4.2). The 'all cities' method simply sums all populations, assuming that those with unknown sizes have 1,000 inhabitants. 'Known size' follows the same approach, but removes those with uncertain sizes.

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The 1,000 and 5,000[343] threshold methods sum only the cities that meet the population threshold (assuming unknown sizes to be 1,500), while 'known 1,000 threshold' applies the 1,000 threshold only to those of known size. The '1.25x' and '1.75x' methods multiply the total populations of all known city sizes by the corresponding factors, following Hanson's suggestion to account for the unknown sizes.[344] The application of these methods to both individual coasts is also provided. The 'reasonable' method applies Hanson's 1.25x method to the Italian urban population, the all cities method to the Dalmatian, and sums these values, to provide what I believe to be the most reasonable of all of these estimates. This is based on the fact that the 1.25-1.75 factors recommended by Hanson use his data where 64% of all sites have known sizes. For the Adriatic, this is 58%, but 73% for the Italian Adriatic and only 25% for *Dalmatia*. This would suggest that the lower factor be used for *Italia* and the higher for *Dalmatia*. However, as the Dalmatian sites are so uncertain, unknown cities were assumed to have populations of 1,000, which provides a conservative total population, but slightly more than that produced by applying a 1.75 factor, which seems too low, particularly with so much uncertainty. This method produces a total urban population of 452,775, which is a good middle ground of values produced. This value will be used as the estimated total urban population of the Adriatic for calculating various other dependent values discussed below. However, the corresponding values for all methods are provided in Appendix E for comparison. Analysing the application of the reasonable method to the Italian and Dalmatian coasts individually offers further insight into how the actual urban population of the entire region was distributed. The total urban population of Adriatic *Italia* comes to 321,100, a density of 5.9 inhabitants/km$^2$ and 90,150 with a density of 5 inhabitants/km$^2$ for *Dalmatia*. This suggests that both coasts had broadly similar levels of urbanism. For all methods, ranges of between 4 and 5.5 are reasonable for overall urban population densities, with the 5,000 threshold and 1.75x methods providing far lower and higher density values respectively. The density of the urban population of *Dalmatia* is only significantly lower than that of *Italia* when the unknown cities (75% of Dalmatian sites) are removed all together. This seems to confirm that the reasonable method provides the most likely estimate, with the 5,000 threshold and the blanket 1.75x methods being realistic. Moreover, this again suggests that urban population densities across the Adriatic region were not drastically different. It appears that access to the Adriatic may have been a significant factor dictating the patterns of urbanism across the region.

**Table 4.2- Total Urban Population Ranges.**

*Subsequent discussion and calculations will generally assume a total urban population of around 450,000 for the region, following the 'reasonable method', which gives an Italian urban population of 360,000 (1.25x) and 90,000 (All Cities) for Dalmatia.*

[343] It should be noted that this value of 189,550 is considerably lower than that produced by any other method.
[344] Hanson (2016), 69.

| Method | Urban Population | Cities |
|---|---|---|
| **All Cities (Region)** | 411,250 | 169 |
| **Known Size (Region)** | 337,250 | 95 |
| **1,000 Threshold (Region)** | 403,850 | 157 |
| **5,000 Threshold (Region)** | 169,550 | 13 |
| **Known 1,000 Threshold (Region)** | 329,850 | 83 |
| **1.25x (Region)** | 421,563 | 169 |
| **1.75x (Region)** | 590,188 | 169 |
| **Reasonable (Region)** | **452,775** | **169** |
| **All Cities (Italy)** | 321,100 | 112 |
| **Known Size (Italy)** | 290,100 | 81 |
| **1,000 Threshold (Italy)** | 315,900 | 103 |
| **5,000 Threshold (Italy)** | 146,600 | 11 |
| **1.25x (Italy)** | 362,625 | 112 |
| **1.75x (Italy)** | 507,675 | 112 |
| **All Cities (Dalmatia)** | 90,150 | 57 |
| **Known Size (Dalmatia)** | 47,150 | 14 |
| **1,000 Threshold (Dalmatia)** | 87,950 | 54 |
| **5,000 Threshold (Dalmatia)** | 22,950 | 2 |
| **1.25x (Dalmatia)** | 58,938 | 57 |
| **1.75x (Dalmatia)** | 82,513 | 57 |

We can apply this in more detail to the micro-regions. Fig. 4.2 and Table 4.3 offer an overview of the urban site densities across the region. MR 12 is the clear outlier, with a density of cities far greater than any other micro-region. This is in part due to the small size of MR 12. However, as will become more apparent throughout, the density of other sites in MR 12 is significant, with this not being repeated to similar levels with other smaller micro-regions, such as MRs 9 and 14. Only MR 11 has no known urban centres. Notably, this micro-region is adjoining MR 12, and it may be the case that the dense urban population of MR 12 was supported by a more rural population in MR 11. MR 19, the northern Croatian islands, has perhaps a surprisingly high concentration of cities, highlighting the importance of the islands to the Adriatic economy. Notably, the Central Dalmatian micro-regions of MRs 10, 12 and 13 all have particularly high concentrations of cities. This is mirrored on the opposing coast in MR 4, which has the densest concentration of Italian Adriatic cities. This may begin to point to a shared system between these opposing coasts, with closer connections across the sea than over land.

The total urban population densities can also be seen in Fig. 4.3 and Table 4.3. The situation is broadly in line with city density, though it is apparent that though MRs 2 and 5 have relatively few urban centres, they are generally large sites, with both being considerably higher up the table in terms of urban population density when compared to raw city density. Again, MR 12 is the clear outlier, with the high urban population of Salona meaning the micro-region has a far denser urban population than any others. Additionally, while MR 19 had a dense concentration of cities, these are not particularly large individual sites, and so the density of urban population in MR 19 is not quite so high. These general trends of urban population density are used to compare the micro-regions throughout the study.

**Table 4.3- Micro-region urban density.**

*The areas are calculated using the $area function in QGIS. Figs 4.2 and 4.3 offer visualisations of this same data.*

| MR | Area ($km^2$) | Cities | Cities/1,000 $km^2$ | Urban population | Urban Inhabitants/$km^2$ |
|---|---|---|---|---|---|
| **1** | 11,853 | 21 | 1.77 | 31,375 | 2.65 |
| **2** | 4,498 | 10 | 2.22 | 33,188 | 7.38 |
| **3** | 1,729 | 1 | 0.58 | 1,250 | 0.58 |
| **4** | 16,982 | 51 | 3.00 | 119,312 | 6.03 |
| **5** | 22,822 | 24 | 1.05 | 170,625 | 6.20 |
| **6** | 1,226 | 2 | 1.63 | 1,875 | 2.04 |
| **7** | 2,530 | 3 | 1.19 | 5,000 | 1.58 |
| **8** | 1,460 | 2 | 1.37 | 2,000 | 1.37 |
| **9** | 721 | 7 | 9.70 | 6,900 | 9.57 |
| **10** | 3,793 | 15 | 3.95 | 16,500 | 4.35 |
| **11** | 620 | 0 | 0.00 | 0 | 0.00 |
| **12** | 103 | 4 | 38.99 | 11,700 | 114.05 |
| **13** | 1,977 | 6 | 3.03 | 7,200 | 3.64 |
| **14** | 420 | 3 | 7.15 | 3,000 | 7.15 |
| **15** | 2,087 | 4 | 1.92 | 5,000 | 2.40 |
| **16** | 1,956 | 4 | 2.04 | 4,000 | 2.04 |
| **17** | 2,622 | 1 | 0.38 | 3,000 | 1.14 |
| **18** | 4,108 | 3 | 0.73 | 20,650 | 5.03 |
| **19** | 1,850 | 7 | 3.78 | 8,500 | 4.59 |
| **20** | 1,345 | 1 | 0.74 | 1,700 | 1.26 |

Comparing the urban population densities of the micro-regions offers some more information (Figure 4.11). With only 20 micro-regions, the data are fairly limited, but it does appear that there may have been a similar relatively local level of centralisation between the less densely urbanised micro-regions, with MR 12 clearly being primate in this, with a distinctly convex curve to the rest of the micro-regions. This may suggest that there were some centralised sites within the micro-regions, but that MR 12 and, presumably, Salona, had disproportionate access to the wider system, which disproportionately benefited this micro-region over the others. We cannot draw concrete conclusions from this analysis, but this diagnostic approach does allow us to further investigate some of the trends that have arisen.

Urbanism in the Adriatic region shows that there is not a marked difference between the coasts, beyond what we might expect from the differing availability of data. Each coast has distinct clusters of cities, and otherwise conform to a general trend of urban settlements spreading relatively evenly across the flatter terrain between the sea and the mountainous interiors. Moreover, although the sizes of these urban centres appears to have been generally larger on the Italian coast, both coasts have similar overall densities for the urban populations. This pattern is part of a wider trend of urbanism observed across the Italian peninsula, whereas urbanism on the Dalmatian Adriatic coast appears to be far more pronounced than in the interior beyond the Dinaric Alps. This further suggests that access to the sea (be it the Adriatic or the Tyrrhenian) had a greater impact on the urban, and therefore economic system of the region, than the administrative differences between provinces. The prominence of MR 12 and Salona is quite apparent, suggestive of a disproportionate role in the wider system beyond the Adriatic, likely due to Salona's unique (in the Adriatic) position as a provincial capital. Ultimately, the hierarchy of the Adriatic urban system is suggestive of a well-connected and integrated whole, with centralisation likely significant at very local levels, with Salona a clear outlier. Importantly, these levels of centralisation do not seem to be due to the east-west coastal split.

## 4.3 Urban Consumption

Urban centres were some of the most important markets for production, exchange and especially consumption in the ancient world. It is important to understand these patterns of consumption in order to model economic specialisation, exchange and ultimately cohesion. First, based on the geographic factors outlined in Chapter 2, agricultural suitability across the region is quantified. Following this, the consumption of three staple commodities is analyses, in the form of grain, wine and oil, before the relationship between centre and hinterland is discussed. This provides the basis for the system of consumption within the Adriatic and its micro-regions, and highlights where exports of surpluses would likely be possible, as well as where imports would be necessitated.

### 4.3.1- Quantifying Agricultural Suitability

While the agricultural suitability of archaeological landscapes is relatively often discussed, it is rarely discussed in quantitative, easily comparable terms.[345] A quantitative approach to agricultural suitability provides a means by which direct comparisons can be made between the suitability of

[345] Some of the principles and methodology discussed here are expanded upon in McLean (forthcoming).

different regions, micro-regions or site distributions. By using geographical data, a quantifiable proxy for suitability can be utilised, even in the absence of archaeological investigation. The current method for quantifying agricultural suitability is derived from data discussed in Goodchild (2009), detailing sites across Roman Central Italy.[346] The Slope and Aspect of the location of these sites are outlined, and were used to generate a potential suitability value, based on the percentage of sites that lie within specific ranges of aspect and slope (Tables 3.4 and 3.5). The slope and aspect data discussed in Chapter 2 were compared to the distribution of sites in Goodchild (2009) to create a suitability value for the Adriatic (Fig. 4.12). This was achieved by assigning a value between 100 and 0 to ranges of slope and aspect based on the percentage of sites found within these ranges in Goodchild's data. The range with the largest percentage of sites is assigned a value of 100, and every other range, a value based on the percentage of sites compared to the range with the largest. For example, a slope between 0 and 6% contains the most sites, at 37%, and 32% of sites are within a slope range of 6-12%, which is 87% of 37% (see Table 4.5). As such, a slope range of 6-12% is assigned a value of 87 and a slope range of 0-6% 100. Weighting was then applied to aspect and slope, using standard deviations and the number of ranges required to include 90% of the sites. Comparing the standard deviations between slope and aspect, slope had a standard deviation some 3.4 times smaller than that of aspect, and so was weighted at 3.4. Additionally, in order to include 90% of sites or more, three ranges of slope were required, and seven ranges of aspect, meaning slope is weighted at 2.3 of aspect by this metric. The mean value between both weightings is 2.86, which was used to generate the weighted values (multiplying the raw slope value by this factor). The slope and aspect value of a given location in the landscape was then summed for a total agricultural suitability value. The most suitable situation is a southward facing slope of 0-6%, with the maximum value of 386. Dividing the values into quartiles, the upper half ranges from 361-386, and represents land that can be considered to have been suitable for agriculture.

With a quantified proxy for agricultural suitability we can compare micro-regions more meaningfully. The mean value for all micro-regions is above 136, indicating the all micro-regions are generally quite suitable for agricultural production (Table 4.6). Notably, there appears to be no discernible correlation between urban population and agricultural suitability (Fig. 4.13), with MR 12 having a distinctly average mean agricultural suitability, and MRs 9, 14 and 16, with some of the next densest urban populations, having the lowest mean agricultural suitability values. On the other hand, MRs 1, 2 and 5 have particularly suitable agricultural land. This is much the same when we compare

[346] Goodchild (2009), especially 774-781. Non Adriatic sites had to be used to avoid any circular reasoning, and Goodchild's data and approach are particularly well suited and documented for establishing this value, while being in a relatively similar ecological and economic region.

the density of suitable agricultural land (a suitability value over 361) in each micro-region. This might suggest that the area of arable land in a micro-region had a minimal impact on the urban population that could be sustained, and so we have to look elsewhere to explain the distribution and hierarchy of these urban centres.

**Table 4.4- Aspect Suitability.**

*The suitability is based on the percentage of sites that are on slopes of specific aspects. The weighted suitability adjusts for different levels of importance between aspect and slope. As slope is weighted at 2.86 of aspect, aspect is unchanged in the weighting. Data is after Goodchild (2009).*

| Aspect | Sites % | Suitability Share | Weighted Suitability |
|---|---|---|---|
| **N** | 7 | 43.75 | 43.75 |
| **NE** | 10 | 62.5 | 62.5 |
| **E** | 14 | 87.5 | 87.5 |
| **SE** | 15 | 93.75 | 93.75 |
| **S** | 16 | 100 | 100 |
| **SW** | 15 | 93.75 | 93.75 |
| **W** | 12 | 75 | 75 |
| **NW** | 8 | 50 | 50 |
| **Flat** | 3 | 18.75 | 18.75 |

**Table 4.5- Slope Suitability.**

*The suitability is based on the percentage of sites that are on slopes within a specified range. The weighted suitability adjusts for different levels of importance between aspect and slope. As slope is weighted at 2.86 of aspect, the weighted value for slope is simply 2.86 multiplied by the suitability share. Data is after Goodchild (2009).*

| Slope (%) | Sites % | Suitability Share | Weighted Suitability |
|---|---|---|---|
| **00-06** | 37.31 | 100.00 | 286.44 |
| **06-12** | 32.5 | 87.11 | 249.51 |
| **12-18** | 20.17 | 54.06 | 154.85 |
| **18-24** | 7.88 | 21.12 | 60.50 |
| **24-30** | 1.56 | 4.18 | 11.98 |
| **30-36** | 0.46 | 1.23 | 3.53 |
| **36-42** | 0 | 0.00 | 0.00 |
| **42-48** | 0.08 | 0.21 | 0.61 |
| **48-51** | 0.04 | 0.11 | 0.31 |

**Table 4.6- Micro-region Agricultural Suitability.**

*Subsequent discussion and calculations will generally assume a total urban population of around 450,000 for the region, following the 'reasonable method'; an Italian urban population of 360,000 (1.25x) and 90,000 (All Cities) for Dalmatia.*

| MR | Area ($km^2$) | Urban Inhabitants/$km^2$ | Mean Agricultural Suitability Value | $km^2$ of Suitable Agricultural Land | $km^2$ of Suitable Agricultural Land/$km^2$ |
|---|---|---|---|---|---|
| **1** | 11,853 | 2.6 | 354 | 6,494 | 0.548 |
| **2** | 4,498 | 7.4 | 353 | 2,389 | 0.531 |
| **3** | 1,729 | 0.7 | 256 | 298 | 0.173 |
| **4** | 16,982 | 7.0 | 233 | 2,051 | 0.121 |
| **5** | 22,822 | 7.5 | 357 | 1,354 | 0.593 |
| **6** | 1,226 | 1.5 | 283 | 314 | 0.256 |
| **7** | 2,530 | 2.0 | 300 | 842 | 0.333 |
| **8** | 1,460 | 1.4 | 233 | 191 | 0.131 |
| **9** | 721 | 9.6 | 184 | 44 | 0.062 |
| **10** | 3,793 | 4.4 | 321 | 1,442 | 0.380 |
| **11** | 620 | 0.0 | 249 | 85 | 0.137 |
| **12** | 103 | 114.1 | 271 | 24 | 0.244 |
| **13** | 1,977 | 3.6 | 257 | 381 | 0.193 |
| **14** | 420 | 7.1 | 196 | 51 | 0.122 |
| **15** | 2,087 | 2.4 | 276 | 577 | 0.277 |
| **16** | 1,956 | 2.0 | 200 | 229 | 0.117 |
| **17** | 2,622 | 1.1 | 268 | 786 | 0.300 |
| **18** | 4,108 | 5.0 | 309 | 1,573 | 0.383 |
| **19** | 1,850 | 4.6 | 269 | 356 | 0.192 |
| **20** | 1,345 | 1.3 | 215 | 117 | 0.088 |
| **Total** | 84,702 | 9.3 | 269 | 19,598 | 0.231 |

While this approach provides a useful quantitative proxy for agricultural suitability, the limits of the methodology should be understood before the wider discussion of the results is presented. These values are based only on existing comparative data, though from an area that has been intensively surveyed and published. Furthermore, the model does not take into account mixed cultivation, which would have undoubtedly been a component of the Adriatic agricultural economy. With mixed cultivation, such as the *arbustum*, both vines and olive trees could be cultivated in very close proximity, though the conditions necessary could impact the quality of the product.[347] Finally, in much of the land below the necessary suitability value, crops could have been cultivated, just with reduced yields and efficiency, with the values above this threshold representing more intensive cultivation necessary for specialised production and export. As such, the suitable agricultural land is a relatively conservative estimate for the total arable land, and is more representative of the land useable for more intensive cultivation.

### 4.3.2- Grain

[347] Van Limbergen (2016).

In order to understand the economic effect of these urban populations on the region, it is of course necessary to understand the resources consumed by the population.[348] Past attempts to calculate the population of Rome have utilised the figures for grain import and expected calorific requirements.[349] Estimates for these calorific requirements vary, but generally fall somewhere between 200 and 320 kg of grain each year in order to satisfy an individual's daily calorific requirements.[350] This of course varies greatly between individuals based on age, sex and occupation, and Tchernia proposes that, with a demographic breakdown in Rome being 40% female to 60% male and 65% adults, an average of 2,900 calories per capita would be reasonable.[351] On average, it is expected that around 75% of daily calorific requirements were met by grain, so a little over 2,000 calories.[352] With 1 kg of wheat providing roughly 3,340 calories, 2,000 calories can be met by around 0.6 kg a day, or 216 kg annually.[353] With all of this, an annual per capita requirement of 200-250 kg of grain seems entirely sensible for an ancient urban population. If we have a total urban Adriatic population of around 450,000, this suggest an annual grain requirement of between 90-113 million kg. Tchernia, in estimating the population size of Rome itself, suggests a reasonable wastage figure of around 20% for grain, with other scholars going as high as 25% or 33%.[354] These are largely to do with grain import, and we could expect greater wastage for grain being imported by sea, where it is more likely to dampen.[355] Increasing this figure by 20% does not seem unreasonable to arrive at the figure that would actually need to have been produced for the population. So, between 240 and 300 kg of grain per annum per capita, or a total of 108-135 million kg of grain each year for the entire urban population of the Adriatic region, would need to be produced and/or imported. These are very rough figures, and work on a number of assumptions, but as with the rest of this chapter, this range provides a reasonable figure that we can work with to begin to understand the requirements of the urban population, and the potential of the hinterland of the Adriatic to provide for this population.

Now that we have the actual grain requirements of the urban Adriatic population, we can begin to discuss what would be needed in terms of land and manpower to provide this grain, and whether it is feasible that the Adriatic could sustain the population without imports. Estimated yields, based on volume sowed, for Roman grains vary, with as little as 1:4 without fertilising to as high as

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[348] A breakdown of all of the quantities and percentages listed in 3.3.2-3.3.4 can be found in Appendix E.
[349] Morley (1996); Hanson (2016), 51-53. Tchernia (2016), 190-194 offers an in-depth discussion of some of these studies.
[350] Jones (1964), 698, 1040; Liebescheutz (1972), 95; Garnsey *et al.* (1983), 118; Morley (1999), 35; Hanson (2016), 54; Tchernia (2016), 193; Van Limbergen *et al.* (2017), 358.
[351] Tchernia (2016), 193
[352] Garnsey *et al.* (1983), 118; Morley (1999), 35.
[353] Van Limbergen *et al.* (2017), 358.
[354] Gallant (1991), 94-98; Rickman (1991); Garnsey (1998), 78; Tchernia (2016), 195.
[355] Tchernia (2016), 194.

1:15.[356] The generally accepted output for grain is around 400-500 kg/ha, with as much as 1,000 kg proposed for the likes of Egypt, and 400 kg generally accepted for Italy.[357] Indeed, if we look to the Roman Agronomers, this seems to be confirmed. Varro suggests yields between 1:10 and 1:15 (Varro, *Res Rusticae*, 1.44.1) while Columella shows disdain for yields as low as 1:4 (*De Re Rustica*, 3.3.4).[358] This is all quite in keeping with the idea that yields varied greatly dependent on the situation, but that we might take an average yield to be around 1:8. Varro further elaborates, suggesting that depending on the grain, 5, 6 or 10 *modii* to the *iugerum* is best for wheat, barley and spelt respectively (1.44.1). As we have generally used wheat for the calorific requirements, it is best to use an estimate of 5 *modii* to the *iugerum*, this also provides a relatively conservative estimate for the entire yield. So, with this, around 17,460 litres of grain would be sowed per km$^2$ with a yield of 1:8 producing some 140,000 litres or around 22,080 kg/km$^2$. Increasing this yield to 1:15, which would be reasonable, assuming that Varro's lower volume of sowed wheat was reliant on a greater yield, we get 41,400 kg/km$^2$, or around 400 kg/ha. Using a yield of 40,000 kg/km$^2$ for the Adriatic region, the total land required to satisfy the annual grain requirements for the urban population is between 2,716 and 3,395 km$^2$. This is between 3 and 4% of the entire land of the Adriatic region, and this requirement accounts for only the urban population, with the rural being considerably larger by any estimates. Reducing this yield to 1:8, 4,921-6,151 km$^2$ are necessary, more than 7% of the total land. However, using the agricultural suitability discussed above, it is likely that the vast majority of Roman agriculture would only be taking place over an area of around 19,598 km$^2$. As such, as much as 31% of this more suitable land would be required to sustain the urban population's grain requirements alone.

It is difficult to accurately gauge the manpower that would be required to produce this volume of grain. But it is generally accepted that vineyards were considerably more labour intensive than other forms of agriculture (excluding vegetables) (compare Cato, *De Agricultura*, 11.1 and 10.1).[359] Taking the figures for vineyards discussed below, we can assume that fewer than 64 workers/km$^2$ would be needed. If a figure similar to oil production is used, 20 workers per km$^2$ does not seem unreasonable. This comes to 98,420-123,020 grain workers needed to supply the urban population of the Adriatic. Likely a little under a quarter of the total urban population.

[356] See Pritchard (1972); Spurr (1986), 82-88; Erdkamp (2005),34-46; Goodchild (2007), 256-297; 337; 414-418; Campbell (2000), 320-322 and especially Kron (2012), 162 for discussions and comparative studies of these possible yields.
[357] Spurr (1986), 82-88; Sallares (1991), 374-375; Jongman (2003), 115; Kehoe (2012), 551; Van Limbergen (2017), 359.
[358] Erdkamp (2005), 37; Kron (2012), 162.
[359] Kron (2012), 169.

### 4.3.3- Wine

Of course, more than just grain was required by the urban populations. As has been pointed out, two of the most important and best documented staple commodities of the Roman world were oil and wine, likely comprising a combined 15% of total calorific intake. As such, in addition to the required grain production, analysis of the wine and oil requirements of the Adriatic urban population is essential to understand the potential for surplus production.

It has been suggested that Cato's annual ration of 250 litres of wine for his slaves can be used as a basis for the average annual consumption of wine in the Roman world.[360] Taking into account the requirements of women and children, who likely needed as little as half of that, an annual average figure of around 100 litres for each individual is usually accepted, but again taking Tchernia's breakdown of the population of Rome being 40% female, to 60% male, with 65% being adult, this could be as high as 173.75 litres.[361] With the overall urban population of the Adriatic region being 452,775, this provides an annual wine consumption figure of between 45 and 79 million litres. The higher end is roughly the figure Morley suggests for the city of Rome itself during the 1st century BC, with a similar population of around half a million.[362]

With this figure, how much suitable land would be required to supply the urban population with wine? Varro, quoting Cato, suggests that some parts of Italy are capable of producing as much as 10-15 *cullei* of wine per *iugerum*:

> *'In what land does one iugerum bear ten and fifteen cullei of wine, as do some sections of Italy? Or does not Marcus Cato use this language in his Origines? "The land lying this side of Ariminum and beyond the district of Picenum, which was allotted to colonists, is called Gallo-Roman. In that district, at several places, ten cullei of wine are produced to the iugerum."' (Varro,* Rust.*, 1.2.7).*

Converting these figures, we have a possible output of between 2,100,000-3,144,000 l/km$^2$. This is mentioned by Varro as a particularly impressive output. Indeed, he later suggests that Cato's recommendation that a 100 *iugera* vineyard should have a vat capacity of 800 *cullei* was to allow for the maturation of wine, so as not to sell all of the wine every year (Cato, *De Agricultura*, 11.1; Varro, *Rust.*, 1.22.4). Nonetheless, it has been generally accepted that 21 hl/ha (exactly 2,100,000 l/km$^2$)

360 Purcell (1985), 13-15; Morley (1999), 113; Tchernia (1986), 26; Haas and Toll (2017), 358.
361 Tchernia (2016), 193.
362 Morley (1999), 113.

suggested by Columella is a reasonable average output in the Roman period.[363] Taking this lower estimate, some 21-38 $km^2$ would be required to supply the urban population of the Adriatic region. This is an extremely small portion of around 0.2% of suitable land. However, Van Limbergen *et al.* argued that much of Italian vine cultivation would have been polycultural by the time of the Empire.[364] By their estimates, using comparative studies, this yield could be reduced to about a tenth.[365] Even with this, only 210-380 $km^2$ would be required to supply the urban population of the Adriatic with wine, or around 1% of the suitable land. With this, it seems very plausible that the Adriatic, as a whole, was entirely capable of exporting a surplus of wine, given the levels of urbanism.

Looking again to Cato, we can estimate the number of workers necessary to produce this volume of wine. Cato suggests a vineyard of 100 *iugera* should have 'a total of 16 persons' working on it, including 10 labourers (Cato, *De Agricultura*, 11.1). Although this would surely have been seasonal, greatly increasing during harvest, we can take a figure of 64 workers per $km^2$. So, for the 210-380$km^2$, 13,400-24,448 workers would be required. This works out to one vineyard worker being capable of producing enough wine for 189 urban consumers (2,100,000 litres per $km^2$ is enough for 12,000 people with 64 workers per $km^2$).

### 4.3.4- Oil

By considering the consumption of olive oil, we can continue to develop a more complete picture of the resource demands of the urban population. Average annual oil consumption levels range from between 4 and 60 litres for each individual.[366] This large variation is due to the calorific requirements being some 4-7 litres while using oil for the likes of hygiene and illumination increases this dramatically, particularly for cities where we might expect greater demands per capita for illumination.[367] For the urban population, we can take a range of around 30-40 litres, and applying this to the total urban population of the Adriatic, provides a range of between 14 and 18.5million litres.

A generally accepted output for oil is 450 l/ha.[368] Or converting this to $km^2$ we have likely output of 45,000 l/$km^2$. In order to meet the needs of the urban population of the Adriatic region, some 311-411 $km^2$, or around 2% of the suitable land, would be required. This can be used to

[363] Kron (2012), 159; Van Limbergen *et al.* (2017), 359.
[364] Van Limbergen *et al.* (2017).
[365] *Atti lnch. Agr.* (1884), 723, 750; Van Limbergen *et al.* (2017), 364-365.
[366] Mattingly (1988a), 33-34; (1988b), 159-161; Morley (1999), 114; Brun (2003), 169; Foxhall (2007), 86; Van Limbergen (2017), 358.
[367] Morley (1999), 114; Van Limbergen (2017), 358.
[368] Frank (1933); White (1970); Antolini (1986); Osbourne (1987); Forbes (1992); Mattingly (1994); Brun (2003); Van Limbergen (2017), 359.

understand the labour requirements for this level of production. Cato suggests that his 240 *iugera* olive yard should have 13 workers, including 5 labourers (Cato, *De Agricultura*, 10.1). Using this as a rough figure, we have 22 workers for every km$^2$. This comes to 6,842-9,042 oil yard workers to supply the urban population of the Adriatic. Or, every oil yard worker could produce enough oil for between 51-68 urban inhabitants.

With all of this, in order to supply the urban populations of the Adriatic region, some 3,040-6,554 km$^2$ of arable land would have been required. This is between 3 and 8% of the total land of the Adriatic and between 15 and 33% of the total suitable land. This does not suggest that these demands could not be met largely by the local population.

### 4.3.5- City and Hinterland

At this stage we can begin to look at individual cites in more detail. Though it is clear that there was enough suitable land to provide for the resource demands of the Adriatic's urban population, not all of this land was in the hinterlands of the cities. Ranges of 3 and 5 km can be used as a rough estimate for the immediate hinterland of cities, as Goodchild shows that more than 80% of all early imperial villas and farms were within 3 km of an urban centre in the middle Tiber valley.[369] In order to apply this to the Adriatic, the total area of suitable land (a suitability rating of greater than 361) within a 3 and 5 km radius of each urban centre was calculated, and compared to the requirements of the urban population. Using the higher consumption values and lower yields, only 18 urban centres have enough suitable land within 3 km; increasing this to 5 km, 64 urban centres have sufficient agricultural land. For low consumption and high yield, there are 33 urban centres with suitable agricultural land within 3 km and 87 within 5 km. The two extremes of this seem unlikely and 33 urban centres also seems too low. As such, the values from a 5 km radius and high consumption low yield values are used here (Figure 4.14. The numerical results of all four scenarios can be found in Appendix D). For the majority of cities in the Adriatic region, it should be expected that agricultural produce was being imported from beyond the immediate hinterlands. Notably, many of the cities without excess suitable land in their immediate hinterlands are not only located in the more mountainous less agriculturally suitable terrain, but often near the coast. As such, it might be suggested that these coastal cities benefited from maritime connections, allowing the cities to draw on the resources of wider areas and support larger populations than the surrounding 3-5 km could provide for. Indeed, none of the four island cities have suitable agricultural land, with the connecting nature of the Adriatic itself likely facilitating the growth of these cities. Moreover, the most notable concentration of cities with insufficient

[369] Goodchild (2009), 779.

suitable land is to be found in the northern and central Adriatic, in MRs 4 and 5 (Fig. 4.15 and Table 4.7). MR 10, on the opposing coast of MR 4, has one of the higher potential urban surpluses, suggesting that surpluses of agricultural produce could be produced across MR 10, and find sufficient consumer markets in MRs 4 and 5, as well as the nearby MR 12. While some of the MRs with the densest urban populations seem to have the least sufficient land, this is not a straightforward correlation, as can be seen in Fig.4.16. Once again, it does not seem that dense urban populations are necessarily located in areas of particularly high agricultural potential. Instead, we must look to other factors, such as connectivity and mobility. Indeed, the five cities with seemingly the greatest deficiency of suitable agricultural land are Altinum, Patavium, Ravenna, Dyrrachium/Epidamnos, and Aquileia. With the exception of Patavium, these are all major port cities on the coast, and it seems very likely that these sites must have been able to sustain such large populations only through importing produce from across the sea. Notably, Patavium was well connected to the sea through a series of river ports and canals linking it to the wider network of which Ravenna, Altinum and Aquileia were all also a part.[370] This suggests that the urban system in this area of the northern Adriatic was supported by an economic system that enabled the sustained exchange of a large quantity of goods across the sea.

**Table 4.7- Micro-region excess agricultural land.**

*The total land required to supply the urban population of each micro-regions urban centres is calculated, as outlined above. This is then subtracted from amount of land within 5 km of each site that has a suitability value of over 361. The result is the excess land outlined below, with a positive value indicating more land than necessary for the urban population, and a negative, insufficient agricultural land.*

| MR | Excess Land |
|---|---|
| **1** | 186.11 |
| **2** | -92.15 |
| **3** | -10.82 |
| **4** | -1,041.89 |
| **5** | -1,179.18 |
| **6** | -18.21 |
| **7** | 18.14 |
| **8** | 0.60 |
| **9** | -86.64 |
| **10** | 140.42 |
| **12** | -134.66 |
| **13** | 12.84 |
| **14** | -37.89 |
| **15** | 20.28 |
| **16** | -45.53 |
| **17** | -23.60 |
| **18** | -222.75 |

[370] This is discussed in detail in Chapter 5.

| | |
|---|---|
| **19** | -23.87 |
| **20** | -21.20 |

## 3.4- Circuit Theory

The quantitative data produced through Circuit Theory (CT) analysis can be applied to the urban centres in order to better understand the impact of potential mobility and connectivity on the distribution and hierarchy of these sites.[371] Like with agricultural suitability, the mean current value around each urban centre for each of the 48 sailing scenarios was taken. In this instance, a radius of 3 km was used, as the location of cities are accurate well within this and, as has been highlighted, the majority of agricultural sites are within 3 km of an urban centre.[372] Additionally, Using larger radii did not significantly impact the results. In order to understand site distribution, the mean current values for each site's 3 km radius are combined to provide a single city mean current value (cmcv) for each scenario (Table 4.8). A one sample t-test is run against these cmcvs in order to reject the null hypothesis of random site distribution. Further, by subtracting the total mean current value (tmcv) of the CT output from the corresponding cmcv, a difference value is produced. A high difference value indicates that sites are mainly distributed in locations of higher than expected current.

**Table 4.8- City mean current value (cmcv) differences.**

*These are the mean values for every urban centres imcv value in each of the 48 scenarios, subtracted by the tmcv of each respective scenario. As all are positive, this is a good indication that urban centres are distributed in areas of high current, i.e. high potential mobility/connectivity. All imcv differences can be found in Appendix F.*

| | North | East | South | West |
|---|---|---|---|---|
| **Jan** | 0.879 | 0.822 | 0.636 | 0.213 |
| **Feb** | 0.757 | 0.801 | 0.622 | 0.246 |
| **Mar** | 0.624 | 0.879 | 0.866 | 0.220 |
| **Apr** | 0.681 | 0.839 | 0.674 | 0.228 |
| **May** | 0.667 | 0.812 | 0.644 | 0.217 |
| **Jun** | 0.816 | 0.844 | 0.637 | 0.236 |
| **Jul** | 0.667 | 0.831 | 0.815 | 0.221 |
| **Aug** | 0.480 | 0.899 | 0.874 | 0.216 |
| **Sep** | 0.453 | 0.762 | 0.859 | 0.235 |
| **Oct** | 0.603 | 0.767 | 0.672 | 0.224 |
| **Nov** | 0.560 | 0.766 | 0.751 | 0.235 |
| **Dec** | 0.747 | 0.892 | 0.698 | 0.225 |

[371] Some of the research in this section has been published under McLean and Rubio-Campillo (2022).
[372] Goodchild (2009), 779.

The hierarchy of the urban population can also be explored by analysing mean current values around specific sites. Rather than combining all of the sites mean current values to get a cmcv for each scenario, the current mean value of each individual urban centre can be used. These individual mean current values (imcv) can then be compared to the tmcv of a scenario by subtracting the tmcv from the relevant imcv. This produces 48 difference values for every urban centre, corresponding to each of the scenarios, which can be combined to get a single difference value for every site. Again, a higher difference value would suggest that the individual site is in an area of higher than expected current. By comparing the difference values of sites with different populations we can begin to understand how potential mobility might have impacted the hierarchy of the urban population.

The results for the one sample t-test run for the cmcv and imcv difference values consistently produced p values of < 0.001, using a *mu* value of the tmcv. As such, the null hypothesis, that site distribution is not in some way affected by current values, is rejected. Additionally, the difference value of all 48 cmcv and all 169 imcv are positive. This suggests that site distribution strongly favoured areas of higher current. However, the situation with site hierarchy is somewhat more complicated (Fig. 4.16). While all sites have positive total difference values, there is not a straightforward correlation between these difference values and population size. However, only 2 of the sites with known estimated populations significantly above the mean value have difference values significantly below the mean of the difference value. These represent two particularly interesting anomalies in Iguvium and, in particular, Dyrrachium. Iguvium is land locked, and on the very edge of the study region, so access to the Adriatic is unlikely to have been as major a concern for the location of this site as it would be for the port cities on the Adriatic. Dyrrachium, on the other hand, is a very large city, with a population over 10,000 on the eastern coast at the southern limit of the region. Explaining this is more difficult. However, we might view this in relation to the consistently low cmcvs for sailing west, and for the relatively low current values for sailing east in the southern Adriatic. Dyrrachium is particularly well placed for movement east and west between Italy and the east.[373] As such, we might expect a lower imcv for a southern site from which movement would primarily have been east and west. Although even with Dyrrachium, the imcv difference value is still positive. Furthermore, the largest sites do generally have high difference values (Table 4.9), though the sites with the highest difference values (Table 4.10) are not all those with higher populations. As such, the impact of potential mobility on population hierarchy seems to have been more complex than on site distribution. It is particularly notable that of the five urban centres with the least sufficient amount of agricultural land, four of these are significantly above the mean value in terms of potential

[373] Degrassi *et al.* (2012).

connectivity, with Dyrrachium again being the only exception. This suggests that a combination of limited agricultural land and high potential connectivity can in fact lead to particularly high populations. Those cities with large populations and low difference values likely had closer connections beyond the region, the potential of which is not modelled in the current CT analysis. This makes particular sense regarding MR 12 and Salona, which has been shown to likely have preferential access to wider networks beyond the Adriatic. A similar situation may be represented in the likes of Iguvium, Amiternum, Brundisium and especially Dyrrachium.

**Table 4.9- Imcv differences of the largest urban centres.**

*These urban centres represent those that are more than one standard deviation above the mean population of urban centres in the region.*

| Site | Population | Difference Value |
|---|---|---|
| **Patavium** | 26,000 | 1.179 |
| **Altinum** | 25,600 | 1.154 |
| **Ravenna** | 22,600 | 1.121 |
| **Dyrrachium/Epidamnos** | 14,250 | 0.639 |
| **Aquileia** | 13,500 | 1.430 |
| **Luceria** | 11,250 | 1.012 |
| **Amiternum** | 9,750 | 0.855 |
| **Brundisium** | 9,300 | 0.860 |
| **Iguvium** | 9,000 | 0.794 |
| **Tarentum** | 9,000 | 0.970 |
| **Salona** | 8,700 | 0.915 |

**Table 4.10- Populations of the cities with the highest imcv differences.**

*These urban centres represent those that are more than one standard deviation above the mean imcv difference of urban centres in the region. Notable, many of the largest sites are here, but also some which are far smaller.*

| Site | Difference Value | Population |
|---|---|---|
| **Aquileia** | 1.430 | 13,500 |
| **Forum Iulii** | 1.360 | 1,200 |
| **Tergestum** | 1.290 | 1,500 |
| **Concordia** | 1.225 | 4,200 |
| **Tarsatica** | 1.199 | 900 |
| **Mutina** | 1.179 | 5,400 |
| **Patavium** | 1.179 | 26,000 |
| **Opitergum** | 1.174 | 3,700 |
| **Tarvisium** | 1.159 | 3,000 |

| | | |
|---|---|---|
| **Altinum** | 1.154 | 25,600 |
| **Parentium** | 1.138 | 800 |
| **Ateste** | 1.127 | 5,000 |
| **Bononia** | 1.126 | 5,000 |
| **Vicetia** | 1.122 | 2,800 |

## 4.4 The Rural Population of the Adriatic

Before moving on, it is useful to briefly consider estimates for the rural population. The urban population of the Adriatic would have been a small fraction of the total population, and the majority of this urban population would not have been directly involved in the cultivation of vines or olives. Below, the estimated rural population, based on likely urbanism levels, is discussed, before being compared to the sparse archaeological evidence.

### 4.4.1- What numbers of rural population are suggested by the urban population?

Various ratios have been proposed between the urban and rural population for the Roman Empire. It has been generally accepted that the ratio between urban and rural populations across the Empire as a whole was around 1:8 or 1:9, or urbanism levels of 12.5 and 11.1%.[374] That being said, the Adriatic, particularly the Italian coast, was likely one of the most urbanised areas of the Empire, and a figure as high as 20% could be possible. Simply taking these figures, we can arrive at various total populations for the Adriatic region based on the methods outlined above for calculating the urban population. Using the reasonable figure of 452,775 for the urban population to calculate the rural population, results in a range between 3,169,425 and 3,626,279, or a total combined urban and rural population of 2,263,875-4,079,054. The upper numbers might be slightly higher than what is suggested by De Ligt's estimates of a total Italian population of 5.7 million under Augustus. However, as much of this methodology has been based on Hanson (2016), which produced a similarly slightly higher result, this range of 2-4 million for the total Adriatic population is in line with the methodology.[375] Using the manpower requirements outlined above, the percentage of the rural population required to produce a surplus for the urban population is likely less than 4%. By all of these estimates, it is very unlikely that any more than 8% of the rural population would need to produce a surplus in order to provide for the urban population. As such, it seems very probable that a large portion of the Adriatic population would have been in a position to sell any surplus to external markets. Of course, it could

[374] Erdkamp (2012), 243; Scheidel (2007), 78; Hanson (2016), 69.
[375] De Ligt (2012), 244; Hanson (2016), 72.

simply be that the entire rural population existed essentially at subsistence level, with the small surpluses produced across the region going only to nearby urban markets.

Taking these figures for the total population, we can estimate the total basic staple needs of the Adriatic populace. Using the highest estimates for the per capita resource requirements and the upper value for the population, this comes to around 1.2 billion kg of grain, 709 million litres of wine and 83 million litres of oil. In terms of land necessary for this, assuming the lower grain yield of 22,000 kg/km$^2$, this would be some 55,421 km$^2$ for grain, 3,374 km$^2$ for wine and 3,625 km$^2$ for oil, a total of 62,423 km$^2$. This value is considerably more than the estimated 19,598 km$^2$ of available suitable land in the Adriatic. However, this is still within the 84,701 km$^2$ total area. More pertinently, the 19,598 km$^2$ figure is for the most suitable land, so we should expect the yield for this land to be towards the higher end of estimates. The total population is, as has been mentioned, on the higher end, this combined with the high per capita requirements results in this unrealistic maximum land requirement. On the other hand, the lower requirements and population estimates can be used to compare the minimum land requirement. Using these parameters, 543 million kg of grain, 226 million litres of wine and 68 million litres of oil would be required for the total population of the Adriatic. Using the more generous grain yields of 40,000 kg/km$^2$, suggests that 13,583 km$^2$ would be required for grain, while 1,076 km$^2$ and 1,509 km$^2$ would be needed for wine and oil cultivation respectively, a total of 16,168 km$^2$. This is a little over 80% of the total suitable land. However, it is unlikely that a yield of 40,000 kg/km$^2$ would be consistent across the Adriatic, even within this more suitable 19,598 km$^2$. As such, we might expect the true value to be somewhere in between. Using the lower population estimate (3,704,600 (a median of 3,171,464)), a lower grain requirement that takes wastage into account (240 kg/p), the upper annual wine requirement (173.75 litres), the lower annual oil requirement (20 litres) (reasonable as the rural population would likely need less for lighting etc. than in urban contexts) and an average grain yield of 31,000 kg/km$^2$, more reasonable estimates can be arrived at. This results in a required 543 million kg of grain, 393 million litres of wine and 45 million litres of oil. In terms of land, this would be 17,516 km$^2$ for grain, 1,871 km$^2$ for wine and 1,000 km$^2$ for oil, a total of 20,387 km$^2$. This is just around 104% of the total suitable land in the Adriatic. This would suggest that the region was incapable of producing a significant surplus. However, none of this takes imports into account. As is shown in subsequent chapters, the imports into the region would have been significant, making up a large percentage of the overall consumption, especially in the port cities, which also have amongst the densest populations of the region.

It has been shown that the Adriatic region would have been reliant on the wider economic system in order to support the population. The very high potential connectivity of some of the largest sites in the region clearly indicate that frequent exchange within and beyond the region would not have been a difficult obstacle to overcome given the geography of the region. Furthermore, it is apparent that the micro-regions of the wider region did not function independently, with particular micro-regions, especially MR 12 and the provincial capital of Salona, likely having disproportionate engagement with the wider extra-regional system. With these core markets for consumption established, we can begin to look to the centres of production in more detail, further expanding our understanding of the complex regional economy, and how far we may consider it to have been a cohesive whole.

# Chapter 5: Wine and Oil: *Amphorae* and Presses in the Adriatic Region

*'For what Campania is to Rome, Istria is to Ravenna—a fruitful Province abounding in grain, wine, and oil; so to speak, the cupboard of the capital.'* - Cassiodorus, *Variae*, 22,22.

Wine and oil were amongst the most important commodities, culturally as well as economically, in the Roman world. In attempts to understand the economy of the Roman Adriatic, an understanding of wine and oil production, exchange and consumption is particularly insightful. In this chapter the evidence for where these important commodities were being produced is the focus. A brief discussion of the benefits and some of the issues of using wine and oil as evidence for economic activity is offered, before a general overview of this evidence in the Adriatic is detailed. Finally, the specific micro-regions are discussed, and those where specialised wine and oil production was most likely to have been undertaken are highlighted. Ultimately, this shows that the organisation of wine and oil production across the Adriatic would have required specialised micro-regional economies and a high level of market integration across the wider region.

## 5.1 Wine and Oil as Evidence for the Economy

Before considering the Adriatic, it is necessary to discuss wine and oil more generally. The benefits and issues with using this evidence are briefly outlined, before *amphorae* and presses are specifically discussed. The difficulties in differentiating wine from oil production is then outlined.

Wine and oil are present at every level of Roman society, from expensive luxury wines found at the tables of the elite, to the cheap lower quality wines readily available to the general populace.[376] As such, the exchange of these commodities takes place from the local level up through to the inter-regional and beyond. This makes them excellent proxies for understanding market integration on an inter-Adriatic scale. Moreover, wine and oil have been referred to as 'specialised' commodities, produced for specific markets.[377] Therefore, not only are wine and oil important to understanding general organisational trends within the Roman economy, but are particularly well suited for

[376] Purcell (1985), 2.
[377] For example, Mattingly (1988), 193; Tchernia (1993), 284; Erdkamp (2005), 167; Foxhall (2007), 132.

developing our understanding of some of the key economic concepts with which the current study is concerned. It should of course be noted that there were other important commodities in the Roman economy, many likely more economically or nutritionally significant than wine or oil. Grains in particular were of course a major component of the Roman diet, as has been highlighted in Chapter 4.[378] The cultivation of vegetables, other fruits, the rearing of livestock, catching fish and processing fish products are but a few additional components.[379] Furthermore mining ores, quarrying, metalworking, felling trees and processing timber are additional non-agricultural processes vital to the diverse Roman economy.[380] It should not be overlooked that wine and oil are only two parts of this diverse whole, but they will remain the focus as an invaluable proxy for economic activity. While many of these commodities, including wine and oil, do not survive well in the archaeological record, the ceramic vessels in which wine and oil were typically transported do survive in considerable quantities.

### 5.1.1- *Amphorae*

The study of *amphorae* has a long history within studies of the ancient world. As such, typologies are often very well established, allowing for the origin, contents and chronologies of specific *amphorae* to be known with relative confidence. However, as with any proxy, there are issues with *amphorae* as evidence for economic activity. First of all, these are maritime transport vessels, and so their absence might not indicate that wine or oil was not reaching these sites, rather that they were not reaching the sites from overseas in *amphorae*.[381] The coastal nature of the current study largely negates this, although when considering sites beyond the Adriatic, such as Magdalensberg across the Alps, this must be accounted for. Skins, barrels and other perishable containers were likely used for transport overland and along rivers throughout much of antiquity.[382] Moreover, it is likely that they increasingly replaced heavy and relatively inefficient *amphorae* in later periods, even for maritime transport. Again, the timeframe considered here, in the early Empire, helps to minimise the impact of this on the data considered. However, the use of barrels is particularly interesting given the current Adriatic context. Most examples of extant barrels come from the north-western provinces, and there is some evidence for such containers originating in north-western Europe.[383] However, it is also true that the

[378] Garnsey *et al.* (1983), 118; Morley (1996), 35.
[379] See Kron (2012); Crowe *et al.* (2010); Killgrove and Tykot (2013).
[380] See Russell (2013) for quarrying and the stone trade; Dungworth (2016) for metalworking in Roman Britain; Vairo *et al.* (2013) and Veal (2017) for timber.
[381] There is a wide body of scholarship discussing alternate transport vessels such as barrels and skins, for example, Desbat (1991); Marliére (2002); Wilson (2009), 220-224.
[382] Bevan (2014), 392, 395.
[383] Bevan (2014), 395.

wet, anaerobic conditions of north-western Europe are particularly well suited to preserving perishable wooden barrels. Similar conditions can be found in the lagoons of the northern Adriatic, indeed, shipwrecks have been recovered in remarkably good condition from this area, though I am unaware of the presence of any such barrels.[384] While *amphorae* are the best suited proxies for the current study, great care is given to keep in mind that these were only one form of possible container.

It must also be noted that *amphorae* represent only the final, quaternary process in the overall process of wine or oil production (Fig. 5.1). These are transport vessels used for the exchange of the commodities, and how they fit into the overall process itself is complicated.[385] Indeed, while every stage of this process could occur at a single site, every stage could equally be at an entirely different location, as is often the case with modern wine production. Nevertheless, evidence for the production of *amphorae* at a site, through the identification of a kiln, can help us to understand how the bottling process was organised in any given area. If a site can be shown to have produced wine or oil *amphorae*, it was clearly involved in this wider process.[386] While *amphorae* are not perfect proxies for the Roman economy and they would not have been the only transport containers that were being used, they are certainly amongst the best proxies we have at present.

### 5.1.2- Presses

The archaeological evidence for the secondary processes, grape or olive pressing, comes largely from the extant remains of pressing installations. These include the pressing mechanisms themselves: press beds, the *arbores* and associated support blocks, *stipites* or counter-weights.[387] Additionally, collection vats or basins, or channels to direct the flow of the liquids can indicate that wine or oil was being produced at a site. Evidence, of any form, for a pressing installation has significant implications. Even a single press requires substantial investment in both time and capital before any profit could be made, but would indicate large scale production beyond what would be necessary for domestic consumption.[388] The presence of a press clearly shows production beyond domestic requirements, whether the ultimate consumption location was relatively local, beyond the Empire or anything in between.

There are some issues with the archaeological evidence for pressing installations. Presses

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[384] See for example the Comacchio wreck, Beltrame and Costa (2016).
[385] *Amphorae* were also involved in the exchange of unprocessed olives and other fruits, but this is less common than *amphorae* as transport vessels for wine and oil.
[386] The distribution and exchange of wine and oil *amphorae* is discussed in more detail in Chapter 6.
[387] See Brun (2003); Brun (2004) for in-depth discussions of the varied mechanics behind Roman presses.
[388] See Marzano (2007), 93; Amouretti and Brun (1993); Brun (2004).

are not uniformly designed across the Empire, different techniques and press types are used even within particular provinces.[389] Furthermore, as with all archaeological remains, they are not always reliably preserved. The absence of any materials related to pressing at a site does not necessarily indicate that there were never any pressing installations. The very fact that the construction of pressing facilities required significant capital investment would make the materials themselves valuable, and they are subject to frequent reuse and re-purposing.[390] No database, can be an exhaustive catalogue of all sites where wine or oil pressing was carried out. Furthermore, wine and oil can be produced without a mechanical press. Wine, in particular, can be produced from grapes through treading.[391] Treading floors can be, and have been, identified (eg. Fig.5.2), but leave far less identifiable remains than mechanical presses do. Indeed, the majority of wine or oil production would likely have been on a small, local scale. However, the scale of production implied by market integration and economic specialisation would have been far beyond what was possible at the majority of such small-scale sites. As such, the limited understanding of smaller scale production is less problematic for the current study, and a focus on larger scale pressing sites is sensible.

### 5.1.3- Wine or Oil?

So far, we have discussed wine or oil production largely as a single process, but of course differentiating between the two is important for understanding any level of specialisation or market integration. The presence of a press alone is rarely sufficient to determine whether it was wine or oil that was being produced, as the secondary processes for producing both commodities are largely the same. There are, however, ways of differentiating between the production of the two commodities. The primary processes for vine or olive cultivation are, of course, different. Vine and olive tree planting pits leave distinct archaeological traces, with olive orchards requiring greater spacing between trees than is necessary between vines.[392] However, it is very rare to uncover archaeological evidence for this primary process, with most examples only known from areas covered by volcanic tephra, such as Campania.[393] Furthermore, without evidence for pressing installations, a site with vineyards or olive orchards might not have been directly engaged in the secondary production of wine or oil; today, grapes and olives are commonly pressed far from where

389 Brun (2004), 5.
390 Mattingly (1993), 494; Foxhall (2007), 146, 172; Van Limbergen (2011), 75.
391 Rossiter (1998), 48; Busana (2003), 119.
392 Glicksman (2007), 46
393 For some examples see Settefinestre, Villa Regina, Centocelle, or Kumenat in Dalmatia. Carandini and Settis (1979); De Caro (1994); Brun (2004), 18-20; Gioia and Volpe (2009); Glicksman (2007), 46. Or an example of carbonised olive pits from Val Maddona, Matijašić (1993), 252.

they were grown. While evidence for this primary process can help to differentiate between wine and oil production, it cannot be relied on.

Some aspects of the pressing process are unique to wine production. Fermentation, following pressing, is essential for wine, but not oil. The presence of *dolia*, huge ceramic vessels used for storage and fermentation, is likely indicative of wine production.[394] The freshly pressed liquid could be fermented in *dolia* before the final product was decanted into *amphorae* and exported. However, it is not necessarily the case that the wine stored in *dolia* must have been pressed on site. The wine could have been pressed elsewhere and then transported to separate storage/fermentation locations. Splitting the processes like this might be less efficient, but cannot be discounted as a possibility. Nevertheless, fermentation is an integral part of the process of wine production, and so a site with evidence for fermentation should be seen as a site involved in wine production, whether or not the wine was pressed on site. However, *dolia* are not definitive evidence for wine fermentation, as it is possible that they were also used for the storage of oil, other liquids or even foodstuffs.[395] The only reference to anything other than wine being stored in a *dolium* seems to come from the occasional use of the term '*dolia olearia*' (for example, Cato, *De Agricultura*, 69). However, there is no archaeological evidence, to my knowledge, for this practice. Indeed, transferring liquid to and from *dolia* was not a straightforward process (Cato, *De Agricultura*, 154). The need to ferment wine for long periods of time lessens the impact of this transfer, but it would be inefficient, even impractical, to store oil in *dolia*. While *dolia* are not definitive indicators of wine production, they do suggest very likely wine production. As such, sites with *dolia* and no other pressing evidence, are considered likely wine production sites, but not necessarily pressing sites, in this study.

Oil production also has some particular processes that can differentiate it from wine production. Crushing during pressing is necessary only for oil production. Evidence for this process comes largely in the form of olive mills. These distinctive devices come in a variety of shapes and sizes, but were all used to crush the stones of olives. As such, olive oil was very likely being produced at any site with olive mills. Indeed, it is unlikely that olives would be crushed and pressed at separate sites, even more so than grapes being pressed and fermented at different sites. The main issue with olive mills as evidence is their survivability. The mills were solid stone, and so valuable, but also relatively portable. This combinations means that olive mills are frequently removed and reused, more so than the other more substantial structural remains of pressing installations.[396] Furthermore,

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394 Busana (2003), 117.
395 Rossiter (1998), 599; Busana (2003), note 4.
396 Van Limbergen (2011), 75.

while fermentation is not necessary for oil production, separation is. The presence of separation vats with multiple connected chambers (Fig. 5.3.) are likely indicators of oil production, as this separation process is unnecessary for wine production.[397] Additionally, acidic olive oil has been shown to cause erosion in a way that wine does not. This leaves traces in the archaeological record on presses, occasionally showing that olive oil was being pressed on site (Fig. 5.4.).[398] The absence of an olive mill, press erosion or separation vats do not necessarily indicate that oil was not being produced on site, but the presence of any is strong evidence that oil was being pressed, and as such, sites with an olive mill or separation vat are considered to be oil press sites. While differentiating wine from oil production is a difficult process, it can occasionally be achieved. However, it should be emphasised that confirming oil production does not indicate an absence of wine production, and *vice versa*.

Despite the various issues outlined above, careful analysis of production sites can begin to highlight how far regional economies may have been integrated, and whether or not specialised production and exchange was being carried out on a micro-regional scale.

## 5.2 Wine and Oil Production in the Adriatic

There have been several studies focused on wine and/or oil production in the Adriatic, or more accurately, specific areas of the region. In this section an overview of some of the general trends in the scholarship of wine and oil production across the Adriatic are outlined and discussed. After this, the evidence for wine and oil in the region are detailed with reference to the ancient sources, the Adriatic *amphorae* forms and the types of pressing installations. Modern studies generally break the region down based on modern borders. The current study consciously aims to move beyond such arbitrary distinctions, but these modern differences affect the available data, and are outlined before a more pragmatic analysis based on the physical micro-regions (Fig. 2.4.) outlined in Chapter 2 is offered.

### 5.2.1- Current Scholarship

The modern scholarship of Adriatic wine and oil can be broken down into what I see as six main areas: the Italian Southern Adriatic, the Italian Central Adriatic, the Italian Northern Adriatic, Istria, the Balkan Adriatic Coast and the Southern East Adriatic. These areas are largely based on the scholarly tradition and the current archaeological record rather than on real regional distinctions

[397] Rossiter (1981), especially 356-360; Tyree and Stefanoudaki (1996), 174; White (2010), 157.
[398] Karaman (1930), 211; Brun (2004), 34-35; Glicksman (2007), 43; Van Limbergen (2016), 173.

observable during the early Roman Empire. The Italian Southern Adriatic corresponds roughly to modern Apulia, consisting of micro-regions (MRs) 1, 2 and 3. The Italian Central Adriatic is made up of the modern Italian regions of Molise, Abruzzo and the Marche, roughly corresponding to MR 4. The Italian Northern Adriatic constitutes the Adriatic portion of the plain of the Po and the northern Italian coast to Trieste and Istria, essentially MRs 5 and 6. Istria, here, constitutes the entire peninsula, MRs 7 and 8. The Balkan Adriatic Coast can be thought of as the Adriatic coasts of Croatia (excluding Istria), Bosnia and Herzegovina and much of Montenegro; roughly MRs 9 to 16 and, including the Croatian islands, 19 and 20. The Southern East Adriatic consists of some of the Adriatic coast of modern Montenegro and all of the Albanian Adriatic coast. The Southern East Adriatic corresponds to MRs 17 and 18. While the scholarship of the Adriatic can effectively be broken down into these areas, they do not correspond exactly to the ecological micro-regions established in Chapter 2. Beyond this section discussing the scholarship, the micro-regions will be used for reference, rather than these essentially arbitrary divisions.

Volpe is amongst the most prominent scholars working in the Italian Southern Adriatic, with a long history of studying the villas and economy of Puglia, though often focusing on the Late Antique as opposed to Roman remains.[399] Indeed, there is evidence for significant production of wine and oil at various sites in Puglia in Late Antiquity, but is often unclear how far this was a continuation of earlier Roman trends.[400] Historically, the Italian Central Adriatic this has been a relatively understudied area of Roman Italy, but in recent years, the work of Van Limbergen has greatly added to our understanding.[401] This area has some of the most convincing evidence for wine and oil production anywhere in the Adriatic, and the Tyrrhenian dominance of central Italy can begin to be rethought. Several scholars studying the Central Italian Adriatic also analyse the Italian Northern Adriatic. The latter has a much longer scholarly tradition, with Carre, Busana, Pesavento Mattioli and Cipriano offering some of the most influential works studying the economy of the area.[402] However, wine and oil production in the Italian Northern Adriatic is particularly difficult to understand as ancient descriptions of many wines from the area is not supported particularly convincingly in the archaeological record. It does seem unlikely, as is shown, that there was a major production of wine or oil in the northern Adriatic. Istria is often included as part of the northern Adriatic, but the drastic differences between the archaeological records of the Italian Northern Adriatic and Istria warrant a

[399] Volpe (1990); (2002). See also, Caracuta and Fiorentino (2009).
[400] Volpe (2002).
[401] See Van Limbergen (2011); Van Limbergen (2016): Van Limbergen (2018); Van Limbergen (2019); but also Busana *et al.* (2009); Van Limbergen *et al.* (2017).
[402] See Cipriano and Carre (1989); Cipriano (2009); Cipriano and Mazzochin (2002); Busana *et al.* (2009); and especially Pesavento Mattioli and Carre (2009).

distinction be made between them. Moreover, while Istria consists of MRs 7 and 8, discussions of the Roman economy of the peninsula are almost always limited to the western coast (MR 7), where the overwhelming majority of the archaeological remains are. Nevertheless, there are a number of important studies focusing solely on Istria, and Matijašić has written intensively on the economy of the peninsula.[403] The archaeological and literary evidence from the western coast of Istria all point to this area being the prominent producer of wine and especially oil in the Adriatic. Though Istria is often considered as a single whole, the western coast, MR 7, is geographically and archaeologically distinct from the eastern coast, MR 8. Furthermore, the former was part of Roman Italia, while the latter was in the territory of the province of Dalmatia. In this case, the physical, archaeological and historical administrative boundaries all seem to result in the same division. Therefore, considering MRs 7 and 8 as a single whole is misleading. The economy of the Balkan Adriatic Coast has been subject to considerably less intense study than the Italian coast. The early work of Wilkes and more recently of Glicksman studying Dalmatia, as well as the maritime studies of Royal and Jurišić are some of the most prominent focusing on this area, with some more recent research by Kopáčková specifically looking at wine and oil production in Late Antique Dalmatia.[404] While wine and oil production was clearly being undertaken here, the evidence is very limited. The modern archaeological issues that may explain this are discussed in detail below. The Croatian islands, MRs 19 and 20, are regularly considered as part of this Balkan coast. However, there are studies specifically concerned with some of the larger of these islands, especially Brač and Hvar.[405] The archaeological evidence from these islands also differs considerably from the rest of the Balkan coast, due to modern as well as ancient circumstances, and so these islands are considered as entirely separate micro-regions here. The Southern East Adriatic has seen very little work undertaken to understand the economy of the area, with the southern coast of modern Albania and the eastern portion of the ancient province of Macedonia receiving far more attention than the Adriatic coasts.[406] Nevertheless, the evidence from these areas does not suggest particularly large scale wine or oil production.

Like with much of Adriatic scholarship, there have been very limited attempts to consider the wine or oil production across the whole region. This results in a complex web of varying availability and levels of understanding of the evidence for wine and oil production. However, by considering

[403] See Bezeczky (1998): Tassaux (2001); Matijašić (2007a); Matijašić (2012); Šprem (2021); or Matijašić (1993) for an older Istrian study that included Dalmatia. For a more recent work on Istria see the unpublished MPhil thesis Rendina (2018).
[404] Wilkes (1969); Glicksman (2005); Glicksman (2007); Jurišić (2000); Kopáčková (2014); Royal (2015).
[405] Gaffney *et al.* (1997); Stančič (1999); Gaffney and Kirigin (2006); Radić (2009a); Kirigin *et al.* (2009).
[406] Bowden *et al.* (2004), 413; Reynolds (2004); Reynolds (2010); Reynolds *et al.* (2008); Karivieri (2008); Karambinis (2019).

the ecological micro-regions and how they might have interacted with one another, a more comprehensive understanding of the available data can be achieved.

### 5.2.2- Ancient Sources

Discussing wine and oil from the Adriatic is not a modern phenomenon, and the ancient sources can offer important insight into production in some of the micro-regions. For example, Picenum, roughly MR 4, seems to have been well known for its wine production in antiquity. Polybius (*Historíai*, 3.8.1) and Varro (quoting Cato) (*Res Rusticae*, 2.1.7) attest to the presence of wine production during the Republican period in the area, with Cato describing an impressive 200 hl/ha harvest in the *Ager Gallicus*.[407] This renown seems to have intensified through the imperial period, with Strabo describing the area around Ancona as 'exceedingly productive of wine and wheat' (*Geographica*, 5.4.2). There are two mentions of a wine from Picenum by Greek Augustan poets (*Anthologia Palatina*, 6.257, 9.232). Indeed, the specific wines *Hadrianum* and *Praetutianum* can both be fairly confidently provenanced to southern Picenum (though Pliny mistakenly attributed *Hadrianum* to the northern Adriatic) (Pliny, *Naturalis Historia*, 14.67, 14.60, 14.75; Silius Italicus *Punica*, 15.586). Epigraphic and papyrus remains attest to  the likely export of wine from Picenum continuing into at least the 3rd century AD, with Picenum being mentioned in Diocletian's Price Edict of AD 301 and Hadrianum being listed in multiple third century Egyptian papyri.[408] Olive oil is considerably less well-attested in the literary record. Pliny does not include Picenum in his list of oil producing areas (*Naturalis Historia*, 14.3.16). However, the quality of the olives themselves are mentioned in the ancient sources on multiple occasions (Silius Italicus, *Punica*, 6.648-650; Ausonius, *Epistles*, 3.1; Martial, *Epigrams*, 1.43.7-8, 4.46.12-13, 4.88.7, 5.78.1721, 7.53.4-5, 9.54.1, 11.52.11, 13.36.1-2).[409] Epigraphic evidence in the form of a *titulus pictus* reading '*oliva picena*' found on a storage jar in north eastern France appears to attest to the continued export of olives from the region into at least the 3rd century AD.[410] While olives from Picenum were regarded as a high quality product, it appears that MR 4 was better known for wine rather than oil production in antiquity.

There are some limited mentions of olives or olive oil from MRs 5 and 6, in the literary or epigraphic record.[411] Pliny does generically mention olive trees common to the Plain of the Po (*Naturalis Historia*, 17.201), but otherwise it is difficult to find specific references. Indeed, it has been

[407] Van Limbergen (2011), 72; Van Limbergen *et al.* (2017).
[408] Rathbone (1983), 90-94; See Van Limbergen (2011), 72 for a detailed breakdown of this literary evidence.
[409] Van Limbergen (2011), 72.
[410] Paci (2009); Van Limbergen (2011), 72-73.
[411] Buonopane (2009); Busana *et al.* (2009), 35.

suggested that the oil produced in this region was of fairly low quality, thus not attracting the attention of the writers of the time.[412] On the other hand, grapes and wine from MR 5 are frequently discussed in the literary record. Catullus criticises the Raetican grape (*Veronensis Liber*, *frg*. 7), while Pliny (*Naturalis Historia*, 14.16), who places the origin of the grape and wine around Verona, Virgil (*Georgics*, 2.95-96), Strabo (*Geographica*, 4.6.8) and Cato (*Ad Filium*, *frg*. 8) all praise the wine produced from this grape.[413] Pliny, who would have been familiar with the area having been born there, offers more nuance, describing a grape from the Maritime Alps, similarly taking its name from Raetica, which was of far inferior quality to the Raetican grape he praised (*Naturalis Historia*, 14.16). Indeed, Tiberius and Augustus were said to have enjoyed the grapes and wine, respectively, from this area (Pliny, *Naturalis Historia*, 14.16; Suetonius, *Augustus*, 77). Beyond this specific grape variety, the sources generally refer to the Plain of the Po as exceptionally fertile, producing an 'overabundance' of wine,[414] as well as great quantities of wheat and turnips according to Pliny (*Naturalis Historia*, 18.127). Strabo offers a particularly interesting insight into wine production in this area, describing the abundance of local pitch allowing for the cheap production of wooden barrels 'larger than houses' (Strabo, *Geographica*, 5.1.12), though it is unclear exactly how widespread the use of such barrels was in reality. Most of these literary references concentrate on the foothills and the Plain of the Po in western MR 5, but there are some limited references to wine being produced in the eastern coastal area. Pliny describes *Pucinium*, as having been produced near Aquileia, and being the favoured wine of Livia (*Naturalis Historia*, 14.8.60).[415] More generally, Herodian describes the countryside around Aquileia as being particularly favourable for wine production (8.4.5 and 8.6.3). Strabo describes wine and oil, amongst other commodities, being traded, particularly by the Illyrians, at Aquileia (*Geographica*, 5.1.8). There is some confusion with Strabo's use of the phrase '*τὰ ἐκ θαλάττης, καὶ οἶνον ἐπὶ ξυλίνων πίθων ἁρμαμάξαις ἀναθέντες καὶ ἔλαιον*', which has been translated as meaning both 'goods from sea trade' and 'products obtained from the sea'.[416] The latter would suggest that fish or fish products were among the products, like wine and oil, being produced and exchanged at Aquileia. On the other hand, the former would indicate that products, such as wine and oil, were imported into Aquileia from across the sea, where they were later exchanged. It remains unclear whether or not Aquileia was particularly well-known for its own large scale wine production, though the archaeological evidence for this is sparse, and, as the circuit theory analysis of Chapter 4 highlighted, Aquileia was in a particularly prominent position

412 Busana *et al.* (2009), 36.
413 Buchi (1996), 373.
414 Buchi (1996), 374.
415 Pesavento Mattiolo (2007), 462.
416 Raviola (2002), 202; Buonopane (2009).

to take advantage of the connectivity afforded by the Adriatic itself. These are just some of the ancient sources discussing wine from the Northern Adriatic.[417] However, it is clear that a variety of wine, often regarded as high quality, was produced across MR 5 and was well known to ancient writers.

Multiple ancient sources discuss the quality of Istrian oil from MR 7. Pliny describes it as being second only to Italy in quality and equal to that produced in Baetica (*Naturalis Historia*, 15, 9). Martial and Pausanius compare different oils to the high quality of Istrian oil (Martial, *Epigrams*, 12.63); (Pausanius, *Hellados Periegesis*, 10.32.19). Cassidorus' description of Istria as 'a fruitful Province abounding in grain, wine, and oil' (*Variae*, 22.22) clearly attests to the productive capabilities of the peninsula.[418] Indeed, his suggestion that Istria acted as a form of breadbasket to Ravenna, suggests specialised production on the peninsula, at least during Late Antiquity, reliant on a highly integrated regional economy. The ancient sources highlight Istria as being a highly productive area, particularly in regard to oil production and, as is shown below, this is backed up emphatically by the archaeological evidence. The ancient sources are relatively quiet when it comes to discussing wine or oil from Dalmatia. There is some evidence for oil production in Liburnia, an area roughly corresponding to MRs 9, 10, 19 and 20. This evidence comes from Apicius describing a recipe (*De Re Coquinaria*, 1.7), which seems to be repeated by Palladius, for making Spanish oil taste like Liburnian oil.[419] Glicksman argues that this is indicative of Liburnian oil being of particularly high quality, and presumably expensive, though, sensibly, points out that this should not be applied to Dalmatia as a whole.[420] Nevertheless, this clearly shows that there was at least a market for oil from these micro-regions, with writers beyond the area being aware of the product and even seeming to think very highly of it. However, it is unclear how widespread this market could have been, with such limited mentions in the literary record. It may be that this was a small scale but well regarded oil, a situation that would not necessitate large scale specialised production. Indeed, the sources are largely silent beyond these suggestions of an expensive Liburnian oil.

There are some limited references to wine and oil production on the Dalmatian islands (MRs 19 and 20). Agatharchides is supposed to have described a wine from Issa, on Vis (MR 20) as 'better than all others' (Athenaeus, *The Deipnosophists*, 1.28d). Similarly, Strabo describes the Dalmatian islands generally as being particularly well suited to olive cultivation and wine production

[417] For detailed discussions of the ancient sources, see Buchi (1996); Buonopane (2009).
[418] Matijašić (1993), 248; Buonopane (2009); Busana *et al.* (2009), 42.
[419] Glicksman (2007), 47; See Cerva (1997) for a discussion of this recipe and its origins.
[420] Glicksman (2007), 47-48.

(*Geographica*, 7.5.10).[421] This suggests that wine was being produced on at least one of the islands, and that it was known that wine and oil could be produced across MRs 19 and 20 in antiquity. However, it is unclear exactly how large scale this production was.

The ancient sources suggest that the Adriatic was a diverse region with a variety of well-regarded wines and oils. This diverse, variable nature is entirely conducive to the development of a highly integrated regional economy where different micro-regions could fruitfully specialise in the production and exchange of different commodities.

### 5.2.3- *Amphorae* Forms

Turning to the archaeological evidence, six main *amphorae* forms seem to have been produced across the Adriatic in various micro-regions (Table 5.1 and Fig. 5.5). The Adriatic late Greco-Italic and the Lamboglia 2 are the main Republican wine *amphorae*, while Dressel 6A, 6B, Adriatic Dressel 2-4 and flat-bottomed (Forlimpopoli) *amphorae* were produced throughout the early Empire.[422] The most convincing evidence for the production of Greco-Italic *amphorae* comes from MR 4, but the significant production of the *amphorae* across Campania/Magna Graecia seems to have included Tarentum, and possibly other parts of MR 1. There is also some evidence for the production of these Republican wine *amphorae* at Adria in MR 5.[423] Moreover, it has been suggested that this largely Italian production was supplemented by the production of *amphorae* on the Croatian islands (MRs 19 and 20), following on from earlier Greek traditions, but the kilns, once identified as such, have been lost.[424] It is difficult to disentangle the long history of these *amphorae*, with past misidentifications and conflations with now differentiated sub-types making the identification of specifically Adriatic production problematic. However, the majority of identified Greco-Italic kilns in the Adriatic region are in MR 4, which seems to have been a major producer of wine *amphorae* from an early time.

Lamboglia 2 are the second Republican *amphorae*. The production of these wine *amphorae* gradually replaced the Greco-Italic from c. 150 BC and production ceases around the end of the Republic. Originally identified as oil *amphorae*, the discovery of pitching on some examples from shipwrecks confirmed wine as the main contents of the *amphorae*, as oil would have degraded any pitch coating the *amphorae*.[425] Again, the majority of the evidence for Adriatic production comes

[421] Gaffney and Kirigin (2006); Carre *et al.* (2014), 426.
[422] Van Limbergen (2018), 201.
[423] See Van Limbergen (2018), 202-206 for a detailed discussion of these *amphorae*.
[424] Carre *et al.* (2014), 427.
[425] Charlin *et al.* (1978); Formenti *et al.* (1978); Van Limbergen (2018), 207; Brun *et al.* (2020).

from MR 4 and the evidence suggests significant production in the micro-region.[426] There is also evidence for Apulian production, and it was once thought that these *amphorae* were only produced in Apulia (MR 1), but the discovery of several kilns in MR 4 clearly show a wider Adriatic production.[427] Furthermore, there is some limited evidence for these *amphorae* being produced in MR 5, in the Veneto region and at Modena.[428] Some stamps also link Lamboglia 2 to the gens Gavia, known from Verona and Aquileia.[429] MR 4 does seem to have been the main Adriatic producer of both Republican wine *amphorae*, but the epigraphic record shows likely production across much of the north of the region.

**Table 5.1- Adriatic *Amphorae* Forms.**

*These are the main amphorae forms thought to be produced in the region. Not all of these forms are unique to the Adriatic, and there are others that may have been produced one some level. However, this gives a working overview of the most significant forms and their possible production micro-regions.*

| ***Amphorae*** | **Contents** | **Date Range** | **Micro-Regions** |
|---|---|---|---|
| **Adriatic Greco-Italic** | Wine | 250/225-150/125 BC | 1, 4, 5, 19, 20 |
| **Lamboglia 2** | Wine | 150/125-50/25 BC | 1, 4, 5 |
| **Dressel 6A** | Wine | 50/25 BC-AD 25-50 | 4, 5 |
| **Dressel 6B** | Oil | Rep-Imp | 5, 6, 7 |
| **Adriatic Dressel 2-4** | Wine | 50/25 BC-AD 150-175 | 1, 4, 6 |
| **Flat-Bottomed (Forlimpopoli)** | Garum/Wine | AD 50/75-225/250 | 4, 7, 9 |

From around the middle 1st century BC Dressel 6A gradually replaced Lamboglia 2, and continued to be produced into the middle of the 1st century AD.[430] There have been historical problems with differentiating Dressel 6A and 6B. Originally they were simply not differentiated, and both were identified as likely oil containers, based largely on the evidence for their production in oil rich Istria.[431] However, the discovery of painted labels (‘*mulsum*’ (CIL XV, 4582) and ‘*vinum*’ (CIL XV, 4653)) on some of the vessels, along with many still being lined with resin, has allowed for a general consensus to be established that most examples of what we now call Dressel 6A *amphorae* were in fact wine *amphorae*, and quite distinct from Dressel 6B.[432] The epigraphic evidence from stamped *amphorae* suggests multiple production sites in Picenum, but also some possible production in the

426 Van Limbergen (2018), 206-209.
427 Van Limbergen (2018), 207.
428 Note that a possible Aquileian kiln has since been shown to be a coarseware and not an *amphorae* kiln. See Maselli Scotti (1987); Pesavento Mattiolo (2007), 462 for suggestions that this was a Lamboglia 2 kiln and Carre *et al.* (2014), 421 for details of its refutation.
429 Pesavento Mattiolo (2007), 462-465.
430 Lamboglia (1955); Van Limbergen (2018), 210.
431 Degrassi (1962); Van Limbergen (2018), 201.
432 Baldacci (1967); Callender (1970); Van Limbergen (2018), 211.

plain of the Po.[433] Indeed, Adriatic 6A *amphorae* can generally be divided into two separate forms. The first is from Picenum, and well documented in the epigraphic record as well as the evidence for kilns.[434] The second form seems to have been produced across Cisalpina, with many being stamped with the names of families well known from the area (for example the Hostilii, Gavi, Valeri, Ebidii and Ebidieni).[435] Moreover, the *amphorae* depicted on the so called Aquileian pyramid very likely depict Dressel 6A (Compare Figs. 5.6 and 5.7).[436] However, the evidence for Dressel 6A kilns around Aquileia, and in MR 5 generally, is problematic, and are rarely attested at sites where wine production is also evidenced.[437] While kilns for these *amphorae* are less well documented, the epigraphic evidence again points to MR 4, and to a lesser extent MR 5, as the main Adriatic production centre of these wine *amphorae*.

The production of Dressel 6A and Dressel 2-4 Adriatic wine *amphorae* begin at around the same time in the 1st century BC, but the production of 2-4 continues into the late 2nd century AD. Dressel 2-4 *amphorae* are well documented and discussed, but mainly in Tyrrhenian contexts, with their Adriatic production only recently being studied in any depth.[438] Dressel 2-4 production has been identified at a number of sites in MR 4: Silvi Marina, Cesenatico, Castelluccio, Marino del Tronto, and possibly the Ager Firmanus.[439] Some attempts have been made to identify an Adriatic fabric for Dressel 2-4 *amphorae*, but differentiating them from the better studied Tyrrhenian examples remains problematic, limiting the extent to which Adriatic distributions can be confidently hypothesised.[440] The epigraphic record also supports the production of these *amphorae* primarily in MR 4, but also in MR 1, particularly at Brundisium and possibly around Tergestum in MR 6.[441] Once again, it appears that a significant portion of the production of these wine *amphorae* was being undertaken in MR 4, but there is evidence for smaller scale production across the north of the region.

Dressel 6B are thought to have been oil *amphorae*. Baldacci had suggested the *amphorae* carried *liquamen*, based on *tituli picti* observed on Dressel 6B *amphorae* from Milan.[442] However,

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433 Susini (1989), 141-143; Buora (1995), 185; Cristofori (2004), 60-61; Van Limbergen (2018), 211.
434 Van Limbergen (2018), 210-211.
435 Pesavento Mattiolo (2007), 460-461.
436 Pesavento Mattioli and Carre (2009), 460.
437 Pesavento Mattioli and Carre (2009), 460.
438 Van Limbergen (2018), 213.
439 Staffa (2002); Staffa (2003); Stoppinoi (2009); Menchelli (2011); Antognozzi *et al.* (2014); Van Limbergen (2018), 213.
440 Mercando (1979); Cipriano and Carre (1989); Mazzeo Saracino (1991), 79; Giuliodori *et al.* (2007), 415; Bezeczky, (2010); Cafini and D'Alessandro (2010); Gamberini (2014), 552-553; Menchelli and Picchi (2014); Monsieur and Carboni (2017); Van Limbergen (2018) 213.
441 Cipriano and Mazzocchin (2016), 220; 'University of Southampton Roman Amphorae' website https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/cat_amph.cfm (accessed 02/12/21).
442 Baldacci (1967), 15; Cipriano (2009), 173.

more recent studies have questioned this and even point to an almost exclusive use of these vessels as oil *amphorae*. This is based largely on the very limited evidence for pitch, suggesting it was eroded by oleic acid, and the production of the *amphorae* being linked to oil producing areas. As such, it has been suggested that their use as containers for fish products be relegated to nothing beyond occasional reuse.[443] Locating exactly where these *amphorae* originate from is yet more complex. Early in their study, it was suggested that they were Istrian (MR 7) in origin, but later epigraphic evidence also linked them to the Sepulli of Patavium (MR 5).[444] Indeed, there was certainly some level of production at Patavium until the middle 1st century AD, with close analysis of the epigraphic and prosopographic data as well as archaeometric analysis, indicating production in an area roughly from Patavium and Venice in the south, up to Bassano and Treviso in the north.[445] Moreover, some stamps suggest production around Tergestum, in MR 6.[446] As such, a more general origin, in northern Adriatic Italy and Istria, has recently been argued for.[447] However, the only extant kilns that can definitively be shown to have produced these *amphorae* are in Istria.[448] Furthermore, the epigraphic evidence has long shown that a huge quantity of these *amphorae* were from the Istrian workshops.[449] It seems likely that Dressel 6B oil *amphorae* were produced in some quantity across the Northern Adriatic, but on a particularly large scale in MR 7.

The flat bottomed *amphorae* are not entirely well understood. They have clear production centres in MR 5, north of Ariminum and particularly around Forlimpopoli.[450] There is also some evidence for kilns in MR 4 producing smaller quantities of the *amphorae*.[451] However, the distribution of the flat bottomed *amphorae* from MR 4 seems to be limited to relatively local sites, other than Rome.[452] Of the three possible subcategories of the flat bottomed *amphorae*, one was likely intended for wine, while the other two seem more likely to have transported *garum*.[453] The production of these *amphorae* continues into the 2nd and 3rd centuries AD.[454] It seems likely that small scale production of these *amphorae* was being undertaken in the north of MR 4, but that the focus of this

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443 Carre (1985), 225; Tassaux (2001), 504; Cipriano (2009), 173.
444 Degrassi (1953); Degrassi (1956); Baldacci (1967), 15; Cipriano (2009), 173.
445 Carre and Pesavento Mattioli (2003), 462; Cipriano (2009), 182-183; Cipriano *et al.* (2020).
446 Tassaux (2001), 516-517; Cipriano (2009), 173.
447 Buchi (1973), 632; Carre (1985), 222-223; Cipriano (2009), 173.
448 Cipriano (2009), 176.
449 Bezeczky (1998).
450 Staffa *et al.* (1995); Staffa (2001), 195; Staffa (2002), 58; Staffa (2003), 119, 130-132; Van Limbergen (2018), 213.
451 Van Limbergen (2018), 213.
452 Panella (1989); Panella (2010), 195; Staffa (2003), 130-132; Salvini (2003), 18; Van Limbergen (2018), 213.
453 Aldini (1996); Aldini (2000); 'University of Southampton Roman Amphorae' website https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/cat_amph.cfm (accessed 02/12/21).
454 Gamberini (2014), 553-558; Van Limbergen (2018), 213.

production was in the south of MR 5. In both cases, this was likely mainly as wine amphora rather than *garum*.

Some interesting early conclusions can be drawn from these general trends in Adriatic *amphorae* production. MR 4 clearly has the most robust evidence for wine *amphorae* production, with convincing evidence for the production of all major wine *amphorae* known from the Adriatic. Indeed, the only one of these six main forms not known to have been produced in MR 4 is the Dressel 6B oil *amphorae*. This seems to support what the ancient sources suggest of MR 4, minimal oil production but intensive wine production. Some level of wine production is also suggested by the presence of *amphorae* production in MRs 5 and 1. However, the evidence for *amphorae* production in MR 5 is somewhat underwhelming, given the manner in which wine from the area is discussed in the ancient sources. Nonetheless, a variety of wine *amphorae* were produced here over an extended period. The Dressel 6B oil *amphorae* were clearly produced, primarily, in MR 7, but some level of production seems likely across MRs 5 and 6, so we might expect some level of oil production across much of the northern Adriatic, but concentrated on the western coast of Istria. Given the prominence of Istrian oil in the sources, it seems quite clear already that MR 7 was a centre of major Adriatic oil production. The lack of evidence for *amphorae* production across much of the eastern coast is significant. Like with the ancient sources, the evidence from *amphorae* for large scale wine or oil production is limited largely to the Croatian islands, and on the island of Vis, the possible remains of *amphorae* workshops have been identified.[455] It would be tempting to relate this to the wine Agatharchides describes, though there is no definite evidence for this. Beyond the islands, it has been suggested that Greco-Italic and Lamboglia 2 *amphorae* were imitated in Dalmatian workshops near Narona.[456] However, this is similarly yet to be definitively proven, and there seems to be no evidence for distinctive *amphorae* forms produced anywhere in Dalmatia. There are archaeological issues associated with the Dalmatian coast, which are discussed below, which might explain this paucity of evidence. However, what the literary sources and *amphorae* evidence seem to suggest, is that large scale wine production was primarily undertaken in MRs 5 and especially 4, while large scale oil production was carried out in MR 7 more than anywhere else. This is not to suggest that wine and oil were not produced anywhere else in the Adriatic, nor that any of these micro-regions exclusively produced wine or oil, but from the evidence discussed thus far, these seem to be the most promising micro-regions for specialised production.

[455] Van Limbergen (2018).
[456] Cambi (1989), 321-323; Mardešić and Šalov (2000), 4; Glicksman (2005), 197; Lindhagen (2009) also argued for a Dalmatian origin for Lamboglia 2 and Dressel 6A, but the concept of this production being comparable in scale to the Italian coast has been quite emphatically refuted by Carre *et al.* (2014).

## 5.2.4- Pressing Installations

A wide variety of different press typologies were used across the ancient world to produce wine and oil; the Adriatic is no exception, and wine and oil were produced by different means across the region.[457] The most detailed evidence for pressing installations comes from MR 4. The identification of press sites in this micro-region is based on a series of indicative archaeological remains, mainly the press beds or vats themselves, but often the base blocks for the *arbores* and concentrations of *amphorae* and/or *dolia*.[458] Press beds in MR 4 are mainly *opus spicatum* or hydraulic *cocciopesto*, with channels encircling the press beds and leading to collection basins or vats (Fig. 5.8).[459] Some stone press beds have been identified, but all, stone or not, were circular.[460] The vats are generally quite small, though some have capacities of more than 10,000 litres, and are usually lined with hydraulic mortar.[461] Only two known complete olive millstones, neither of which were in context, have been identified, both of which are of the *mola olearia* type.[462] Moreover, no counterweights have yet been discovered, though Van Limbergen does suggest that the presses could have functioned with or without counterweights.[463] Almost all of the stone base blocks for the *arbores* are square and all have two rectangular notches (for example Fig. 5.9).[464] However, no remains of the *arbores* themselves have survived. It is possible that they were all wooden, and so do not survive.[465] However, the possibility remains that stone *arbores*, like those discovered in North Africa, were used but have since been spoliated.[466] The presses generally seem to be of the lever and screw typology, like those described by Pliny (*Naturalis Historia*, 18.317) and found across much of the Italian peninsula.[467] This identification is based on all pressing installations having only one base block for the *arbores*, suggesting a screw mechanism was used rather than *stipites* and a windlass to move the lever.[468] While there are of course variations between sites within MR 4, these general trends can be observed across the micro-region.

The pressing installations found on the western coast of Istria, MR 7, are similar in some ways

[457] Brun (2004), 5.
[458] See Van Limbergen (2011), Appendix 1.
[459] Van Limbergen (2011), 75.
[460] Van Limbergen (2016), 175.
[461] Van Limbergen (2011), 79.
[462] Pupilli (1994), 27, 48; Van Limbergen (2011), 75. There are fragmentary olive millstones at two additional sites, see Pignocchi (2001); Pupilli (1994), 78-79; Van Limbergen (2011), 75.
[463] Van Limbergen (2011); 78.
[464] Van Limbergen (2011); 78.
[465] Van Limbergen (2011); 78.
[466] Drachman (1932), 93-95; Glicksman (2007), 44-45.
[467] Van Limbergen (2011), 78.
[468] Van Limbergen (2011), 78.

to those of MR 4. Press beds in MR 7 are often circular *opus spicatum* (such as the Kastel Gomilia press Fig. 5.10) like in MR 4, but are more commonly quadrangular stone constructs (Fig. 5.11).[469] The use of both circular tile and quadrangular stone press beds has been identified at a Cervar Porat in MR 7 (Fig. 5.12), suggesting a less standardised pressing process.[470] The vats used in MR 7 are also broadly similar to those used in MR 4, being generally small stone basins, lined with hydraulic mortar.[471] However, there is also evidence for the use of circular stone basins (Fig. 5.13), and again, there is evidence for the use of both at individual sites, although this does not always seem to have been contemporaneous.[472] Additionally, *dolia* were repurposed at Cervar Porat, by being cut in half, as basins for the collection of wine or oil, though this has not been observed anywhere else.[473]

Much like in MR 4, there are few examples of extant olive mills from Istria, particularly given that the evidence generally points to large scale oil production on the western coast of the peninsula.[474] Furthermore, all of these are also *mola olearia*, with the possible exception of one of the *rouleaux et cuves* class from Lakuza (Fig. 5.14).[475] Like in MR 4, no counterweights are known from MR 7, and Matijašić has argued that they were not used in the presses of Istria.[476] Moreover, the *arbores* blocks in MR 4 and 7 are generally all stone, rectangular and with two notches of various sizes and distances apart (Fig. 5.15).[477] Similarly, no remains of the *arbores* themselves have been discovered, and Matijašić argues that they were wooden, like Van Limbergen argues for MR 4.[478] While the situation seems to be quite similar between MR 4 and 7, the presence of *stipites* in Istria suggests that lever and drum, or windlass, presses were used more regularly than the lever and screw presses identified in MR 4.[479] It has traditionally been argued that this form of press was more primitive than the screw press, and that the latter largely superseded the former in later periods. However, Burton and Lewitt have convincingly argued that this was not the case.[480] As such, we should view these as regional differences, rather than evidence for more or less sophisticated wine or oil production techniques.

While there are certainly similarities between pressing installations in MRs 4 and 7, the

[469] Matijašić (1993), 254.
[470] Matijašić (1993), 251-252.
[471] Matijašić (1993), 254.
[472] For example at Barbariga, Matijašić (1993)251.
[473] Matijašić (1993), 252.
[474] Matijašić (1993), 251-253.
[475] Brun (1986), 69-70; Matijašić (1993), 252-254.
[476] Matijašić (1993), 249-252.
[477] Matijašić (1993), 249.
[478] Matijašić (1993), 249, 252, 254.
[479] Kopackova (2014), 77.
[480] Burton and Lewit (2019), 555-556. See also Drachman (1932), 50; Curtis (2001), 386; Thurmond (2016), 160.

variation in pressing installations seems to have been considerably more pronounced in the latter. MR 4 had an earlier Republican tradition of wine pressing that increased in scale and developed over a long period of time, while large scale oil pressing in MR 7 seems to have come about relatively quickly with an influx of wealth and outside influence exploiting the newly available land. Indeed, the explosion of press sites in Istria takes place largely during the 1st century AD, while several press sites from the 2nd and 1st centuries BC are known from MR 4. Furthermore, there would have been a variety for different influences at play during this time in MR 7, including local pre-Roman and Greek traditions of wine pressing (albeit on a smaller scale), as well as the later Italic influence after the Roman conquest. Essentially, in MR 4, we can see the development, from largely local traditions, of large scale wine production from the Republic into the early Empire. In MR 7, a variety of different agents with a variety of different influences actively sought to exploit a promising economic situation as it emerged at the end of the Republic. Both of these situations can be explained through economic specialisation, though of different forms. In MR 4 the scale of wine production expanded and specialised as the demand for wine grew with the incorporation of more territory into the Empire. On the other hand, the active exploitation suggested by the situation in MR 7 would indicate production with specific target markets in mind, and as such, likely specialisation. The evidence for pressing installations across the Dalmatian coast (broadly, MRs 8-20) is quite limited compared to the two micro-regions already discussed. The lack of press sites has been interpreted as indicating lesser production of wine or oil.[481] This is discussed in more detail below, but some general trends can be observed in the pressing installations that have been analysed. *Stipites* are common at most pressing installations, leading to the identification of these presses as lever and drum or windlass, presses like those seen in MR 7.[482] However, the *stipites* are either sunk below the press beds or buried (Fig. 5.16), in a manner that I am unaware of being documented in MR 7.[483] Having raised press beds has caused the press beds to survive in considerably worse condition than those from elsewhere, but those identified seem to have been circular, like those in MR 4.[484] Again, the stone *arbores* base blocks are generally rectangular with two square notches.[485] Like in Istria, it has been argued that the *arbores* must have been wooden, as none survive. However, this has been countered, as wooden *arbores* would not have been suitable for the pressures involved while using these forms of presses.[486] Additionally, of the few olive mills identified, all are again *mola olearia*,

[481] Glicksman (2005), 211; Glicksman (2007), 47. It should be noted that this is based on current archaeological understanding, and Glicksman is clear that this might not be the case with further study.
[482] Glicksman (2007), 44.
[483] Matijašić (1993), 257; Glicksman (2007), 44-45.
[484] See Castel Gomilica and Manastrine, Matijašić (1993), 257-258.
[485] Matijašić (1993), 257.
[486] Drachman (1932), 93-95; Glicksman (2007), 44-45.

with no known use of the *trapetum*.[487] Furthermore, some of the *mola olearia* have a less typical form, with higher sides (Fig. 5.17), possibly indicating a level of variability similar to that observed in MR 7.[488] It does appear that the development of large scale pressing across Dalmatia was closely linked to that in Istria, presumably also a later targeted expansion of production. However, as is discussed, the evidence simply does not suggest that this was ever on the scale that can be observed in MR 7.

It is clear that wine and oil were being produced across MR 5, but the evidence from pressing installations is relatively minimal.[489] It has been suggested that the presses in the area were simply dismantled and repurposed after their use, or that these presses were of a form that are less archaeologically visible.[490] It is possible that the remains have disproportionately been destroyed in MR 5, as the north of Italy is today considerably more densely populated that the central Adriatic coast. Furthermore, it does seem likely that presses in MR 5 were not of the lever and drum or lever and screw found in MRs 4, 7 and across Dalmatia. Often, only the counterweights remain from presses in MR 5, and the evidence for pressing in the Bassano foothills comes entirely from the discovery of such counterweights.[491] This is in stark contrast to everywhere discussed thus far, where no counterweights have been identified. Indeed, a form of wall mounted screw press seems to have been used at a number of sites around Lake Garda, beyond the Adriatic limit of the Plain of the Po.[492] Rather than the screw being fixed to the ground in this arrangement, it is attached to a counterweight and the pressing side of the lever is fixed to a wall (Fig. 5.18).[493] These wall mounted screw presses were less likely to break than screw presses fixed to the ground, but were not capable of generating the same pressure, and so we might expect a reduced scale of production.[494] Busana *et al.* have gone as far as to describe these facilities as being so different '*tali da essere poco riconoscibili*' ('such as to be hardly recognisable').[495] Indeed, while this form of press is documented across the eastern Mediterranean and described in the literary sources, it is largely unknown elsewhere in the Adriatic or Italy.[496] These presses do not require *arbores* to be mounted in support blocks but do require a raised press bed.[497] As such, we might expect the press beds to survive less well, like in Dalmatia.

[487] Matijašić (1993), 258, mentions a possible *rouleaux et cuves* form from Sv. Petar, but this seems to have since been discounted.
[488] Glicksman (2007), 44.
[489] Busana *et al.* (2009), 41.
[490] Busana *et al.* (2009), 41.
[491] See Liverani (1987), 57 for a discussion of this, and note 11 for a bibliographic breakdown of specific sites.
[492] Scagliarini Ćorlaita (1997).
[493] Liverani (1987); See also Ad and Frankel (2012); Burton and Lewit (2019).
[494] Liverani (1987).
[495] Busana *et al.* (2009), 41.
[496] Liverani (1987). For similar wall mounted drum presses identified in Israel, see 'Ad and Frankel (2012).
[497] Burton and Lewit (2019).

Additionally, without *stipites* or *arbores* base blocks, we would be far more reliant on finding counterweights to identify pressing installations in MR 5 than in micro-regions using more conventional pressing techniques. With this, identifying pressing becomes more difficult, even if pressing was fairly prevalent.

The lack of presses in MR 5 has also been explained through the possibility that non-mechanical means were used to produce wine across MR 5. Indeed, at the Mottorana villa, the remains of a large *dolium* embedded into a *cocciopesto* floor have been discovered and Busana suggested that the *cocciopesto* floor was a treading floor, with the grape must being collected in the sunken *dolium*.[498] This single *dolium* in isolation is unlike the concentration of multiple *dolia* found at other sites used for long term storage/fermentation, and so this could very probably be a collection basin, like the *dolia* at Cervar Porat in MR 7.[499] Furthermore, Busana has argued that the similarities between the decorated pressing room at the Joannis villa near Aquileia, where there is rare evidence for two mechanical presses, is very similar to that observed in rooms at the nearby Ambrosan villa, where there is no evidence for mechanical presses.[500] With these similarities, Busana argues that wine was being produced at Ambrosan without a mechanical press, through treading. However, this is far from certain, and while detecting treading archaeologically is more difficult than detecting pressing, the scale of production implied by treading is far smaller than that implied by pressing. Even if the scarcity of press sites in MR 5 is due to the frequent use of treading and wall mounted screw presses, we should expect the capacity of production to be less than in micro-regions where conventional and more productive mechanical presses are found more regularly.

An additional peculiarity in MR 5 is the scarcity of vats or *dolia*. This has been explained by the use of wooden containers. Rather than wine being stored and fermented in *dolia*, perishable above ground containers, such as barrels, were instead used.[501] This could go some way to explaining the limited *dolia* evidence, and there is evidence for such practices in the Celtic tradition of wine pressing and Strabo makes reference to the use of barrels in the area (*Geographica*, 5.1.12).[502] However, there are no actual examples of barrels being used from MR 5. Large scale specialised wine production requires extensive use of *dolia*, as is evidenced in MR 4, and so we would expect a similar quantity of barrels in MR 5. Of course, barrels are perishable where *dolia* are not. Nonetheless, with the

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498 Rossiter (1998), 352; Busana (2003), 118-119; See also Columella, *De re rustica*, 7.18.5; Palladius, *Opus agriculturae*, 1.18; Macrobius, *Saturnalia*, 7.12.15 for some ancient sources on fermenting wine in dolia.
499 Matijašić (1993), 252.
500 For a more in-depth discussion of the Ambrosan villa and these similarities, see Busana (2003), 119.
501 Busana (2003), 119.
502 Baratta (1997), 109-112; Desbat (1997), 113-120; Busana (2003), 119.

particularly ideal conditions for preservation in MR 5 and much of the lagoon landscape northern Adriatic, it is significant that not a single barrel has been identified. This would suggest that the scale of wine production across MR 5 was considerably smaller than in MRs 4 or 7. What is clear, is that the method of wine or oil production in MR 5 was markedly different to that observed elsewhere in the region.

With this general overview of pressing installations, some four distinct Adriatic pressing traditions can be identified. Those of MRs 4, 7 and the Dalmatian coast, share a number of similarities, but can certainly be distinguished from one another. MR 5, on the other hand, is quite different from any of these, despite being physically between these micro-regions. This might suggest that wine and oil production in the Adriatic shared related origins or organisational control, outside of MR 5. MR 5 may have been more influenced by earlier Celtic traditions, while the Latin and Greek traditions of pressing were dominant across the rest of the region, with the variation within Istrian pressing being explained by the relatively diverse agents involved. More than this, it is likely that the purpose of the production differed more between MR 5 and the rest of the region. There may have been closer economic ties between the rest of the region, with the exchange and production of wine and oil being conducted on a highly integrated, specialised basis, with a level of interdependence resulting in similar, but distinct, processes of wine and oil production. On the other hand, wine produced in MR 5 was reserved more for local consumption, particularly given the large urban population of MR 4, or for destinations beyond the Adriatic, such as central Europe and across the Alps, where exchange within the region would have been unnecessary. This combined with earlier Celtic influences, could lead to a deviation from the general processes of pressing observed across the region. This is of course only one explanation for the differences noted between MR 5 and the rest of the region, and it should be noted that no micro-region was monolithic in its pressing traditions. However, looking at this regional scale, it is clear that wine and oil production was organised in a different manner in MR 5, whether this was due cultural, economic or indeed a combination of both factors.

## 5.3 Wine and Oil Micro-Regions of the Adriatic

Beyond general typologies, closer analysis of the distribution of oil and wine production sites across the region allows for a deeper understanding of how this production may have been organised. The sites discussed in this section can be broken down into two main categories: villa sites and non-villa rural sites. Villa sites are those which have evidence for complex architecture, particularly domestically focused, such as decorative mosaics or wall decorations, peristyle courtyards or bath complexes. Some villa sites and some non-villa rural sites are also press sites, and while all press sites have evidence for wine or oil production, not all villa or non-villa rural sites do (see Fig. 5.19). In order for a site to be designated as producing wine or oil, it must have evidence for any of the first three processes in Fig. 5.1. However, not all sites with evidence for wine or oil production have extant presses: a press is an indication of wine or oil production, whereas the presence of *dolia*, for example, indicates likely wine production but was not necessarily a press site. The data for non-villa rural sites comes almost exclusively from the database provide by the Croatian Archaeological Sites website. As such, comparison between Croatia and other modern Adriatic countries is not possible for this category, and the focus is on villa and press sites. Fig. 5.20 offers a general overview of the site distribution, with Appendix G providing some brief detail on each specific site.[503] A total of 419 sites were considered across the micro-regions. 121 can be thought of as villa sites, 41 (34%) of which have evidence for wine or oil production. The remaining 298 are non-villa rural sites (only 53 of these are in Italy), 87 (29%) of which have evidence for wine or oil production. Of the 66 press sites, 25 (38%) are villas and 41 (62%) non-villas. The non-villa rural sites with no evidence for wine or oil production are discussed for MRs 10 and 13 below. Very few of the sites producing wine or oil, with or without presses, can definitively be shown to have been producing specifically wine or oil. 48 sites having likely evidence for wine production and 36 for oil, though the majority of these are far from definitive. Only one micro-region, MR 8, has no evidence for a site of any category, while an additional four, MRs 6, 9, 11 and 16, have no evidence for wine or oil production. This, of course, does not mean that no wine or oil was being produced in these micro-regions, and the evidence for *amphorae* production in MR 6 suggests involvement in the quaternary process at least. Indeed, it must be emphasised that this data cannot be a complete account of all sites in the region, and for no individual micro-region should it be assumed that all of the sites producing wine or oil, even with presses, have been identified. What this section does provide is an analysis of the distribution and breakdown of some sites in each micro-region, with reference to specific sites as well as a discussion of how far the evidence for production does and does not line up with the ecological, urban and CT data discussed above. All of this points to specific examples of micro-regional economic specialisation, suggestive of a high degree of market integration across the wider region.

### 5.3.1- Southern Adriatic Italy (MRs 1, 2 and 3)

There are a fairly limited number of extant villa sites across the south of the region (Fig. 5.21 and Table 5.2). Both Posta Crusta in MR 2 and Santa Maria di Merino in MR 3 have been identified as

[503] This image provides a general overview, but more detailed images are provided throughout, as micro-regions are discussed individually.

sites pressing oil, though both also have *dolia*.[504] It has been argued that oil was being produced at Santa Maria di Merino as the dimensions of the estate and vat seem to line up with Cato's description of an oilery, though Volpe has acknowledged that this does not exclude wine production.[505] Indeed, the large quantity of *dolia* suggest that wine production was also being carried out on the site. Whether this was purely for fermentation, or if grapes were also pressed on site is unclear, but the production of both oil and wine on site is very likely. The site plans of Posta Crusta show what is clearly a press bed with a channel leading to a vat (Fig. 5.22), although the documentation does not mention a press. It is unclear exactly why Posta Crusta has been identified as oil production, but the presence of *dolia* again suggests wine production of some scale. It is similarly unclear exactly why La Minoia and Agnuli in MRs 1 and 2 respectively have been identified as oil producing complexes, though, there is a long tradition of oil production in the area, and so these sites likely were producing oil on some scale.[506] On the other hand, the San Giusto villa has been excavated and documented quite extensively, and so the evidence for wine production here is quite convincing, though this was primarily undertaken in Late Antiquity.[507] Indeed, there is a significant amount of evidence for intensive oil production across these micro-regions in Late Antiquity, though it is unclear the extent to which this was the case during the early Empire.[508]

**Table 5.2- Sites of Southern Adriatic Italy (MRs 1, 2 and 3).**

*These are the main rural sites across MRs 1, 2 and 3, with relatively limited evidence for wine or oil production on a signifcant scale.*

| Site | Oil or Wine | Presses | MR |
|---|---|---|---|
| **Porto Saturo** | Neither | 0 | 1 |
| **Gravina di Puglia/Vagnari** | Wine | 0 | 1 |
| **La Minoia** | Oil | 0 | 1 |
| **Posta Crusta** | Either | 1 | 2 |
| **Faragola** | Neither | 0 | 2 |
| **Agnuli** | Oil | 0 | 2 |
| **San Giusto** | Wine | 1 | 2 |
| **Piano di Carpino** | Neither | 0 | 3 |
| **Santa Maria di Merino** | Either | 1 | 3 |

It is unlikely that there was large scale specialised wine or oil production being undertaken

[504] See Gliozzo *et al.* (2010), 176; For Posta Crusta see Volpe (1990), 198-200; or for Santa Maria di Merino, Goffredo *et al.* (2013).
[505] Volpe (1990), 198.
[506] Volpe (1996); Caracuta and Fiorentino (2009), 374.
[507] Volpe (2002).
[508] See Volpe (2002), especially 319.

in MRs 2 or 3 during the early Empire. Both are better suited to pastoralism (Table 2.2), particularly MR 3, where vines and olives would have been relatively difficult to cultivate. Posta Crusta lies in the hinterland of Herdoniae, and so it is likely that the wine and/or oil produced at this site was primarily intended to fulfil the requirements of the nearby urban population, rather than exporting beyond the micro-region. Santa Maria di Merino, on the other hand, is some distance form any of the urban centres of MR 3. However, it is on the northern coast of the Gargano peninsula. This site was well placed to capitalise on the low cost transport afforded by the Adriatic. It is likely that this site is an example of the adverse ecological conditions being overcome by the particularly high degree of potential connectivity that maritime transport provides. Producing oil or wine in these relatively difficult circumstances was worth the effort due to the ease with which the commodities could be exported to markets where they were needed. This clearly was not the case for much of this mountainous micro-region. Ultimately, while wine and oil were clearly produced in MRs 2 and 3, likely for export to the wider region in the case of Santa Maria di Merino, the archaeological evidence simply does not suggest that wine or oil was a specialised product in either micro-region. The proximity to MRs 1 and 4, which were highly suitable for wine and oil production, would have given these micro-regions comparative advantages in different agricultural pursuits, particularly those related to pastoralism. This certainly suggests some involvement in the wider economy, but wine and oil would likely have been imports more often than exports.

MR 1 is slightly different, being well suited to the cultivation of vines in particular. Two sites here have evidence for wine and oil production respectively, which is not particularly strong evidence for large scale production, and neither have presses. While much of this production may have been going to the urban markets of MR 1, it is clear that there was an excess of suitable agricultural land across the micro-region, so a surplus for export would certainly have been possible. That being said, the evidence for this being capitalised on is minimal, perhaps indicating that the need for imports elsewhere in the wider region were met by production and export in other micro-regions, or indeed beyond the Adriatic.

### 5.3.2- The Central Italian Adriatic (MR 4)

In recent years, MR 4 has become a relatively well-studied area of the Adriatic. The archaeological evidence for wine and oil production is quite robust (Fig. 5.23 and Table 5.3). Almost all of the villa sites have evidence for wine and/or oil production as well as presses. This is one of the largest concentrations of wine and oil production sites in any micro-region, though the majority (73%) of sites have evidence for only one press, and only two have more than two presses. Cupra Maritima

San Michele likely had three separate presses, with three individual *arbores* base blocks having been identified.[509] Monte Torto di Osimo certainly had four presses, with four *opus spicatum* press beds and four blocks for mounting the *arbores*.[510] With this alone, it is difficult to argue that large scale wine or oil production was not being carried out in MR 4.

The distribution of these sites further suggests large scale specialised wine or oil production. The sites are generally in the north and central portion of the micro-region, though this is possibly due to research bias, as the main source from this region comes from Van Limbergen's work, which generally does not consider the southern extreme towards MRs 2 and 3. However, the press sites are distributed quite evenly between the coast and the interior of the micro-region, with Monte Torto di Osimo being in the interior and Cupra Maritima San Michele on the coast. This contrasts with the kiln evidence discussed above, with all of these being coastal. Additionally, both kiln and press sites are located along the various river systems of the micro-region.[511] This all suggests that wine or oil was being produced across the micro-region and sent down the river networks to coastal bottling sites where they would presumably have been exported across the Adriatic. This certainly suggests that wine and oil production was on a large scale with specific export markets in mind, pointing to specialised production and a high degree of wider market integration and economic cohesion.

The relationship between press sites and urban centres in MR 4 can offer further insight. Other than a single press found along the limit of the city walls of Potentia, none of the pressing installations are urban; they are instead concentrated in the hinterlands of the urban centres.[512] This is in contrast to the likes of Istria where pressing installations are found in both rural and urban centres across the peninsula.[513] This could suggest that the urban centres of MR 4 were not integral to the wine and oil production of the area, rather, they acted primarily as consumers of wine and oil. However, this would be an over-simplification. The hillier interior along the waterways of MR 4 is more suitable for vine and olive cultivation than the coast. Indeed, a majority of press sites in the MR 4 are found along these fertile waterways, often in the interior. More convincingly, while there is limited evidence for urban centres being involved in the secondary process of pressing, it is clear that the bottling process was often undertaken, and at considerable scales, in and around the urban centres. Seven extant kilns have been identified at each of the urban centres of Firmum and Potentia. As such, it appears

[509] Ciarrocchi (1999), 53-56; Van Limbergen (2011), 88.
[510] Hägglund (1995); Pignocchi (2001); Van Limbergen (2011).
[511] These systems are discussed in detail in Chapter 5.
[512] Van Limbergen (2011), 76.
[513] Matijašić (2007b), 13; Rendina (2018), 54.

**Table 5.3- Sites of Central Adriatic Italy (MR 4).**

*These are the main rural sites across MR 4, primarily derived from the work of Van Limbergen (2011).*

| Site | Oil or Wine | Presses |
|---|---|---|
| **Fano Contrada S. Cristina** | Either | 0 |
| **Cesano di Senigallia** | Either | 2 |
| **Jesi Villa Romagnola** | Either | 1 |
| **Gallignano di Ancona** | Either | 1 |
| **Monte Torto di Osimo** | Either | 4 |
| **Castelfidardo** | Either | 1 |
| **Potentia** | Either | 1 |
| **Chiarino di Recanati** | Either | 2 |
| **Cingoli Moscosi** | Either | 1 |
| **Cingoli Piano San Martino** | Either | 1 |
| **Fermo San Salvatore** | Either | 2 |
| **Monterubbiano (Montegiorgio?) S. Gregorio** | Either | 1 |
| **Moresco Valdaso** | Either | 2 |
| **Massignano San Giuliana** | Either | 1 |
| **Cupra Marittima Bocca Bianca** | Either | 1 |
| **Cupra Marittima S. Basso** | Either | 1 |
| **Cupra Marittima San Michele** | Either | 3 |
| **Ripatransone Castelluccio** | Either | 2 |
| **Offida San Giovanni** | Either | 1 |
| **S. Benedetto Porto d'Ascoli** | Either | 1 |
| **Tortoreto Case Ozzi** | Either | 1 |
| **Castrum Novum Via Turati** | Either | 0 |
| **Castelnuovo Vomano** | Either | 1 |
| **Piano della Monaca** | Either | 1 |
| **Montorio Brecciano** | Either | 1 |
| **Colombarone** | Neither | 0 |
| **Fermo Villa Vitali** | Oil | 1 |
| **Fermo Penna San Giovanni** | Oil | 1 |
| **Colombara di Acqualagna** | Wine | 1 |
| **Ripe San Pellegrino** | Wine | 1 |
| **Pollenza Santa Lucia** | Wine | 1 |
| **Grottzzolina** | Wine | 1 |
| **Tortoreto Muracche** | Wine | 2 |

that it was more efficient to process the olives and grapes in the interior hinterlands of MR 4, where the crops could be more efficiently cultivated, before sending them to coastal sites where they could be consumed, as well as bottled and sent for wider export. In MR 4, we have evidence for the primary, secondary and tertiary processes being undertaken in the interior, with the quaternary process and export being conducted at the coast, often in and from urban centres. This division of labour is indicative of specialisation within the micro-region, and of coastal urban centres acting as points of redistribution, engaging directly with the wider economy as an interdependent, cohesive whole.

A closer look at some individual pressing installations in MR 4 can help to clarify whether it was more likely that wine or oil was produced at the site. The clearest way to differentiate between the two is the presence of an olive mill used during the pressing process. This indicates that oil was definitely produced on site, but does not necessarily show that wine was not being produced. Similarly, *dolia* are likely indicators for wine production, but again their presence does not discount the possibility of oil production. Only four sites have clear evidence for olive mills in MR 4, two of which have evidence for more than one press. At Fermo Villa Vitali and Fermo Penna San Giovanni, the only evidence for pressing installations comes from the olive mills themselves, making it likely that only oil was being produced. However, further investigation may reveal evidence for additional presses or possible wine production. While the olive mills at Fermo Villa Vitali and Fermo Penna San Giovanni are complete, the remaining two mills discovered in MR 4 are fragmentary.[514] At Moresco Valdaso, two press blocks were also discovered, suggesting that there were at least two presses, and so wine and oil production is entirely possible, though it is more likely to have been solely oil production, given the lack of a treading floor or *dolia*. Monte Torto di Osimo, on the other hand, has evidence for four presses, with only one olive mill and more than 20 *dolia*.[515] In this case, it is most likely that both wine and oil production was being undertaken. However, it is unclear whether this was contemporary and how the presses would have been divided between the two productions if so. Nevertheless, it is significant that of the identified sites in MR 4, the site with the evidence for the largest scale production also has evidence for the production of both wine and oil. Van Limbergen suggests that his data in 2011 showed that 12% of sites had definite evidence for mainly wine production and 23% had the same for oil production and the remaining 65% of sites were unclear.[516] This clearly emphasises the difficulty in differentiating wine and oil production from one another. While Van Limbergen is quite right in that we cannot be certain about this remaining 65%, I would argue that much of it would likely have been wine production in this specific case. Definitive evidence for oil production is more readily available than for wine, though, of course, neither are particularly common.[517] However, some 29% of sites have *dolia*, all but two of which had more than one.[518] It is

[514] Van Limbergen (2011), 75.
[515] Pignocchi (2001); Van Limbergen (2011), 88.
[516] Van Limbergen (2011), 85.
[517] Van Limbergen (2011), 87. While the wider conclusions drawn are broadly in line, it should be noted that Van Limbergen does not regard *dolia* as definitive evidence for wine production in this breakdown. Additionally, *dolia* are regarded as evidence for the pressing of wine or oil, while in my data, *dolia* indicate wine production, but not necessarily pressing.
[518] See Van Limbergen (2011), Appendix 1.

very likely that wine was being produced at these sites, though not necessarily exclusively. As such, there does not seem to be a great difference between the identified wine or oil production sites. Indeed, I would argue that only at two sites (7%) is there definite evidence for oil production. On the other hand, five sites (17%) have similar evidence for wine production, in the form of *dolia* and/or treading floors. Additionally, if we consider the ancient sources and the *amphorae* evidence discussed above, it is clear that wine from MR 4 was better known than oil, and that *amphorae* production was mainly for wine transport vessels. While oil was undoubtedly being produced in considerable quantities in MR 4, the bulk of the produce being produced for export beyond the micro-region was likely wine.

The evidence for MR 4 as a major wine or oil producer makes sense ecologically. MR 4 is one of the micro-regions best suited to wine or oil production. The micro-regions to the north and south (MRs 2, 3 and 5) as well as across the sea (MR 10), are better suited to grain production or pastoralism. As such, MR 4 would not only have an absolute advantage in wine or oil production, but this would have given the neighbouring micro-regions comparative advantages in alternative production activities. At this stage, it can be suggested that MR 4 was one of the major producers of wine in the wider Adriatic region, but that considerable quantities of oil were also produced. Exactly where these products were ultimately exported to, within or beyond the Adriatic, is the subject of subsequent chapters. Though the evidence already seems to point to specialised wine production in MR 4, with the dense urban population being supplied with grain from much of the northern Adriatic and the Central Dalmatian coast at MR 10, where there was an excess of suitable land.

### 5.3.3- The Plain of the Po and Trieste (MRs 5 and 6)

MR 5 is the largest single Adriatic micro-region, yet, across MRs 5 and 6 there are only eleven villa sites four of which have evidence for wine or oil production (Fig. 5.24 and Table 5.4). The site in the Bassano foothills, in the north of the micro-region, has only been identified through the presence of counterweights, not *in situ*.[519] This suggests there was a site nearby with multiple presses, or multiple sites with single presses in the area. The other two press sites, the Joannis villa and the Villa della Punta, both show somewhat clearer evidence. Wine was being pressed using two presses at the Joannis villa, and an olive mill was discovered at Villa della Punta, indicating oil production and likely pressing.[520] Additionally, *dolia* discovered at Enel suggest likely wine production.[521] There is only one

[519] Liverani (1987), 57.
[520] Strazzulla Rusconi (1979); Busana (2003), 119; Goffredo *et al.* (2013); Busana *et al.* (2009), 29.
[521] Goffredo *et al.* (2013).

villa site in MR 6, Via Colombo, and it does not have any evidence for wine or oil production. This is not particularly convincing evidence for widespread wine or oil production in either MR 5 or 6. This could be due to archaeological issues and the different pressing process discussed above. However, the lack of presses can be more convincingly explained through an ecological and economic model. First of all, MR 5 is not especially well suited to vine or olive cultivation. More than this, it is very close to MRs 4 and 7, which are ecologically very well suited to vine and olive cultivation. Being less well suited to vine and olive cultivation than the immediate neighbouring micro-regions gives an absolute advantage in wine and oil production to these other micro-regions. Furthermore, the flat expanse of the Plain of the Po is very well suited to the cultivation of grains, as the ancient sources discussed above attest to, and the foothills, the areas best suited to vine and olive cultivation, would have been ideal pasture land. Indeed, the ancient sources also discuss excellent wool from Patavium, Altinum and Mutina (Strabo, *Geographica*, 5.1.12; Pliny, *Naturalis Historia*, 32.11; Martial, *Epigraphs*, 14.155). A comparative advantage for the cultivation of grains and possibly pastoralism in MR 5 is likely. MR 6 is somewhat more problematic, as it is well suited to vine and olive cultivation. However, this might be explained by the proximity to MR 7, which is the best suited to this production anywhere in the region. Moreover, the hills of MR 6 are particularly well suited to pastoralism, more so than vines of olives, and the archaeological evidence points to the area being used by shepherds and for transhumance from the prehistoric period onwards.[522] On top of all of this, the CT analysis of Chapter 3 suggests that the area around MR 6 was an area of particularly high potential mobility and connectivity. Placing this micro-region in a particularly good position to access wider regional, and indeed, extra-regional commodities. As such, it appears that MR 6 would have a comparative advantage engaging in pastoralism, and an absolute *dis*advantage for wine and oil production, despite its suitability, as compared to MR 7. All of this, even accounting for the archaeological biases, suggests that MRs 5 and 6 would not have been specialised producers of wine or oil, but were integral components of a wider economic system.

[522] Boschian and Montagnari-Kokelj (2000), 347-350.

**Table 5.4- Sites of The Northern Adriatic (MRs 5 and 6).**

*These are the main rural sites across MRs 5 and 6, with very limited evidence for large scale pressing.*

| Site | Oil or Wine | Presses | MR |
|---|---|---|---|
| **Carlino Chiamana** | Neither | 0 | 5 |
| **Pradamano** | Neither | 0 | 5 |
| **Carlino Planais** | Neither | 0 | 5 |
| **Pavia** | Neither | 0 | 5 |
| **Mandrie** | Neither | 0 | 5 |
| **Tavolini Villas** | Neither | 0 | 5 |
| **Villa della Punta** | Oil | 1 | 5 |
| **Bassano Foothills** | Oil | 2 | 5 |
| **Joannis** | Wine | 2 | 5 |
| **Enel** | Wine | 0 | 5 |
| **Via Colombo** | Neither | 0 | 6 |

### 5.3.4- Istria (MRs 7 and 8)

In MR 7 there are at least 45 identified sites, 23 of which have evidence for wine or oil production, and 15 have presses (Fig. 5.25 Table 5.5).[523] Seven of the press sites have a single press, five have two presses and the remaining three have more than two presses, with two having more than four. This makes MR 7 the most abundant micro-region in terms of evidence for wine and oil production, despite being around 10% the size of MR 5 and less than 15% of MR 4. The vast majority of all sites are coastal, and generally cluster around the southern half. However, there are two sites with convincing evidence for wine or oil production north of Parentium, Sv. Ivan Kornetski and Červar Porat. No extant press has been discovered at Sv. Ivan Kornetski, but there is an olive mill, showing that oil was produced and likely pressed on site. The site also had a small associated port and limestone quarry.[524] Additionally, a press and olive mill have been identified at Červar Porat, again indicating that oil was pressed here.[525] Červar Porat is further significant due to the kiln discovered and the excellent natural harbour it had access to.[526] Indeed, the major Istrian *amphorae* production centre at Loron was within 1 km of Červar Porat, and seems to have been incorporated into the site from around AD 10.[527] Even in this less densely clustered area of MR 7, there is clear evidence for large scale oil production and export beyond the requirements of the micro-region.

[523] Matijašić (1993), 248, 255; Rendina (2018), 24.
[524] 'IARH' website http://baza.iarh.hr/public/locality/detail/5197 (accessed 10/09/20).
[525] 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).
[526] Jurkić-Girardi (1979); Rendina (2018), 43.
[527] Auriemma (2015), 479; Rendina (2018), 78

**Table 5.5- Sites of Istria (MR 7).**

*These are the main rural sites across MR 7, with some of the largest sites, in terms of presses and overall production, anywhere in the region.*

| Site | Oil or Wine | Presses |
|---|---|---|
| **Mala Vala** | Either | 2 |
| **Kolci** | Either | 4 |
| **Val Madonna** | Either | 6 |
| **Uvala Verige** | Either | 2 |
| **Busuja** | Either | 1 |
| **Valkanela** | Either | 2 |
| **Uvala Lešo** | Either | 1 |
| **Škicini** | Either | 0 |
| **Zambratija** | Neither | 0 |
| **Katoro - rt Tiola** | Neither | 0 |
| **Sv.Jelena** | Neither | 0 |
| **Karpinjan** | Neither | 0 |
| **Santa Marina** | Neither | 0 |
| **Brestić-Višnjan** | Neither | 0 |
| **Bačva** | Neither | 0 |
| **Vrsar** | Neither | 0 |
| **Monte Ricco** | Neither | 0 |
| **Dragonera South 2** | Neither | 0 |
| **Krvavići - Boškina** | Neither | 0 |
| **Valbandon** | Neither | 0 |
| **Pomer** | Neither | 0 |
| **Vižula** | Neither | 0 |
| **Kuje** | Neither | 0 |
| **Tar - Stancija Blek** | Neither | 0 |
| **Dolzan** | Neither | 0 |
| **Labinci** | Neither | 0 |
| **Sorno** | Neither | 0 |
| **Monbrodo** | Neither | 0 |
| **Šijana** | Neither | 0 |
| **Burle** | Neither | 0 |
| **Sv. Ivan Kornetski** | Oil | 0 |
| **Červar Porat** | Oil | 1 |
| **Uvala Vestar** | Oil | 1 |
| **Uvala Marić** | Oil | 0 |
| **Dragonera South 1** | Oil | 0 |
| **Dragonera North** | Oil | 0 |
| **Stancija Peličeti** | Oil | 0 |
| **Sv. Pavao** | Oil | 2 |
| **Betiga** | Oil | 1 |
| **Šaraja** | Oil | 1 |
| **Barbariga** | Oil | 8 |
| **Umag** | Oil | 0 |

| Site | Oil or Wine | Presses |
|---|---|---|
| **Čubani** | Oil | 2 |
| **Valencan** | Oil | 1 |
| **Sv. Elizej** | Wine | 0 |

The most impressive cluster of wine and oil production sites in MR 7 can be found south of Parentium, just north of Pola. This might be due to the intense survey around Pola, but examination of the sites themselves suggests particularly large scale production. Furthermore, within a few kilometres of Pola the second major Dressel 6B production centre in Istria, Fažana, can be found. Some 12 sites around Pola and Fažana, including those on the island of Brijuni, have evidence for wine and oil production. Of these 12, only two do not have definitive evidence for presses. At Dragonera South 1 the earlier masonry was re-purposed as *arbores* base blocks for four presses in Late Antiquity (Fig. 5.26). However, the fragments of olive mills and the 1st century AD phasing of the site suggest oil production on some scale during the early Empire, whether this used presses or not, is impossible to tell.[528] At the roughly contemporaneous Dragonera North, oil production seems to have been a major economic activity at the site into the 4th century AD. This is evidenced by separation vats, though no extant press beds have been discovered.[529] Both of these sites are coastal, with associated pier facilities and with evidence for large quantities of *amphorae*, particularly Dressel 6B.[530] More convincingly, at Šaraja and Uvala Veštar, there is evidence for single presses. The press at Šaraja is attached to a settling tank, and so was likely related to oil production.[531] At Uvala Veštar, it is unclear if this press was for oil or wine production, but a pier was built next to the site, with a likely shipwreck discovered off the coast, with a cargo consisting mainly of Dressel 6B oil *amphorae*.[532] If this shipwreck was associated with Uvala Veštar, oil production seems likely. However, it is unclear whether the oil pressing occurred before the 4th century AD. Three production sites around Pola have likely evidence for two presses. Sv. Pavao and Betiga have not been excavated, but the surface remains of *arbores* bases indicate multiple presses at both, it is unclear whether wine or oil was produced at either.[533] At Mala Vala, two separate production lines for wine and oil were discovered. It is unclear exactly why wine production has been suggested at this site, as an olive mill was discovered, though there is nothing to suggest that both could not have been produced.[534] The

[528] Kopackova (2014); Starac (2010); Starac (2012).
[529] 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).
[530]'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).
[531] 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).
[532] 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).
[533] Matijašić (1994), 49-50; Busana *et al.* (2009), 43.
[534] 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).

evidence from these seven sites indicates large scale specialised wine or, more likely, oil production and export. However, the majority of sites in MR 7 have evidence for considerably larger scales of production.

The remaining four production sites have between four and as many as 28 presses. Three sites are on Brijuni, Kolci, Val Madonna and Uvala Verige, the fourth being Barbariga. At Kolci, four separate presses have been identified (See room 5 in Fig. 5.27), as well as a storage room with capacity for some 100 *dolia defossa*.[535] It had originally been thought that oil was being produced in this villa, but Brun later argued this was more typical of wine production and Shrunk and Begović suggested the initial production of oil was later changed to wine, or wine and oil.[536] Given the quantity of *dolia*, it does seem unlikely that no wine was being produced, though there is nothing that would suggest oil could not have been produced using at least one of the presses. At Val Madonna there are six separate presses built in two distinct phases (See rooms G (earlier) and J (later) in Fig. 5.28). The first three (B) appear to have been for wine production, as they are connected to some 56 *dolia defossa* (only 21 remain across rooms F and D).[537] The third phase of construction, during the later 1$^{st}$ century AD, involved a considerable expansion with the addition of three olive presses (G).[538] It is unclear exactly why these have been designated olive presses, though Matijašić does mention carbonised olive pits, so if these pits are associated with the later phase, oil production is likely.[539] In any case, there were at least six presses at this later phase of the site at Val Madonna. Uvala Verige has evidence for at least one press during its earliest phase, but through a series of expansions into the 1st century AD, some four contemporaneous presses have been identified (Fig. 5.29).[540] No oil mills have been discovered, though a treading floor along with nine sunken *dolia*, with room for a total of 60, suggests that wine was certainly being produced. The Barbariga complex of MR 7 had a truly huge capacity for wine or oil production. It was once thought to have had some 20 separate presses, arranged in two parallel magazines, but there is space for 14 pairs (Fig. 5.30).[541] This has since been questioned, but it seems there must have been at least eight presses.[542] Drainage channels led to two separate spaces, one with a simple single reservoir, the second to a series of rectangular vats as well as large stone circular receptacles, which appear to belong to an earlier

[535] Schrunk and Begović (2000), 265.
[536] Brun (1993), 533; Schrunk and Begović (2000), 265.
[537] Bezeczky and Pavletié (1996), 151; Schrunk and Begović (2000), 268; Begović and Schrunk (2010).
[538] Schrunk and Begović (2000), 256.
[539] Matijašić (1993), 252.
[540] De Franceschini (1998), 668; Schrunk and Begović (2000), 261-263; Rendina (2018), 58.
[541] Matijašić (1993), 251; Rendina (2018), 60.
[542] Mlakar (1966), 65; Matijašić (1994), 59-60; Matijašić (1998), 188-192; Busana *et al.* (2009), 43.

phase.[543] An olive mill was found at the site, and it has been argued that this must show oil production.[544] Certainly oil production was carried out on a huge scale here. However, without the discovery of a storage room and possible associated *dolia*, it cannot be confirmed whether or not wine was also being produced on site.[545] Barbariga represents the single largest scale production of wine or oil anywhere in the Adriatic, and if there were indeed 28 total presses, this would be more presses at a single site than have been identified at many entire micro-regions in total. The scale of this is particularly significant given that this micro-region contains the largest concentration of wine or oil producing sites, regardless of total press count, in the entire region.

Given the ecology of MR 7 and the neighbouring micro-regions, the scale of production evidenced across the micro-region is not necessarily surprising. The western coast of Istria is the best suited, ecologically, to vine and olive cultivation of any in the region. To the north-west, MRs 5 and 6 are better suited to pastoralism and grain cultivation. To the east, where no known villa sites have been identified, MR 8 is particularly ill-suited to the cultivation of vines or olives. Indeed, the mountainous terrain of MR 8 was better suited to pastoralism and the area has had plentiful oak and ash forests since before the Roman period.[546] Neither pastoralism nor forestry leave particularly clear archaeological traces, and so the lack of sites in MR 8 is similarly unsurprising. It seems quite certain that MR 7 would have had an absolute, as well as a comparative, advantage for wine and oil production.

Comparing the organisation of presses in MR 7 to that of MR 4, can offer some insight into how the process of production and exchange might have manifested itself in MR 7. There is only one urban press in MR 4, as has been discussed. On the other hand, every urban centre in MR 7 has evidence for pressing facilities of some form.[547] Additionally, the coast of MR 4 is less suitable for vine or olive cultivation than the interior; in MR 7, the coast is at least as suitable as the interior. Indeed, the lack of urban presses in MR 4 might be due to needing to concentrate the primary and secondary processes of wine and oil production in the fertile interior, while the bottling could be conducted at the coast, where most of the urban centres are located and cheaper export across the sea can be exploited. On the other hand, with the western coast of Istria being so suitable for vine and olive cultivation, there was less need to have pressing sites concentrated further inland away from coastal urban centres where wider redistribution could more readily be conducted. Indeed, the two main

[543] Matijašić (1993); De Franceschini (1998), 616.
[544] Matijašić (1993); De Franceschini (1998), 616; Rendina (2018), 60.
[545] Matijašić (1993), 251-252.
[546] Bragato *et al.* (2004), 172; Frangeš (2010), 13-14.
[547] Rendina (2018), 54; Busana *et al.* (2009), 45.

*amphorae* production sites in Istria, Loron and Fažana, are coastal and within 15 km of major urban centres, Parentium and Pola respectively. Both are surrounded by press sites. It is clear from the archaeological evidence discussed here, that that MR 7 was very well placed to specialise in large scale wine and, especially, oil production. The scale of this production suggests a highly integrated regional economy, in which MR 7 played a major and likely specialised role.

### 5.3.5- The Dinaric Coasts (MRs 9, 14 and 16)

Though the northern, central and southern Dinaric coasts are all separated by intervening micro-regions, they are very similar in terms of ecology as well as evidence for wine and oil production. There are some 30 rural sites across all of these micro-regions, including three on the Pelješac peninsula (Fig. 5.31 and Table 5.6). However, only one of these sites has any evidence for wine or oil production, Podstrana 2 at the northern limit of MR 14. It is likely that the majority of villa sites across these micro-regions were maritime villas, with limited productive elements, largely supplying local domestic markets and functioning as places of *otium*. Podstrana 2 has evidence for a single press and a hypocaust system. Indeed, the vast majority of sites on the Balkan coast have evidence for only single presses, and none have more than two.[548] It is unclear whether wine or oil was being produced at Podstrana 2, or exactly when this production was being undertaken. There is late antique and medieval construction on the site, but ceramic evidence shows earlier Roman activity.[549] Nevertheless, this is the most convincing evidence for large scale wine or oil production anywhere in MRs 9, 14 or 16. This is not surprising, these three micro-regions have some of the lowest suitability for vine and olive cultivation anywhere in the region. On top of this, all of these micro-regions are bordered by micro-regions far better suited to agricultural production, with pastoralism being the most viable agricultural pursuit across these three. Notably, Podstrana 2 is located in some of the more suitable land anywhere in these micro-regions, and very close to the urban populations of MR 12 and Salona in particular. It seems very likely that the majority of the wine or oil produced at Podstrana 2 would have been intended for these urban markets. Furthermore, Podstrana 2 is on the coast, allowing more efficient transport. Similarly, all of the urban centres of these micro-regions are coastal, presumably reliant on imports to maintain their populations. That being said, they were all surely at the lower end of the population scale, with only one having a known size. Tarsatica, MR 9, is 9 ha, and so likely had a population of around 900. The remainder all have unknown sizes and are unlikely to have had populations much more than this. What all of this suggests of these three micro-

[548] Matijašić (1993), 255; Glicksman (2005), 210.
[549] Oreb (1999), 447.

regions, is that there was very limited large scale wine or oil production being undertaken. The wine or oil that was produced on a large scale, would likely have been intended for the relatively small local urban markets, all of which were coastal. Any integration these micro-regions had with the wider economy would be dependent on exporting goods from the interior in exchange for commodities, such as wine and oil, from across the sea. These micro-regions are unlikely to have been the focus of any specialised production, but, as is discussed below, likely played an important role in the regional economy, as the earlier CT analysis suggested of MR 9.

**Table 5.6- Sites of the Dinaric Coasts (MRs 9, 14 and 16).**

*These are the main rural sites across MRs 9, 14 and 16. Only one of the 30 sites has any evidence for wine or oil production.*

| Site | Oil or Wine | Presses | MR |
|---|---|---|---|
| **Havišće** | Neither | 0 | 9 |
| **Selce** | Neither | 0 | 9 |
| **Solin** | Neither | 0 | 9 |
| **Kloštar** | Neither | 0 | 9 |
| **Spasovac** | Neither | 0 | 9 |
| **Starigrad** | Neither | 0 | 9 |
| **Hreljin** | Neither | 0 | 9 |
| **the cave of Škrbina** | Neither | 0 | 9 |
| **Sopaljska gradina** | Neither | 0 | 9 |
| **Belgrad** | Neither | 0 | 9 |
| **Grižane** | Neither | 0 | 9 |
| **Godać** | Neither | 0 | 9 |
| **Podskoć�i** | Neither | 0 | 9 |
| **Bribir** | Neither | 0 | 9 |
| **Humac** | Neither | 0 | 9 |
| **Novi Vinodolski** | Neither | 0 | 9 |
| **Sv.Marin** | Neither | 0 | 9 |
| **Podstrana 2** | Either | 1 | 14 |
| **Gospe u Siti** | Neither | 0 | 14 |
| **Tugare** | Neither | 0 | 14 |
| **Zađe** | Neither | 0 | 14 |
| **Podstrana 1** | Neither | 0 | 14 |
| **Stonsko polje Bare** | Neither | 0 | 16 |
| **Sreser** | Neither | 0 | 16 |
| **Rat** | Neither | 0 | 16 |
| **Gruda u Zagrudi** | Neither | 0 | 16 |
| **Sustjepan-Cavtat** | Neither | 0 | 16 |
| **Donji Obod** | Neither | 0 | 16 |
| **Tiha** | Neither | 0 | 16 |
| **Metale** | Neither | 0 | 16 |

### 5.3.6- Zadar County (MR 10)

There are strikingly few sites with evidence for wine or oil production in MR 10, considering it is the sixth largest of any of the micro-regions. Only one site in particular has evidence for wine or oil production, Danilo 1 at the southern extreme of the micro-region (Fig. 5.32 Table 5.7). A vat was discovered and identified as a grape pressing vat (‘*bazen za tiještenje grožđa’*), though it is unclear exactly why.[550] Danilo 1 is located in the hinterlands of an urban centre, Rider. It is very likely that any wine, or oil, being produced here would have been destined for consumption at this nearby city.

The lack of evidence for wine production in MR 10 is somewhat more complicated to explain than that in MRs 9, 14 and 16. For one, MR 10 is amongst the most suitable for vine or olive cultivation anywhere in the Adriatic, with only MR 7 being more suitable for both, and with the second largest excess of suitable agricultural land after MR 1. Additionally, unlike MR 9, 14 and 6, MR 10 has two sizeable urban centres, at Iader (2,600) and Aenona (1,600), as well as a large number of smaller centres. MR 10 was well suited ecologically and, given the level of urbanisation, economically to the production of wine and oil. Therefore, the lack of wine or oil production must be explained through other means. The modern situation, as compared to micro-regions discussed thus far, affects the archaeological data. This large micro-region is located in Croatia, where turmoil and particularly the use of land mines in the early 1990s has made survey and archaeological investigation very difficult.[551] As such, it is simply not possible to have the depth of archaeological data that is available elsewhere, and this absence of evidence does not necessarily mean that no large scale wine or oil production was being undertaken. Beyond archaeological issues, while MR 10 is well suited to vine and olive cultivation, the flat terrain is better suited to grain cultivation. Indeed, there is certainly evidence for considerable agricultural activity across the area, though it is rarely possible to specifically identify grain cultivation.[552] In many ways MR 10 is similar to MR 5, both have large flat terrain, ideal for grain cultivation, and are fairly urbanised. While the urban centres of MR 10 would put a considerable strain on the local land to meet the grain needs, MR 10 is particularly well suited to meet the needs of its urban populations locally, as is discussed in Chapter 4. Furthermore, the largest city in MR 10, Iader, is one of the few in MR 10 that likely did not have sufficient suitable land within 3 km to meet these needs. However, it is one of the only major coastal sites in MR 10, allowing the wine and oil from MRs 4 and 7 to be more efficiently imported in exchange for excess grain produced across MR 10 or goods imported from the Dalmatian interior. Much of MR 10 could have

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[550] ‘IARH’website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).
[551] See specifically Matijašić (1993), 257. The island surveys and the surveying around Pola are exceptions to this.
[552] ‘IARH’website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).

been self-reliant, and wine and oil would largely have been supplied through smaller scale production in the hinterlands. That being said, the largest urban centres would have been closely integrated with the wider regional economy through the potential connectivity afforded by the Adriatic, thus linking the wider region, through redistribution of commodities, with the urban centres of the interior. Ultimately, while specialised wine or oil production in MR 10 is unlikely, a level of integration within the wider economy is likely.

**Table 5.7- Sites of Zadar County (MR 10).**

*These are the main rural sites across MR 10. Again, only one has evidence for wine or oil production, despite the micro-region being particularly well suited.*

| Site | Oil or Wine | Presses |
|---|---|---|
| **Podvršje** | Neither | 0 |
| **Bosana** | Neither | 0 |
| **Orlić** | Neither | 0 |
| **Otočić Sustipanac** | Neither | 0 |
| **Sv. Martin Ivinj** | Neither | 0 |
| **Trbounje (Zaselak Čupići)** | Neither | 0 |
| **Begovača, Crkvina** | Neither | 0 |
| **Danilo 2** | Neither | 0 |
| **Kožino** | Neither | 0 |
| **Diklo** | Neither | 0 |
| **Zemunik Donji** | Neither | 0 |
| **Gradina Samograd** | Neither | 0 |
| **Bilice** | Neither | 0 |
| **Danilo 1** | Wine | 1 |

### 5.3.7- Split and Southern Šibenik-Knin (MRs 11, 12 and 13)

In terms of wine and oil production, MRs 11, 12 and 13 are all quite similar. There are a total of 38 possible villa sites across MRs 11 and 13, though few of them have convincing evidence for wine or oil production (Fig. 5.33 and Table 5.8). One site in MR 11, Stari Trogir-Loranum, was likely a villa, with substantial remains and an associated pier.[553] However, the only indication for any wine or oil production is the remains of water-proofing plaster, which may have been used in a vat, though this is far from certain. Indeed, it has been argued that this was simply an elite country residence, that may even have received imperial patronage, but not that there is evidence for significant wine or oil production at the site itself.[554] There appears to have been likely wine or oil production being carried

[553] 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).
[554] Zeman (2014), 9-10.

out at two sites in MR 13. At Krstače there is possible evidence for oil production. The site is a large rural building with substantial architectural remains, as well as *amphorae* and what has been described as fragments of grindstones ('*i ulomci žrvnjeva*').[555] It is unclear to me exactly what is meant by this, but it is possible this alludes to olive mills, which would indicate that oil was produced on the site. However, there are no extant remains of any presses. Mišine, on the other hand, had evidence for a press in the form of the base block for the *arbores*, though this has since been lost. It is unclear whether this press was for wine or oil, with the earliest source describing it as an oil press, and more recent sources as a wine press, though none offer any explanation for either.[556] None of this is particularly convincing evidence for wine or oil production, even accounting for the archaeological issues.

**Table 5.8- Sites of Split and Southern Šibenik-Knin (MRs 11, 12 and 13)**

*These are the main rural sites across MRs 11, 12 and 13.*

| Site | Oil or Wine | Presses | MR |
|---|---|---|---|
| **Stari Trogir- Loranum** | Neither | 0 | 11 |
| **Jaz** | Neither | 0 | 11 |
| **Seline** | Neither | 0 | 11 |
| **Split 2** | Neither | 0 | 12 |
| **Split 3** | Neither | 0 | 12 |
| **Resnik Tarce** | Wine | 0 | 12 |
| **Trstenik** | Neither | 0 | 12 |
| **Kolovrat** | Neither | 0 | 13 |
| **Misine** | Wine | 1 | 13 |
| **Mučalova glavica** | Neither | 0 | 13 |
| **Tomaševića njive** | Neither | 0 | 13 |
| **Dugopolje - Vučipolje** | Neither | 0 | 13 |
| **Krstace** | Oil | 0 | 13 |
| **Šušnjar Ruševine** | Neither | 0 | 13 |
| **Gradina Sv.Mihovila** | Neither | 0 | 13 |
| **Nelaj** | Neither | 0 | 13 |
| **Kotluša** | Neither | 0 | 13 |
| **Doci** | Neither | 0 | 13 |
| **Ševače** | Neither | 0 | 13 |
| **Boduljak** | Neither | 0 | 13 |
| **Stražine** | Neither | 0 | 13 |
| **Reljina ograda** | Neither | 0 | 13 |
| **Gradina Vučipolje** | Neither | 0 | 13 |
| **Oglavci** | Neither | 0 | 13 |
| **Smoljina gradina** | Neither | 0 | 13 |
| **Gacko** | Neither | 0 | 13 |

[555] 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).
[556] Stanić (1891), 101-102; 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).

| | | | |
|---|---|---|---|
| **Pavis** | Neither | 0 | 13 |
| **Tomići** | Neither | 0 | 13 |
| **Luščić** | Neither | 0 | 13 |
| **Munivrane** | Neither | 0 | 13 |
| **Crkvin** | Neither | 0 | 13 |
| **Dugiš** | Neither | 0 | 13 |
| **Manastirina** | Neither | 0 | 13 |
| **Ograda A. Sušak** | Neither | 0 | 13 |
| **Banjače** | Neither | 0 | 13 |
| **Sv. Spas** | Neither | 0 | 13 |
| **Balečka gradina** | Neither | 0 | 13 |
| **Lastve** | Neither | 0 | 13 |
| **Satrić Prolići** | Neither | 0 | 13 |
| **Banovića gorica** | Neither | 0 | 13 |
| **Efendići** | Neither | 0 | 13 |
| **Petrada** | Neither | 0 | 13 |

Neither MR 11 nor 13 are well suited to the cultivation of vines or olives. Both are much better suited to pastoralism, though some of the land in the Cetina valley and around the artificial Lake Peruča in the north of MR 13, is quite fertile. Indeed, much like MR 10, there is a considerable concentration of rural sites in this area. These sites vary from stray inscriptions and ceramic scatter, to sizeable rural buildings and settlements (it is not entirely clear how these sites are distinguished between villas in the Ancient Archaeological Sites of Croatia website database, though press sites do seem to be regarded separately from 'rural' sites).[557] However, none of these have evidence for wine or oil production. What this clearly shows, is that there was considerable agricultural activity across MR 13, even if it did not involve the specialised production of wine or oil. Many of the products would likely have been destined for the local urban markets, particularly at Aequum and Setovia, but, much like in MR 10, MR 13 was well positioned to exchange the commodities of the interior of Dalmatia with the coastal centres and across the Adriatic. Again, while there is limited evidence for specialised wine or oil production in MRs 11 or 13, this is in no way evidence that there was no wine or oil production, or that other, less archaeologically visible economic activities were not being undertaken. Nevertheless, it is unlikely that either micro-region was as economically integrated as the likes of MR 4 or 7, or involved in large scale specialised production and exchange.

The ecology of MR 12 is very well suited to the cultivation of vines or olives, though there are few press sites in this micro-region. MR 12 is dominated by the Dalmatian provincial capital at Salona, and while there are four additional small urban centres in the micro-region, there are similarly only

[557] Personal correspondence with the databases project coordinator, Ivana Ožanić Roguljić.

four sites considered here. For the clear outlier in terms of density of urban population, this is quite underwhelming evidence for wine or oil production. Indeed, Resnik Tarce is the only one of these with evidence for wine or oil production, with a number of *amphorae* and *dolia* having been discovered nearby. However, these may be associated with a nearby shipwreck rather than the villa itself.[558] In any case, there are no extant presses at the site. This is quite perplexing, as the micro-region is one of the best suited for vine or olive cultivation anywhere in the Adriatic. There are a number of rural sites across the hinterland, but little evidence for wine or oil production. Again, the archaeological biases associated with Croatia, could explain some of this paucity, in addition to the dense urbanisation of the modern area. However, there are additional explanations. Salona is one of the largest sites in the eastern Adriatic, and while its hinterland is fertile, beyond the immediate vicinity, the land is relatively ill suited to vine or olive cultivation. As was discussed in Chapter 4, the suitable land around Salona alone, was unlikely to have been sufficient enough to support its population. Indeed, the only press sites in the whole of MR 12 are from Salona (Fig. 5.34), which was itself a major port.[559] Much of the primary wine and oil production in MR 12 was surely destined for secondary processing at Salona. This would have to have been supplemented by imports into the provincial capital from across the Adriatic. The lack of evidence for wine or oil production in MR 12 outside of Salona was likely due to the fact that the overwhelming majority, and certainly any large scale production, of wine and oil production would ultimately have been destined for consumption, or indeed redistribution, in Salona. Again, while there is limited evidence for large scale wine or oil production in MRs 10, 12 and 13, the very absence of this evidence points to a highly integrated economic system, where specialised wine and oil were regularly imported on a large scale, maintained by exchanging products from the Dalmatian interior, or simply the administrative benefits associated with a provincial capital.

### 5.3.8- The Neretva Valley (MR 15)

There is only one known site in MR 15, though it does have evidence for wine or oil pressing. Metković was discovered in the early 1930's, a variety of finds were discovered, including numismatic and funerary remains, but there are also the remains of a press.[560] It is unclear whether this was for wine or oil, as there are limited additional details involving the site. However, it is clear that wine or oil was being produced here on a considerable scale. Nevertheless, this is the only known evidence for wine or oil production in MR 15. This lack of press sites is quite surprising, given the ecological

[558] 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).
[559] Wilkes (1969), 237-238.
[560] Šiljeg (2003), 268; Vučić (2012), 80.

suitability of MR 15, although, as ever, the archaeological biases in the area should be kept in mind. That being said, the micro-region is better suited to the cultivation of other fruits, and is particularly well known today for its mandarins.[561] We might expect that this relatively archaeologically invisible process would have been the major economic pursuit in this fertile micro-region. It is notable that the only known site with evidence for wine or oil production is within 5 km of Narona, the main urban centre of the micro-region, and a major Dalmatian site. It is likely that the wine or oil produced at Metković was largely destined for the urban market of Narona, rather than for wider export. The evidence for wine and oil production in MR 15 alone does not suggest that any specialised wine or oil production was being undertaken in the micro-region, or that there was a great degree of economic integration with the wider region.

### 5.3.9- The Croatian Islands (MRs 19 and 20)

The case of the islands of the Dalmatian coast is somewhat different from the mainland. The majority of the pressing installations recorded on the entire eastern coast come from these islands, and especially MR 20 (Fig. 5.20). Though there are some 70 sites across MR 19, only nine have any evidence for wine or oil production, and only two with particularly convincing evidence (Fig 5.35). It is probable that the majority of the remaining sites were maritime villas used mainly for *otium* and lower scale domestic economic activities. While there is no extant pressing apparatus at Caska, the presence of five *dolia defossa* arranged in rows suggests that wine production may have been undertaken.[562] Caska is in the hinterlands of Cissa and it is likely that the possible wine production at Caska mainly targeted this local urban market, rather than being widely exported, and the majority of sites with any evidence for wine or oil production are in close proximity to Cissa. The site of Muline is quite remarkable. There is clear evidence for wine production at this site (see *stipites* and Room 1 in Fig. 5.36) one of the only Dalmatian sites where such definitive evidence can be found.[563] The site had originally been identified as an oil production centre, with at least two and as many as five separate presses.[564] However, it was a misidentification or mislabelling of the *stipites* as olive mills that led to this conclusion.[565] This is understandable, given that the *stipites* are rounded stone constructs with a hole through them, much like standard olive mills. However, the mistake is important: an olive mill is a clear indication of oil production, while *stipites* only indicate the presence of a press, for either wine or oil production. Indeed, there are two rooms at Muline that indicate,

[561] Zovko *et al.* (2018), 61.
[562] Grisonic and Stepan (2017), 76-77.
[563] Glicksman (2007), 45.
[564] Suić (1960), 235; Ilakovac (1998); Glicksman (2007), 45.
[565] Glicksman (2007), 45.

with rare clarity, the presence of wine production. These are two similarly sized rooms with drains in the floor leading to waterproofed basins. This was very likely a grape treading floor. As Glicksman highlights, this does not negate the possibility of oil also being produced on site, but wine was certainly being produced, with at least one of the presses likely being used to extract lower quality wine from the already trodden grape skins.[566] Additionally, there is no mention of more than two presses in the original reports, with Glicksman suggesting that the claims of more presses come from the misreading of site plans, with her own visit to the site confirming only two presses.[567] This is one of the better studied Dalmatian sites, yet there are clear issues with the understanding of it. Unfortunately, this is the case for much of this eastern coast, and it is rare that we can say anything with much certainty about the nature of wine and oil production, though the evidence clearly shows that both wine and oil were being produced. It is notable, that no sites anywhere in MRs 9-18 have evidence for more than one press, while this site on Pašman in MR 19, has evidence for at least two presses. MR 19 is relatively fertile, and some islands, particularly the two largest and northernmost, Krk and Cres, are well suited to vine or olive cultivation. Despite this, there is no clear evidence for large scale wine or oil production on either of these islands. This can likely be explained through the relative proximity of these islands to MR 7. The massive scale production of wine, and especially oil, in MR 7 likely made specialised wine or oil production on these islands economically unviable. Indeed, the majority of the islands are smaller and often considerably less well suited to vine or olive cultivation. However, Muline is similarly located in a more fertile area of MR 19, the northern tip of Pašman. Notably, it is also very close to MR 10 and, importantly, the major urban centres of Iader and Aeona. Notably, the small urban centres of MR 19 are on the other side of the micro-region to Muline, on the larger northern islands. As such, it would seem likely that this larger scale wine or oil production was destined for the urban markets of MR 10. While there is limited evidence for large scale wine or oil production in MR 19, the evidence we do have suggests a degree of market integration and interdependence with the wider Adriatic region, with specialised wine or oil production being carried out at Muline at least.

In MR 20, there are 164 known sites, 48 with evidence for wine or oil production. All but two of the sites with evidence for wine or oil production are on one of the three islands of Brač, Hvar or Korčula (Fig. 5.37). This concentration of sites is far more like that observed in MR 7 than anywhere else on the Dalmatian coast. However, of these 48 only ten have extant remains of the presses themselves. Indeed, the majority of evidence for wine or oil production from MR 20 comes in the form of *dolia*, which, as has been discussed, is not necessarily evidence for the secondary process of

[566] Glicksman (2007), 45.
[567] Matijašić (1993), 257; Brun (2004), 61; Glicksman (2005), 210.

pressing, but for the tertiary process of fermentation. It is possible that grapes were being pressed on the mainland and sent to the islands to be fermented. Furthermore, there are four sites (Stagnjica, Ivončeve njive, Kupinovik and Gospe od Poja 1) with olive mills or separation vats, indicating oil production. Nevertheless, it is likely that grapes were being pressed or trodden at many of the numerous sites across MR 20, suggesting that there may have been a specialised production of wine on the islands.

Closer analysis of the ten sites with possible evidence for presses can help to clarify the nature of this wine and oil production. Bunje (Šolta), Bunje (Brač) and Luke in the north of MR 20 are the only sites with possible evidence for presses on either Šolta or Brač, but Bunje (Šolta) and Luke are not certain. At Bunje (Šolta), there is supposedly a large stone with grooves cut into it that has been identified as the remains of a Roman press.[568] Though I have been unable to find any images of this stone, it does sound similar to the stone press beds found across MR 7 and the Dalmatian coast, and so it is possible that there was at least one press here. However, at Luke, there are several large stones with grooves cut into them (Fig. 5.38) that have been quite convincingly identified as sarcophagus lids, throwing this into doubt.[569] At Bunje (Brač), there are no known remains of a press itself, but the presence of an olive mill (Fig. 5.39) and a separation vat make it clear that oil was certainly produced on site, and very likely being pressed, given the presence of the mill.[570] Wine or oil was clearly being produced across much of Brač. However, the evidence for pressing occurring on the island is limited. It is possible that the island was mainly used as a location for wine fermentation and storage, rather than pressing, or that the presses have simply been lost. In any case, this would suggest a high degree of economic integration between the islands and the mainland where the finished wine was almost certainly destined for, and from where the freshly pressed must may have come from originally.

Looking to Hvar, there are four sites with evidence for presses. Oil appears to have been produced at three of these, while at Rake, references are made to one or more wine presses, though it is listed in the Adriatic Islands Project database as having the remains of a wine or oil press.[571] It is unclear exactly why wine rather than oil production has been assumed, but clearly there was wine or oil production being carried out at Rake. Similarly, at Stagnjica and Ivončeve njive wine or oil presses, one at each site, have been found.[572] These are described as oil presses, but again it is

[568] Bezić (1961), 85.
[569] Jelinčić Vučković (2011), 130; Jelinčić Vučković and Botte (2018).
[570] Stančič (1999), 206; Botte *et al.* (2016), 2.
[571] 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20); Gaffney *et al.* (1997), 263.
[572] 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20); Gaffney *et al.* (1997), 36, 263.

unclear why. Kupinovik has clear evidence for oil production utilising two presses. Two press beds connected to separating vats and two olive mills have been discovered (Fig. 5.40).[573] Hvar does have some particularly suitable land for vine and olive cultivation, so such production is not necessarily surprising. However, there are no urban centres anywhere on Hvar, and it is unlikely that the inhabitants of the island would require the amount of wine or oil suggested by this scale of production. Instead, much of the wine or oil was surely destined for export to Salona, which is around 40 km from the northern shore of the island (where most of these sites are). Again, the evidence for wine and oil production on Hvar, can be best understood through a highly integrated regional economy and specialised production on the island, targeting nearby urban markets.

On Korčula, 22 sites have evidence for wine or oil production, though only four have extant presses. The majority of this evidence comes from *dolia*, and so suggests wine production was undertaken on some scale across the island, a situation similar to that discussed for Brač. It is unclear whether wine or oil was being produced at any of the press sites, though at Bradat - Mirje there are a large number of *dolia*, so wine was likely being produced. However, there are at least two presses here, so oil production cannot be ruled out.[574] Prapatna - Mirje is the only other site on Korčula with evidence for more than one press, again at least two, though it is again uncertain whether wine or oil was being produced here.[575] Gospe od Poja and Majsan both have evidence for only one press.[576] The press at Gospe od Poja has been described as an oil press, though it is unclear exactly why. Wine or oil production was clearly being undertaken on some scale across Korčula. The land is again quite suitable for vine or olive cultivation, particularly in the east and west, but there are no urban centres on the island. Again, it seems that much of this wine and oil production must have been produced specifically for export. Narona and Epidaurum to the east would have been ideal markets for sites on the western tip of the island, while Salona and the coastal urban centres of MR 10 may have been better export destinations for the sites producing wine or oil on the eastern side of the island. All of this points to a sophisticated and highly integrated regional economy, in which the Croatian islands played a prominent role.

One of the largest number of wine and oil production sites in the region can be found in MR 20. This is likely due, in part, to the surveys conducted on the islands allowing for more archaeological

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573 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20); Zaninović (1987); Gaffney *et al.* (1997), 265; Devlahović (2012), 798-799; Devlahović (2013), 617-618.
574 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20); Register of Cultural Heritage of Croatia Website https://min-kulture.gov.hr/register-of-cultural-property/16777 (accessed 14/12/20).
575 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20); Register of Cultural Heritage of Croatia Website https://min-kulture.gov.hr/register-of-cultural-property/16777 (accessed 14/12/20).
576 'IARH'website http://baza.iarh.hr/public/locality/map (accessed 10/09/20).

remains to be identified, which is simply not possible on the mainland.[577] However, it is clear that wine and oil production must have been a major economic activity across MR 20. The ecology on many of these islands is well suited to vine and olive cultivation, and while the local market for wine and oil consumption would have been minimal, the urban markets of MRs 12 and 15, particularly Salona and Narona, would have been readily accessible. Indeed, while both MRs 12 and 15 are well suited to vine and olive cultivation, the evidence for large scale wine or oil production is minimal in both micro-regions. This apparent discrepancy in the archaeological record can in fact be explained through a process of micro-regional specialisation, and participation in a highly integrated regional economy, where production being carried out in MR 20 supported MRs 12 and 15 as they engaged in different economic activities better suited to the mainland.

Wine and oil production was organised in a variety of different ways across the Adriatic region. Often, this diversity lines up with the ecological diversity. Indeed, two of the micro-regions best suited to vine or olive cultivation, from an ecological perspective, MRs 4 and 7, show the clearest evidence for large-scale specialised production of wine and oil. In some cases, such as in MR 5 or 12, the ecological situation seems to be at odds with the archaeological evidence. However, this seeming discrepancy can be explained by considering the archaeological and ecological evidence from the wider region. In the case of MR 5 or 12, it can be shown that it would be more efficient to import wine or oil from neighbouring micro-regions rather than invest in large scale specialised production locally. While it is impossible to accurately determine exactly where wine or oil was ultimately being consumed through only considering the evidence for production, the evidence for this production very strongly suggests a highly integrated Adriatic economy with specialised production occurring in specific micro-regions. A general model for this specialised production can now be proposed. Wine was clearly being produced on a scale exceeding local demands across much of MR 4, and the same can be observed for oil in MR 7, and wine and oil in MR 20. The islands of MR 20, in particular, could not have been densely populated, but the scale of wine or oil production is greater than anywhere else, other than MRs 4 and 7. Indeed, the surrounding micro-regions of MRs 4, 7 and 20, all show relatively little evidence for large scale wine or oil production, despite often being highly urbanised. Much of the wine and oil demands of the urban populations of the region were likely met by these three micro-regions, as the ecology of the Adriatic allowed for absolute advantages in the production of wine and oil in these micro-regions, and comparative advantages in a variety of other productive activities in the other micro-regions. This is not necessarily to suggest that the other micro-regions played lesser roles in this system. Even micro-regions that have very minimal evidence for wine or

[577] See Gaffney *et al.* (1997); Stančič (1999); Gaffney and Kirigin (2006).

oil production, could have still played an important role in the regional economy. The model outlined here for wine and oil production would only have been possible with specialised production and a highly integrated and interdependent regional economy, with access to the wider system, likely through port cities such as Salona. Indeed, the evidence suggests that many of the large the port cities of the Adriatic were ideally suited to function as *emporia*, the economic links of which surely extended beyond the Adriatic itself.

# Chapter 6: Infrastructure: Roads, Waterways and Ports

*'The whole Illyrian seaboard is exceedingly well supplied with harbours… although the reverse is the case with that part of the Italian seaboard which lies opposite, since it is harbourless.'*- Strabo, *Geographica*, 7.5.10

Essential to understanding economic cohesion and market integration is the network of transport infrastructure being utilised in these markets. There are several land routes across the Adriatic region, in the form of the major and minor *Viae Publicae*, such as the *Via Appia* and *Via Flaminia*. These are regularly integrated with the waterways, whether natural rivers or the canal system of the Northern Adriatic, which in turn act to link sites with the Adriatic itself. The sea is an integral part of this network, with port and harbour facilities covering much of the coast. This chapter analyses the transport infrastructure by first detailing the evidence we have for roads, waterways and ports, and then outlining the presence of these three categories in each micro-region. Finally, the Circuit Theory analysis outlined in Chapter 3 is again performed, but this time taking account of the infrastructure, ultimately showing that while the potential mobility in the region is dictated primarily by geography, not human intervention, understanding this infrastructure helps to more accurately model to what extent economic cohesion can be detected across the Adriatic, and where this infrastructure had a greater impact. Figures 6.1-3 can be used as a general reference for the regional infrastructure discussed here, but more detailed figures are provided throughout.[578]

## 6.1- The Evidence for Infrastructure

In this section the evidence for roads, waterways and ports is discussed. The approach engages with both the literary sources and archaeological remains, before each type of infrastructure is further broken down into sub-categories. Some of the issues with the incomplete and often not entirely reliable evidence are discussed here, and as ever, these issues should be kept in mind throughout the entire chapter.

[578] A higher resolution combination of all three can be found here (best viewed at c.200% magnification).

### 6.1.1- Ancient Sources

Several ancient sources offer insight into the transport network in the region. Strabo and Pliny in particular, provide geographical accounts of the Empire, highlighting roads, rivers, canals, ports, and the cities that this infrastructure linked. Analysing some of these sources allows for an understanding of how the infrastructure impacted perceptions of distance and connectivity across the Adriatic. The perceived purpose of this infrastructure is first discussed, before the potential of the sources to inform our understanding of journey times is examined. This affords a firmer grasp of what we can and cannot learn about Adriatic infrastructure from the textual sources.

#### *6.1.1.1- Purpose of Infrastructure*

While discussions of infrastructure are often circumstantial, the practical realities of building and using the infrastructure can be glimpsed through the ancient literature. The tribulations of using the road network are often alluded to in the written sources; frequent allusions to the dust kicked up while travelling along the roads are made (Suetonius, *Caligula*, 43.1; Cicero, *Ad.Atticum.*, 5.14.1; Pliny, *Naturalis Historia*, 15.81; Statius, *Silvae*, 2.2.32).[579] Furthermore, individuals being attacked by bandits along the roads appears to have been a common occurrence, if the journeys of Lucius in Apuleius' *Metamorphoses* are to be taken as representative (1.6; 10.1). Apuleius makes it clear that when travellers arrived at their destination after taking one of the roads of the Empire, they regularly required recuperation at local baths (1.5-6; 1.24). Moreover, Suetonius very explicitly tells us that Augustus preferred easy, more leisurely travel, and so opted to sail rather than use the roads wherever possible (*Augustus,* 82.1).[580] Yet, despite these hardships, it is clear that the roads were frequently used and were a familiar and relatable part of every-day society at every level. Perhaps due to this mundanity, the reasons behind their construction and maintenance are rare topics of discussion amongst the ancient writers. Chevallier identifies only seven mentions of road construction anywhere in all of Livy's surviving works (*Ab Urbe Condita Libri*, 9.29.5; 9.43.25; 10.23; 10.47.4; 38.28; 39.44; 41.32).[581] Strabo discusses, in passing, the construction and maintenance of two Adriatic roads, the *Via Flaminia* and the *Via Aemilia* (*Geographica*, 5.1.11). Importantly, none of this suggests an economic or civil purpose behind the construction of these roads, with the focus instead being on military movement and who was responsible for the construction, though there is only one mention

[579] Chevallier (1976); van Tilburg (2007), 6, 24-25; For recent archaeological analyses of Roman roads, see Capedri *et al.* (2003); Charbonnier and Cammas (2018).
[580] Chevallier (1976), 20.
[581] Chevallier (1976), 17-18.

of the army building roads in Livy (*Ab Urbe Condita Libri*, 39.2).[582] The purpose of these roads, therefore, is framed in terms of political and martial endeavours, rather than economic. It is perhaps due to this fact that the economic importance of the Roman road network has been, until relatively recently, under-studied.[583]

The historians and bigraphers offer some further insight into how ports and harbours were used. As with roads being used by the military, there are frequent mentions of the utilisation of ports by the navy (Tacitus, *Annals*, 3.9). Additionally, there are descriptions of individuals travelling by sea between cities, again much like the discussions of individuals travelling from city to city along the road network. In addition to Augustus' apparent preference for sailing over the road system (*Augustus,* 82.1), there are numerous other examples of maritime travel being the preferred method of transport for various reasons.[584] Tacitus describes Piso travelling from Dyrrachium to Ancona, and how, in order to catch up with the legions marching overland, opts to travel by sea to Rome from Pannonia. Clearly sailing across the Adriatic was understood to be a quicker, easier process than taking the roads. However, Strabo highlights that it is easier to reach Brundisium from Hydruntum overland through Rudiae (*Geographica*, 6.3.5). Additionally, Strabo explicitly claims that it is better to travel between Tarentum and Neretum by land rather than by sea, despite both being on the coast (*Geographica*, 6.3.5). It is unclear if this is due to safety concerns, speed or comfort, but it is apparent that sailing was not always the first choice. That being said, the dangers of sailing were certainly understood by the ancient writers (Suetonius, *Claudius*, 17.2; Cassiodorus, *Varriae*, 12.24). Indeed, the main concern of port construction appears to be the safety they provide (Pliny, *Epistulae*, 6.31.15-17; Rutilius Namatianus, *De Reditu Suo*, 1.237-249; Josephus, *Bellum Judaicum*, 1.407-408).[585] Regardless of the purpose of maritime journeys, the the ports themselves appears primarily to have been constructed due to safety concerns, rather than decreasing sailing times. However, there does seem to have been an appreciation for the importance of ports and harbours for exchange, the movement of goods and the economic benefits this brings. In describing the harbour at Caesarea Maritima, Josephus shows an awareness of the future economic opportunity it will provide for the city (*Bellum Judaicum*, 1.407-408).[586] Strabo discusses the importance of ensuring that the harbour at Ephesus, and the Adriatic ports of Aquileia and Scardona, were deep enough for freight or merchant vessels to access ('*ὁλκάσι or φορτίοις ἀνάπλουν ἔχων*'), contributing to the prosperity of the cities (*Geographica*, 14.1.24; 5.1.8;

[582] Chevallier (1976), 18. For a full discussion of literary mentions of roads, see Chevallier (1976), 17-28.
[583] Cioffi (2016).
[584] Chevallier (1976), 20.
[585] Schörle (2011), 98; See also, Robinson *et al.* (2020), for the relationship between harbour Infrastructure and ship losses.
[586] Schörle (2011), 98.

7.5.4). Indeed, Strabo describes Alexandria as particularly well suited for commercial activity; having particularly good access to maritime commerce sea because of its harbours; and particularly good access to terrestrial commerce due to proximity to the Nile (*Geographica*, 17.13). More indirect economic benefits of ports to the State are also discussed in the form of harbour dues (Livy, *Ab Urbe Condita Libri*, 2.9.7; Chariton, *De Chaerea et Callirhoe*, 1.13.4).

Of course, the safety afforded by artificial harbours would make maritime trade more lucrative by ensuring more successful journeys and efficient loading and unloading, and so the primary purpose of ports could still be thought of as safety. Nevertheless, the acknowledgement of ports' importance in safeguarding trade specifically, is far more apparent as compared to road construction. Cicero writes, during the Republic, of the corrupting influence of port cities, mixing traditional languages and customs. However, this is all worth it, we are told, as 'all the products of the world can be brought by water to the city in which you live, and all your people in turn can convey or send whatever their own fields produce to any country they like' (*De Republica*, 2.7-2.9).

#### *6.1.1.2- Journey Times*

Beyond general descriptions of the use of the infrastructure, descriptions of journeys occasionally offer insight into journey times between specific sites. These journey times are primarily focused on the terrestrial road network, but insight into the efficiency of traveling along the waterways or open sea is also provided (See Table 6.1). For movement utilising the road network, it is important to keep in mind that journey times would vary depending on the purpose of the journey and the individuals. Unfortunately it is not always made clear exactly which mode of transport is being used for any journey. Nevertheless, several sources explicitly describe messengers riding along the roads between Rome and other Italian cities, with a relatively consistent pace of around 1.4 m/s.[587] These journeys would have utilised two major Adriatic roads, the *Via Appia* and the *Via Flaminia*. While we should expect a considerably slower pace for large scale movement of goods along these routes, the relative journey times provides figures with which to compare movement utilising different elements of the transport network. Additionally, we do have evidence for specific travel times and pace for other forms of travel, including marching armies and individuals on foot using smaller roads.[588] All of this suggests that the use of a major road, whether due to better maintenance or better provision for resupplying, had an impact on the efficiency of travel, and that the major roads of the Adriatic may have allowed for these faster terrestrial movement speeds to be achieved. With this basic comparison

[587] For a detailed discussion of mobility and messengers in the Empire, see Kolb (2001), especially 206-220, 308-332). Though, the economic implications of this are not a priority; Adams (2004), 494.
[588] Laurence (1999), 82.

between movement speeds, we might expect the presence of a major road to increase movement speed by up to two times.

**Table 6.1- Journey Times.**

*These example journey times are primarily derived from Laurence (1999), 81-82; De Soto (2010), 354-361; De Soto (2019), 280-283; Malmberg (2015); Casson (1995), 281-292, and the ancient sources listed.*

| Journey | Distance (c. km) | Time (days) | Speed (m/s) | Mode | Source(s) |
|---|---|---|---|---|---|
| **Brundisum-Rome** | 550 | 4.5 | 1.4 | Terrestrial (Individual rider on Major Road) | Plutarch, *Marcus Cato*, 14.4 |
| **Brundisium-Tarentum** | 60 | 0.5 | 1.4 | Terrestrial (Individual rider on Major Road) | Strabo, *Geographica*, 6.3.1; 6.3.3; Pliny, *Naturalis Historia,* 3.100 |
| **Ravenna-Rome** | 360 | 3 | 1.4 | Terrestrial (Individual rider Major Road) | Appian, *Bella Civilia*, 2.32; Historia Augusta, *Maximus and Balbinus*, 25.2 |
| **Clusium-Rome** | 160 | 3 | 0.6 | Terrestrial (Army) | Polybius, *Historíai*, 2.25 |
| **Cales-Suessula** | 40 | 1 | 0.5 | Terrestrial (Army) | Livy, *Ab Urbe Condita Libri*, 24.13.9-11 |
| **Various** | | | 0.4 | Terrestrial (Individual Minor Roads) | Alfenus Varus, *Digesta*, 11.1.11, 38.15.2.3, 50.16.3 |
| **Placentia-Ravenna** | 225 | 2 | 1.3 | Fluvial (Downstream) | Strabo, *Geographica*, 5.1.11 |
| **Juliopolis-Coptus** | 470 | 12 | 0.4 | Fluvial (Upstream) | Pliny, *Naturalis Historia*, 6.102 |
| **Brundisium-Corcyra** | 200 | 0.5 | 4.6 | Maritime (Exceptionally Fast) | Livy, *Ab Urbe Condita Libri*, 45.41.3 |
| **Rhodes-Alexandria** | 600 | 3.5 | 1.9 | Maritime (Favourable Conditions) | Diodorus Siculus, *Bibliotheca Historica*, 5.16.1 |
| **Epidamnos-Rome** | 1,100 | 4.5 | 2.9 | Maritime (Favourable Conditions) | Procopius, *De Bello Gothico*, 10.475 |
| **Epidamnos-Rome** | 1,100 | 10.6 | 1.2 | Maritime (Unfavourable Conditions) | |
| **Ascalon-Thessalonica** | 1,480 | 13 | 1.3 | Maritime (Unfavourable Conditions) | Marcus Diaconus, *Vita Porphyrii*, 6 |
| **Alexandria-Marseilles** | 2,780 | 30 | 1.1 | Maritime (Unfavourable Conditions) | Sulpicius Severus, *Dialogues*, 1.1.3 |

It is clear from the written sources that the waterways often offered considerably faster modes of movement than roads in the ancient world. We can compare the travel times described for these different modes of transport in the sources. Basic comparisons seem to suggest that fluvial movement speed downstream was roughly equivalent to terrestrial movement using the road network.[589] Indeed, if we assume movement speed downriver to have been equivalent to movement on flat land, using the equation discussed in Chapter 3, we get a value of 1.357 m/s, very close to the journey down the Po outlined by Strabo (*Geographica*, 5.1.11). As such, the model uses an average downstream speed of 1.357 m/s. Of course, movement upstream is significantly slower. Exact figures vary, but a scheme of downstream being around three to four times faster than upstream is generally accepted.[590] As such, movement upstream averages 0.339 m/s in this model, considerably slower than movement using major roads along flat terrain.

Journey times using maritime transport have been widely studied. The sailing times and speeds extrapolated from the ancient sources can begin to highlight the even faster pace of travel that sailing could afford.[591] In exceptional circumstances, a sailing speed of some eight knots, or over 4.5 m/s, could be achieved. This is almost four times as fast as the speed of riders utilising the major road network. More standard speeds under favourable winds range from around four to six knots (2-3 m/s), which is still considerably faster than what we might expect the very fastest speeds using the road network to have been. We can apply this to a specifically Adriatic context. Procopius describes a voyage from Epidamnos to Rome as taking less than five days under favourable sailing conditions (Procopius, *De Bello Gothico*, 10.475). Compare this to the journey over land from Brundisium to Rome which takes the same amount of time. Sailing from Epidamnos around the Italian peninsula and up to Rome is a distance of over 1,100 km, while Brundisium to Rome is only 550 km. Despite this, Rome is as close, in practical journey time, to Epidamnos as it is to Brundisium. This is before the ease with which bulky cargo can be transported oversea compared to over land. However, the wind is not always favourable of course. If we apply an average sailing speed of 1.2 m/s under unfavourable conditions to the journey between Epidamnos and Rome, this becomes more complex. Sailing directly from Epidamnos to Rome would require some 10.6 days, more than twice the time needed to travel from Brundisium to Rome over the road network. In this case, it would be quicker to sail to Brundisium and use the road network to reach Rome. This highlights, once again, the key factor of conditions in maritime mobility. However, what is clear from comparing the journey times described in the ancient sources, is that maritime movement, utilising the port and harbour infrastructure of the region, could significantly reduce journey times and bring the sites of the region closer together in practical terms.

[589] De Soto (2010), 354-361; De Soto (2019), 280-283. It should be noted that the exact figure De Soto comes to for downstream/road movement is 2.5 km/h, or 0.7 m/s. However, these are used for calculating actual movement costs and journey times between sites, and so include stopping for rests etc. The current model simply uses speed and time to generate comparative data, with real figures for total travel times unnecessary, hence what appears to be significantly higher movement speeds than those used in the model.
[590] Malmberg (2015); De Soto (2019), 282.
[591] Casson (1995), 281-291; Arnaud (2007).

## 6.1.2- Archaeological Evidence

The archaeological evidence for Adriatic infrastructure is problematic, but can be used effectively in combination with the literary evidence to construct probable networks across the region. It is not within the scope of the current work to attempt a complete reconstruction of this network of infrastructure, but the main datasets used and the limitations of these, are outlined here.

Reconstructing the precise routes followed by the Adriatic roads is impossible. The remains of paved road surfaces are rarely preserved and are found even more infrequently outside of urban contexts. While such remains offer a rare opportunity to exactly place the routes that roads followed, they are rarely preserved for more than a few metres at a time.[592] However, with the literary evidence discussed above and the remains of tombs lining a route, milestones and bridges, reasonable estimates for these routes have been proposed.[593] The remains of bridges are relatively rare, though again offer more exact insight into the routes across the region. The ProjectMercury bridge database (using data from the Barrington Atlas and Talbert *et al.* (2000)) records no bridges for the Adriatic region. However, there are a select few extant examples, such as the bridge of Augustus in Rimini (Ariminum) (Fig. 6.4) or the the *Ponte di Cecco* crossing the Castellano as part of the *Via Salaria*. Even without such built remains, more ephemeral evidence for bridges can be found through survey.[594] Milestones are somewhat more common and can be used to add additional points of connection between sites, often giving actual distances to specific sites.[595] However, milestones are portable objects, and are not always found *in situ*.[596] All of this can be combined with the literary evidence described above, as well as the so-called road books and itineraries, most famously the Puetinger Table and the Antonine Itinerary, to establish the network of roads from which the current data is derived.[597] Nevertheless, it should be kept in mind that the shapefiles for the road network of the Adriatic are far from exact; they offer a visualisation of which sites were connected by roads, and approximate figures for relative lengths of roads, that are, for the most part, probable rather than exact.

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592 For some Adriatic examples see the site at Mali Alan, 'IARH'website http://baza.iarh.hr/public/locality/detail/4686 (accessed 11/11/21); Patsch (1990); Alka (1990); or at Podglavaš, where the remains of a road are observable for some 100 m http://baza.iarh.hr/public/locality/detail/3804 (accessed 11/11/21); Milošević (1998), 79.

593 See especially Chevallier (1976), 78-82.

594 Chevallier (1976), 93-94, 99, 106-111.

595 Chevallier (1976), 39-47.

596 For example, the three milestones found near Bakarac, 'IARH'website http://baza.iarh.hr/public/locality/detail/4581 (accessed 11/11/21); Brunšmid (1895), 154-156.

597 See Chevallier (1976), 28-38, for more detail on these resources.

The archaeological evidence for canals is similarly inexact. Beyond the northern Adriatic, evidence for Roman canals is very limited. Even in the case of the canal network attested in the literary as well as archaeological record, stretching across much of MR 5 from Ravenna to Aquileia, the exact course is conjectural for the most part.[598] Nevertheless, remains of canals have been found in the ports at Aquileia and Altinum (Fig. 6.5). These remains offer insight into the construction techniques and capacities of the canal network, although they cannot provide concrete details regarding the route between the main sites.[599]

Our knowledge of the rivers of the region is derived largely from the courses of modern rivers.[600] Of course, this is not archaeological, and the course of a river changes with time. However, other than the Po and the Neretva, the variation in the course of rivers is unlikely to have been significant enough to cause the waterway routes to be any less precise than those of the road networks. Additionally there are shipwrecks and evidence for river ports along some rivers, which allow us to reconstruct navigable routes.[601]

The archaeological evidence for ports and harbours is somewhat less problematic. While precise maritime routes between ports cannot be known, the location of the ports and harbours themselves are often exact. The main structures for ports (breakwaters/moles) are generally constructed using durable material, such as stone or concrete, and so survive relatively well in the archaeological record.[602] As such, these archaeological remains represent some of the most important nodes in the wider transport network, acting to connect land and sea.[603] In order to understand the less tangible links between these nodes, the ancient sources, material culture distributions and modern sailing experiences must be relied upon.

### 6.1.3- Categories

Each of the three categories of infrastructure i.e., roads, waterways, and ports, can be further broken down into hierarchies, largely based on scale, archaeological remains and literary attestations. Differentiating between these categories allows for more meaningful comparison of different micro-regions in the Adriatic, with different categories perhaps indicating different economic organisation.

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598 Uggeri (1997); D'Agostino and Medas (2010).
599 I am grateful to James Page for sharing vector shapefiles for the canal network of the Northern Adriatic, upon which the shapefiles in this work are based, as well as those from the Project Mercury Canal database https://projectmercury.eu/datasets/#canals (accessed 11/11/21).
600 EEA (2012).
601 Malmberg (2015); De Soto (2019), 281.
602 de Graauw (2019), 1-2.
603 Rice (2012), 4-5; Rice (2020), 241.

These categories should not be taken as absolute, simply as a means to differentiate some lesser and greater infrastructure. The categories of roads are first outlined, before those of the waterways and ports are described.

The road network of the Adriatic can be considered as consisting of two simple categories, major and minor roads. For the purposes of this work, major roads are those that are named in the ancient sources, and/or which are designated as major roads in the Barrington Atlas.[604] While it can be difficult to differentiate between these categories archaeologically, the literary sources suggest that some roads were relatively direct routes between important sites, and that more local and rural routes made up the majority of the network beyond these main destinations. As such, when it comes to inter-regional terrestrial exchange, the major roads can be viewed as the primary vectors by which commodities were transported across the region. On the other hand, the minor roads are those which are less well attested in the literary sources. Minor roads can be thought of as more subsidiary local roads, linking hinterlands and cities or settlements in relatively close proximity to one another. That being said, minor roads should not be taken as of little significance to the wider network, rather, their role would have been more focused on redistribution rather than on the long-distance exchange afforded by the major roads.

Three main categories for Adriatic waterways can be identified, the major rivers, the minor rivers and the canals. Again, major rivers are largely determined by their attestation as such in the written sources, but supplemented with archaeological evidence for navigability. Conversely, minor rivers are those which are not mentioned in the sources, or have no evidence for navigability. Many of the minor waterways are unlikely to have been used for any significant movement of people or commodities, with some being streams rather than rivers. However, for local redistribution, these would surely have been valuable routes. The final category of waterways are the artificial canals of the region. Canals have only been identified in MR 5, but are closely integrated with the minor and major rivers of the area. Canals can be viewed as more akin to the major rivers, in terms of travel time, linking important centres with directed trade.

Port infrastructure can be subdivided into various categories. Schörle provides a useful outline for developing a hierarchy of ports along the Tyrrhenian coast of Italy.[605] This hierarchy is based on the size of the artificially constructed harbour basins and wharves. Such an approach can be useful for

[604] The exact differentiation between Major and Minor roads in the Barrington Atlas is unclear to me, but appears to be based on ‘size’. The only significant deviation between the Barrington Atlas and the current work is for the routes across Dalmatia, which are here considered minor, as there seems to be no evidence of a single major route along the coast.
[605] Schörle (2011).

categorising ports on uniform coasts, though there is not a simple correlation between the size and economic importance of a port, which is the primary concern of the current study.[606] Moreover, as Schörle points out, it is relatively rare that even rough estimates for the size of port infrastructure can be readily acquired.[607] This is even more pronounced in the Adriatic than on the Tyrrhenian, where archaeological investigation on the eastern coast is limited, and the many natural harbours often render artificial harbours unnecessary.[608] As such, I have taken a different approach in this instance, though some rough sizes and ship capacities are offered for select major ports. Instead, ports are broken down into five distinct categories; Major, Significant, Small Urban, Small and Natural (Table 6.2).[609] A combination of attestation in the ancient sources, the scale of archaeological remains and associations with other sites were used to filter these categories. These filters were applied using an R script to the database of sites, largely derived from de Graauw, 2019, and adjusted manually where necessary (57 in total, for example, where association with an urban centre was not highlighted in the database) a summary of which can be found in Appendix H or visualised in Figure 6.3. Additionally, 92 of the sites are considered 'unclassified'. It is unclear exactly how these sites were determined to be potential ancient ports or harbours by de Graauw, as none are mentioned in ancient sources, have any known physical remains, or are in areas specifically noted as having particularly good natural harbours.[610] Nevertheless, it is assumed that these were either natural or small ports, but are differentiated as 'unclassified'.

With these categories, we can begin to understand how the infrastructure of the region might have acted to support certain levels of economic activity, whether specialised production and exchange, or more local, smaller scale redistribution.

## 6.2- The Adriatic

Now that the evidence for the infrastructure has been outlined, we can begin to assess the Adriatic in more detail. Each of these three categories, roads, waterways and ports, are discussed, first with regard to general distribution and trends, and finally looking at specific micro-regions in order to understand how the transport network of the wider region may have functioned.

[606] Rice (2020), 244-246.
[607] Schörle (2011), 95.
[608] See Rendina (2018), 30-41, for some discussion of this in Istria, and especially Rice (2020), 242-244.
[609] A similar approach is taken by Rice (2020), with five similar categories.
[610] de Graauw (2019).

**Table 6.2- Port Categories.**

*Three types of evidence are used to filter the ports into categories, the ancient sources, the physical remains, and nearby associations. If any type of evidence is true for a certain site, it can be filtered into the relevant category. Eg., if a site is associated with a significant urban centre, it can be classed as a Significant port, regardless of being mentioned in the ancient sources or of any physical remains. Forms of evidence marked with an asterix* must be true in combination with at least one other form, eg., a site must be described as a port in the ancient sources, and either have physical remains, or be associated with a major urban centre in order to be filtered into the Major category.*

| Category | Ancient Sources | Remains | Associations | Economic Activity |
|---|---|---|---|---|
| **Major** | Specifically described as a port* | Quays breakwaters or lighthouses | Major urban centre | Probable specialised production/exchange, intra-regional redistribution hub |
| **Significant** | Specifically described as a port | Quays breakwaters or lighthouses | Significant urban centre | Probable smaller scale specialised production/exchange, inter-regional redistribution hub |
| **Small Urban** | Specifically described as small | Fishponds or mooring facilities | Small urban centre* | Possible smaller scale specialised production/exchange, local redistribution hub |
| **Small** | Specifically described as small | Fishponds or mooring facilities | | Possible smaller scale specialised production/exchange |
| **Natural** | Landings are specifically mentioned but the site is not named OR Site is named | | Particularly good modern harbour | Small scale local production/exchange |
| **Unclassified** | | | | Small scale local production/exchange |

### 6.2.1- Roads

The breakdown of the entire road network, can be found in Table 6.3 and Fig. 6.6, and a similar breakdown including only the major roads, in Table 6.4 and Fig. 6.7. In this section, the road network is considered generally before notable micro-regions are discussed, with reference to the major urban centres the roads connect. Only the Croatian islands (MRs 19 and 20), have no apparent evidence for roads. However, this absence of evidence likely reflects a pattern of relatively limited, rather than no, investment in terrestrial infrastructure on the islands. The roads that did exist were unlikely to have been paved roads constructed by the state, and the maritime infrastructure would surely have been significantly more important.[611] Every other micro-region has evidence for roads of some form, though in different concentrations. These can been split into three main categories, those that have

[611] See Charbonnier and Cammas (2018), 194-195 for a discussion of the 'ideal model' of such a road.

concentrations more than one standard deviation *above* the mean, those *within* one standard deviation of the mean, and those more than one standard deviation *below* the mean (Figs. 6.8 and 6.9). Three micro-regions are considered above the sd range, MRs 9, 12 and 14. Of these, only MR 9 has any evidence for major roads, and even then, it has the lowest concentration of major roads, the only micro-region below the sd range. Furthermore, the only micro-region above the sd range in terms of major roads, is MR 8, though neighbouring MR 7 is only just within the sd range. Despite this, MR 8 only has the 10$^{th}$ highest overall concentration. While the north, particularly Istria, and to a lesser extent the west of the region clearly stand out in terms of major roads, this is not repeated in terms of overall concentrations of roads, with the east, and especially the narrow Dinaric Coasts having particularly high concentrations of roads. With all of this, we can see a relatively diverse arrangement of road infrastructure, with the use of terrestrial infrastructure varying significantly between these geographic micro-regions.

**Table 6.3- Concentration of all Roads.**

*Rank, 1-18, ranks the micro-regions from highest to lowest concentrations, while sd Range highlights whether the concentration is one standard deviation above or below the mean, or within this range.*

| GMR | Concentration of All Roads (m/km$^2$) | Rank | sd Range |
|---|---|---|---|
| **1** | 78.3 | 12 | Within |
| **2** | 106.4 | 7 | Within |
| **3** | 27.8 | 18 | Below |
| **4** | 52.1 | 17 | Within |
| **5** | 62.0 | 15 | Within |
| **6** | 122.0 | 5 | Within |
| **7** | 106.3 | 8 | Within |
| **8** | 96.3 | 10 | Within |
| **9** | 273.6 | 2 | Above |
| **10** | 110.4 | 6 | Within |
| **11** | 97.1 | 9 | Within |
| **12** | 314.9 | 1 | Above |
| **13** | 58.5 | 16 | Within |
| **14** | 224.7 | 3 | Above |
| **15** | 86.2 | 11 | Within |
| **16** | 133.4 | 4 | Within |
| **17** | 69.3 | 14 | Within |
| **18** | 76.9 | 13 | Within |

**Table 6.4- Concentration of Major Roads.**

*Rank, 1-9, ranks the micro-regions from highest to lowest concentrations.*

| MR | Concentration of Major Roads (m/km2) | Rank | sd Range |
|---|---|---|---|
| **1** | 32.6 | 4 | Within |
| **2** | 15.6 | 7 | Within |
| **4** | 19.4 | 6 | Within |
| **5** | 32.5 | 5 | Within |
| **6** | 32.9 | 3 | Within |
| **7** | 50.7 | 2 | Within |
| **8** | 71.6 | 1 | Above |
| **9** | 11.1 | 9 | Below |
| **18** | 14.3 | 8 | Within |

#### *6.2.1.1- Southern Italy (MRs 1-3)*

Southern Italy has a number of major roads linking the Adriatic with central Italy (Fig. 6.10). The area covered by major and all roads in MRs 1 and 2 is within the standard deviation range. MR 3, on the other hand, has no major roads, but is the only mainland micro-region to be below for all roads combined.

The major roads in the south of the Italian Adriatic are the *Via Appia* and the *Via Traiana*.[612] Tarentum, and Brundisium, were both major port cities, and it is significant that both sides of the Salento peninsula are connected to central Italy and Rome through major terrestrial routes. The *Via Traiana* splits from the *Via Appia* after Beneventum and takes a northern route to the coast. This northern coastal road similarly acts to link Rome with the Adriatic. Additionally, the *Via Traiana* acts as the main route between MRs 1 and 2, and for connecting multiple urban centres. In this way, two major roads link Rome and the Tyrrhenian coast to the southern Adriatic, on both sides of the Salento peninsula, with both also acting to connect some of the major urban centres of the micro-regions to one another. The majority of minor roads in MR 1 act to connect the *Via Appia* and the *Via Traiana*. As such, the minor roads run roughly perpendicular to these major roads, from coast to coast, rather than parallel with the coasts. On the other hand, the minor roads of MR 2 seem to suggest that certain urban centres, particularly along the *Via Traiana*, were hubs, with a number of minor roads terminating at these sites. In this sense, we can see the terrestrial infrastructure of MRs 1 and 2 as primarily acting to connect the Adriatic coast to the interior of the Italian peninsula and the city of

[612] See Laurence (1999), 13-21, for more detail on the *Via Appia*, though the focus is on Campania rather than the Adriatic.

Rome itself, with a secondary function, fulfilled by the minor roads, for redistribution across the sites of Southern Italy.

There are very few roads in MR 3. The main road seems to have connected Teanum Apulum in MR 2 with the interior of MR 3. Notably, this road is in some of the more agriculturally suitable land in the micro-region, and seems to have connected to Piano di Carpino, one of the only wine or oil production sites in MR 3. There is little evidence for even minor roads between Sipontum in MR 2 and Vibinum, the only plausible urban centre in MR 3. Considering the sites that the roads in MR 3 appear to be connecting, it appears that there was some importance to the relatively fertile land in the interior of MR 3, but that the urban population played a limited role in the wider infrastructure of the Adriatic, and that we may have to look beyond terrestrial infrastructure to understand any wider economic integration with MR 3. Ultimately, the road network of Southern Italy is orientated towards connecting the centre of the peninsula beyond the region with the Adriatic coast.

*6.2.1.2- Central Adriatic Italy (MR 4)*

The roads of MR 4 generally act to connect the coast with the interior (Fig. 6.11). The major roads of MR 4 generally do little to connect the sites of the micro-region, or to connect MR 4 with neighbouring MRs 2 and 5. The primary function likely having been to facilitate movement between the Adriatic coast, the interior and Rome, much like in Southern Italy. However, the *Via Flaminia* does follow the coast from Fanum Fortunae, through Pisaurum and onto Ariminum. From Ariminum, two additional major roads link MR 4 and MR 5. In this sense, the *Via Flaminia* links not only the interior of the Italian peninsula with the Adriatic in MR 4, but also links important coastal sites and is part of the major coastal route linking MRs 4 and 5. As such, we should view the *Via Flaminia* as a major component of the infrastructure of MR 4 acting to connect within and beyond the micro-region. Indeed, Strabo refers to Umbria specifically in terms of this road, and the connection it provided between Ariminum and Rome (5.2.10).[613] Combining this with the potential for surplus production in MR 4 discussed above, reinforces the idea of this micro-region being an important, integrated component of the wider regional and extra-regional economy.

*6.2.1.3- The Northern Italian Adriatic (MRs 5-8)*

While the Northern Italian Adriatic has the most major roads anywhere in the region, with seven such roads crossing the micro-regions, the concentration of roads is generally in line with what we would expect from the average over the entire region (Fig. 6.11). However, MR 8 is the only micro-region

[613] Laurence (1999), 22; Vermeulen (2020), 194-196.

where the major roads cover a significantly higher area than the regional average, and MR 7 is only just within the sd range. The major roads of MRs 5-8 link the northern Adriatic with many of the European provinces, as well as the wider Adriatic region. Two of the major roads begin in Ariminum. The *Via Aemilia* is the more southern of these two roads, passing through a series of urban centres on the southern extreme of the micro-region, and ultimately connects them to the interior of Liguria, Transpadana and Placentia beyond the Adriatic (Livy, 39.2.10).[614] The *Via Popillia* winds north and then east from Ariminum through the major port cities of Ravenna, Adria and Altinum.[615] Indeed, the *Via Popillia* is closely linked to the waterways between these sites, as is discussed below.[616] The *Via Annia* is an extension of the *Via Popillia*, connecting the largest urban centre of the Adriatic, Patavium, with the port of Adria, thus linking Patavium with the Adriatic itself. The exact route is uncertain, and there appears to be some cross over between the *Via Annia* and the *Via Popillia*, but for the current purposes, the former begins at Ariminum and terminates at Concordia, the latter begins at Adria and connects Patavium to the *Via Popillia* outside of Altinum.[617]

Aquileia is at the convergence of three major roads, the *Via Postumia*, the *Via Iullia Augusta* and the *Via Flavia*. The *Via Iullia Augusta* connects Aquileia and the wider Adriatic to the interior and central Europe beyond the Alps. The *Via Flavia* directly connects several major coastal sites across MRs 5, 6 and 7, with Aquileia. This network of roads connects the eastern coast of the Adriatic with the west, through Aquileia and Istria, forming the main terrestrial route between east and west in the region. The high concentration of major roads in MRs 7 and 8 can be viewed in the context of the Istrian peninsula being a natural funnel point for connecting the east and west of the region overland. Beyond the investment in these major roads, there is also evidence for significant bridges being constructed over the Timavo to link east and west, likely under Augustus.[618] It is clear that this north eastern portion of the region received considerable investment in infrastructure, further highlighting the importance of the area to wider potential mobility and connectivity, as the CT analysis originally highlighted.

#### *6.2.1.4- The Dinaric Coast (MRs 9, 12, 14 and 16) and the Zadar Plateau (MRs 10, 11 and 13)*

There are no major roads along the Dinaric coasts of the region. I consider all of these roads to have been minor, particularly when compared to the major roads of Italy. Despite some occasional use of the term *Via Dalmatica* to describe these coastal roads, the Dinaric coastal roads do not appear to

[614] Laurence (1999), 24.
[615] Bosio (1991), 59-67.
[616] Bosio (1991), 60-61.
[617] For alternative separations of these roads, but ultimately following the same routes, see Bosio (1991), 59-81.
[618] Bosio (1991), 215-216.

have taken the form of a single distinct road (Figs. 6.13 and 6.14). MRs 9, 12 and 14 are the only micro-regions with road density more than one standard deviation over the mean, and MR 16 is the next highest density level. For each of these, the road network is essentially a single route following the coast to and from the adjacent micro-regions. There are occasional routes into the interior of Dalmatia, through mountain passes, particularly in MR 16, but otherwise, the coastal route focus is clear. Other than MR 12, these micro-regions have not featured particularly strongly in the discussion so far, as there is relatively limited evidence for large-scale economic activity. The concentration of roads along these micro-regions can likely be explained through geography. Excluding MR 16, these are some of the smallest micro-regions, and so even relatively short lengths of roads contribute significantly to a higher density. Indeed, the main function of these micro-regions, was likely as part of the wider regional infrastructure, rather than direct contribution to the economy as a producer or consumer, offering narrow terrestrial routes to connect the more prosperous and populous intervening micro-regions of the eastern coast. MR 16 is somewhat different, as it is a larger and flatter micro-region. Nevertheless, the evidence for economic activity here is minimal, and the micro-region seems to have acted primarily as part of the infrastructure connecting MRs 15 and 17. MRs 9, 14 and 16 can all be viewed as integral parts of the wider terrestrial infrastructure of the region, even if direct involvement in the wider economy appears to have been relatively limited. MR 12, with the provincial capital at Salona, cannot be viewed in exactly this way, and the particular importance of its port infrastructure is discussed at length below.

The micro-regions of the Zadar Plateau all have road densities within the sd range. The roads generally act similarly to those of the Dinaric coasts, running roughly northwest-southeast parallel to the coast and connecting neighbouring micro-regions (Fig. 6.15). However, much of the road network of MR 10 is focused around Asseria and the major port city of Iader. Asseria is very central, on the main west-east route, Iader is considerably less central geographically, and the number of roads terminating at the city instead appear to reflect the importance of the city itself. While the Zadar Plateau can be similarly thought of as a route across the region, linking the east to the Adriatic, the urban centres, particularly at Iader and Asseria, were clearly focal points of the terrestrial transport network. Asseria likely acting as a terrestrial redistribution hub for commodities from the interior of the province as well as across the Adriatic. While the infrastructure around Iader is far more orientated towards the sea, as is discussed below.

*6.2.1.5- The Dinaric Valleys (MRs 15 and 17)*

MRs 15 and 17 lie along the Dinaric coast. However, they are markedly different to MRs 9, 14 and 16, as they are considerably flatter and larger, due to the Neretva Valley and the valley of Lake

Shkodër/the Bojana River respectively (Fig. 6.16). As such, these two micro-regions are in areas much less enclosed by the Dinaric Alps and so do not act simply as routes along the coast. Indeed, the road networks of both of these micro-regions are much more focused on the urban centres of the interior, with multiple branches terminating at Narona in MR 15 and at Scodra in MR 17. Additionally, these micro-regions represent some of the main routes between the Adriatic coast and the interior of Dalmatia.[619] In this sense, we can view the Dinaric Valleys as more akin to MR 4, where there is infrastructure connecting sites within the micro-region, but the primary focus is between interior and coast. The concentration of roads along the Dinaric Coasts to the north, suggest that at least some terrestrial movement acted to connect MRs 15 and 17 with the major centres to the north, rather than direct maritime connections. While the concentration of road infrastructure is not as dense in these micro-regions as elsewhere in the region, these valleys should be viewed as important routes by which the interior of Dalmatia was connected to the wider region and beyond.

*6.2.1.6- The Albanian Coast (MR 18)*

The only major road of the eastern Adriatic is the *Via Egnatia* in MR 18 (Fig. 6.17). While the density of major roads in MR 18 is within the sd range, it has the lowest density other than MR 9. The *Via Egnatia* links the Adriatic, through the major port at Dyrrachium, with Greece and the Aegean, acting as the only major road connecting the Adriatic to the eastern Mediterranean. The minor roads follow a route more parallel to the coast. As such, the infrastructure of MR 18 appears to be heavily orientated towards an east-west route. Even with the north-south minor roads, these connect the Adriatic to the *Via Egnatia* and on towards the eastern Mediterranean.[620] Again, we have something of a mirroring on both coasts, with the southern extremes of both being heavily orientated towards connecting coast and respective interiors. As the literary sources above suggested, the maritime link between MR 18 and the opposite MRs 1 and 2 was significant, and we may view the road infrastructure in MR 18 as an extension of that linking Rome to the Adriatic.

With all of this, we can see a concentration of major roads in the micro-regions of the Italian coast. However, few of these actually run along the coast itself, with the majority appearing to facilitate connections between the Adriatic coast and important cities of the interior. This is particularly evident for the central and southern Adriatic, where connections to the interior, and especially Rome, are the obvious motivation for the infrastructure. This is somewhat different in the northern Adriatic, where wider connections to the provinces is more apparent. The terrestrial

[619] For more in-depth discussion of the road network between the coast and interior of Dalmatia, see Glicksman (2005), 216-219.
[620] See Hammond (2012), for more detailed discussion of the *Via Egnatia* in Albania.

infrastructure of the northern Adriatic can be viewed more as connecting east and west, but also the ports of the area to the interiors of the European provinces. Istria is once again prominent here, and its role in mobility and connectivity across the region should not be overlooked. The Dinaric coasts can be viewed more as terrestrial routes along the eastern coast, rather than as primary destinations for specialised economic exchange. That being said, there are multiple routes between the coast and interior, particularly in the south, of the eastern coast, similar to that observed on the Italian coast. With this, we have a basic framework for the terrestrial infrastructure, which seems, by and large, to have connected the interior to the Adriatic.

### 6.2.2- The Waterways

In order to understand the fluvial networks of the Adriatic, in terms of large-scale exchange, it is necessary to focus on the navigable, major waterways. The minor waterways are assumed to have had limited use for transport beyond the very local and minor, and most are unlikely to have been navigable for any considerable distance. As such, in this section, the major rivers are discussed, though the concentration of minor waterways is highlighted as necessary. The major rivers used in the current work can be found in Table 6.5 and Fig. 6.2. A general overview of the waterways of the Adriatic is offered before each micro-region is discussed below, with close reference to the literary sources and the modern courses of the rivers.

The Po is by far the largest river in the region, by any metric. The modern Po has a basin area of around 70,000 $km^2$ and an average discharge of 1,470 $m^3/s$.[621] In contrast the Drin/Bojana, the second largest Adriatic river, has a basin of less than 20,000 $km^2$ and an average discharge of 352 $m^3/s$.[622] Most mainland micro-regions have at least one major river flowing through them. However, MR 11 does not, and notably also has no major roads. Additionally MR 11 is one of the few with no evidence for any urban centres. All of this does seem to suggest that MR 11 was of limited economic importance to the wider region. The concentration of rivers for each micro-region can be found in Table 6.6 and Figs 6.18, 6.19 and 6.20. It should be noted that the standard deviation values were quite high, 192.32 $km/km^2$ for all rivers and 79.12 $km/km^2$ for major rivers, compared to means of 413.46 $km/km^2$ and 65.07 $km/km^2$ respectively. The major river values were calculated by excluding micro-regions with no major rivers, but the standard deviation was still greater than the mean, and so, technically none were below the sd range, and only one above, though the lower and higher values are highlighted and discussed below.

[621] Montanari (2012), 3739.
[622] Demiraj *et al.* (2015), 150.

**Table 6.5- Major Rivers.**

*The amount of data available varies between rivers, but relevant sources are provided.*

| Modern Name | Ancient Name(s) | MR(s) | Length (km) | Water Flow (m3/s) | Basin (km2) | Reference | Ancient Source(s) |
|---|---|---|---|---|---|---|---|
| **Ofanto** | Aufidus | 1,2 | 165 | 15 | 2,790 | Campanale *et al*. (2020), 2 | Strabo (6.3.9) |
| **Cervaro** | | 2 | 110 | | 775 | Apollonio *et al*. (2016), 998-999 | Strabo (6.3.9) |
| **Esino** | Aesis | 4 | 85 | 18 | 1,223 | Gioia *et al*. (2015), 1290 | Strabo (5.4.2;6.3.10) |
| **Pescara** | Aternus | 4 | 145 | 52 | 3,171 | Lastoria *et al*. (2008), 30, 32 | Strabo (5.4.2) |
| **Piomba** | Matrinus | 4 | | | | | Strabo (5.4.2) |
| **Sangro** | Sagrus | 4 | 107 | 20 | 1,560 | D'Alessandro *et al.*(2008), 148 | Strabo (5.4.2) |
| **Tronto** | Truentinus | 4 | 115 | 17 | 1,192 | Sembroni *et al*. (2020) | Strabo (5.4.2) |
| **Marecchia** | Ariminus | 4,5 | 70 | 7 | 660 | Santolini *et al*. (2008), 2-3 | Strabo (5.1.11) |
| **Adige** | Atagis | 5 | 410 | 220 | 12,200 | Mozzi *et al.* (2020), 81-82 | Strabo (4.6.9); Pliny (NH, 3.121) |
| **Bacchiglione** | Aedron | 5 | 118 | 30 | 1,300 | Mel (2020), 2 | Pliny (NH, 3.121) |
| **Brenta** | Medoacus | 5 | 174 | 90 | 1,600 | Mel (2020), 2 | Strabo (5.1.7); Pliny (NH, 3.121); Livy (10.2.6) |
| **Lemene** | Reatinum | 5 | | | | | Pliny (NH, 3.126) |
| **Livenza** | Liquentia | 5 | | | | | Pliny (NH, 3.126) |
| **Po** | Padus | 5 | 652 | 1,470 | 71,000 | Montanari (2012), 3739 | Strabo (5.1.4-5, 5.1.11); Pliny (NH, 3.117-123); Polybius (2.16) |
| **Sile** | Silis | 5 | 95 | 30 | 755 | Buosi *et al.* (2020), 81 | Pliny (NH, 3.126) |
| **Stella** | Anaxum | 5 | | | | | Pliny (NH, 3.126) |
| **Tagliamento** | Tiliaventum | 5 | 178 | 81 | 2,580 | Fontana *et al.* (2020), 99 | Pliny (NH, 3.126) |
| **Tartaro** | Tartarus, Sagis, Adrias | 5 | 149 (artifical) | 218 | 2,885 | Mozzi *et al.* (2020), 82 | Strabo (5.1.11); Pliny (NH, 3.120) |
| **Torre** | Turrus | 5 | | | | | Pliny (NH, 3.126); Strabo (5.1.8) |
| **Isonzo** | | 5,6 | 138 | 172 | 3,400 | Žagar *et al.* (2006), 154 | |
| **Natisone** | Natiso | 5,6 | | | | | Pliny (NH, 3.126); Strabo (5.1.8) |
| **Timavo** | Timavus | 5,6 | 54 | 10 | 874 | Bidovec and Zavod (1967), 264 | Pliny (NH, 3.126); Strabo (5.1.8) |
| **Rižana** | Formio | 6,8,7 | | 3 | 204 | Poljanšek *et al.* (2018), 92 | Pliny (NH, 3.126) |

| Modern Name | Ancient Name(s) | MR(s) | Length (km) | Water Flow (m3/s) | Basin (km2) | Reference | Ancient Source(s) |
|---|---|---|---|---|---|---|---|
| **Krka** | Titius | 10,13 | 73 | 50 | 2,427 | Cukrov *et al.* (2008), 1560 | Pliny (NH, 3.140); Strabo (7.5.4) |
| **Neretva** | Naron | 15 | 225 | 341 | 12,000 | Has-Schön (2006), 546 | Pliny (NH, 3.143-144); Strabo (7.5.9) |
| **Drin, Bojana** | Drinus | 17 | 335 | 352 | 19,600 | Demiraj *et al.* (2015), 150 | Pliny (NH, 3.144); Strabo (7.5.7) |
| **Seman** | Apsus | 18 | 85 | 96 | 5,649 | | Strabo (7.5.8); Livy (31.27) |
| **Vjosa, Aoös** | Aous | 18 | 272 | 195 | 6,704 | Schiemer *et al.* (2018), 3 | Strabo (7.5.8); Pliny (NH, 3.145) |

**Table 6.6- Concentration of Major Waterways.**

*Rank, 1-12, ranks the micro-regions from highest to lowest concentrations, while sd Range highlights whether the concentration is one standard deviation above or below the mean, or within this range.*

| MR | Concentration of Major Waterways (km/km$^2$) | Rank | sd Range |
|---|---|---|---|
| **1** | 4.494 | 11 | Within |
| **2** | 73.757 | 5 | Within |
| **4** | 86.210 | 4 | Within |
| **5** | 135.140 | 2 | Within |
| **6** | 276.330 | 1 | Above |
| **7** | 2.419 | 12 | Within |
| **8** | 7.676 | 9 | Within |
| **10** | 17.419 | 8 | Within |
| **13** | 3.312 | 10 | Within |
| **15** | 91.021 | 3 | Within |
| **17** | 36.637 | 7 | Within |
| **18** | 46.423 | 6 | Within |

#### *6.2.2.1- Southern Italy (MRs 1-3)*

MRs 1 and 2 are within the sd range for concentrations of major waterways, though MR 1 is towards the lower end of this range, and MR 2 towards the upper. The majority of rivers in MR 1 flow south into the Gulf of Taranto (Fig. 6.21). The *Via Appia* crosses several of these minor rivers and they could act to connect Silvium and Genusia to the sea. The largest river in the micro-region is the Canale Reale, west of Brundisium.[623] None of these rivers are considered major for current purposes, as there is no evidence for them being navigated for any large-scale transport. Similarly, a series of minor rivers flow from the mountainous interior of MR 3 into the Adriatic, covering much of the coast. The greatest

[623] See Delli Santi and Corrado (2013); Lombardo and Maramgio (1998).

concentration of this is at the eastern extreme of the Gargano Promontory, with the Torrente dell Macchia being the largest of these. There is little apparent interaction between the road and river network of MR 3, and neither do anything to connect Vibinum, the only urban centre, to the wider region. As such, the rivers of MR 1 and MR 3 do not appear to have facilitated any large-scale economic integration or exchange, with the two major roads of MR 1 likely being of greater importance to movement across the micro-region and beyond.

MR 2 offers a slightly different picture, with a significant density of rivers across the micro-region. These generally flow from the Apennines towards the Adriatic coast between MRs 1 and 3. The Ofanto is the southernmost of the major Adriatic rivers, and, due to its size, has been described as the most important river of Apulia in modern contexts.[624] However, in the ancient sources, we are simply told that the 'emporion of the Canusitae' lies upon this river (Strabo, *Geographica*, 6.3.9). This would appear to be a reference to Cannae and Canusium, both of which lie along the banks of the river.[625] This certainly suggests that the Ofanto was navigable from the Adriatic at least as far inland as Canusium. Strabo then describes, but does not name, a river and large salt-water lake ('*στομαλίμνη*') between Salapia and Sipontum. The salt-water lake is likely referring to the salt marshes of *Salina di Margherita di Savoia* and therefore, either the modern Cervaro or Carapelle, though the Candelaro also lies between these two urban centres to the north, and there appears to be some confusion between the naming of these rivers.[626] Nonetheless, Strabo is explicit about the fact that grain is transported along these waterways from Sipontum, and so we know at least one major river was in this area. It is assumed this was the Cervaro, though there are several routes, using the waterways between Sipontum and Salapia, across which grain could be transported into the interior of MR 2 and the wider Italian peninsula. Unlike MRs 1 and 3, the river network of MR 2 appears significant, and would surely have been well used to connect the urban centres of the micro-region to the coast. The relatively limited roads leading to the coast in MR 2 may be understood in this context, with the rivers playing a more important role in connecting coast to interior, while the roads connected MR 2 to the interior of Italy and MR 1.

#### *6.2.2.2- The Central Italian Adriatic (MR 4)*

MR 4 has the longest total length of waterways anywhere in the Adriatic, and the second longest for major rivers. That being said, as it is one of the largest micro-regions, it is still within the sd range of river concentration, almost exactly the mean. The concentration of major rivers is somewhat more

[624] Campanale *et al*. (2020), 2.
[625] Ashby and Gardner (1916), 156.
[626] Apollonio *et al.* (2016), 3-4.

pronounced, as the fourth highest in the Adriatic. Certainly, there are a large number of rivers crossing MR 4, with the entire coast being dotted with the mouths of various rivers (Fig. 6.22). These rivers generally flow west-east from the Apennines to the Adriatic. There is some confusion around the river which Strabo calls the Matrinus. This is described as flowing from Atria, though it had been suggested from an early date that this was a mistake on his part.[627] I am unsure why this was originally suggested, as the Piomba flows relatively close by to Atria, and allowing for changing river courses, there is nothing to suggest that the Piomba could not have been used to link Atria with the Adriatic. Apparently, Atria's port town lies at the mouth of the Piomba and is named after the river (Matrinum), though this is the only mention of any such town I have found. It does suggest that the Piomba was navigable at least as far as Atria. Similarly, we are told that the little town (*πόλισμα*) of Aternum is named after the river upon which it sits, the Aterno-Pescara (Strabo, *Geographica,* 5.4.2). Additionally, that the Pescara could be crossed by a pontoon bridge which lay some 4.5 km from Corfinium in the interior of Italy at the other end of the *Via Tiburtina*. Presumably this pontoon bridge was not the only crossing point of the Pescara, though this is all that Strabo mentions.[628] Strabo then claims that the Sangro is between Hortona and Aternum, though presumably this is actually a mistake, as the Sangro is in fact between Histonium and Aternum (5.4.2). Strabo is explicit in his assertion that Ariminum has a river port upon a river of the same name (modern Marrechia) (5.1.11). Again, the information is limited, and it is difficult to discern how far any of these rivers were navigable, though the fact that some are described as having river ports at their mouth associated with inland sites, makes it clear that they were navigable at least in part. With this, we see both terrestrial and fluvial transport combining, with a focus clearly being on movement from the densely populated interior, towards the coast for both.

The rivers of MR 4 are arranged much like the road network, ultimately representing a transport network largely orientated towards connecting the interior with the coast. Importantly, the concentration of urban centres appears to line up quite neatly with a similar concentration of rivers and roads, highlighting a potential link between the distribution of urban centres and access to transport networks.

*6.2.2.3- The Northern Adriatic- The Po and Canals (MR 5)*

While MR 5 is the largest single micro-region in the Adriatic and has the second highest total length of waterways, the density of all waterways is one of the lowest anywhere in the Adriatic, though still

[627] Smith (1894).
[628] Nissen (1912), 439.

within the sd range. The majority of these waterways can be considered to have been major rivers (or canals), and as such, MR 5 has the second highest concentration of *major* rivers anywhere, with only MR 6, a far smaller but adjacent micro-region, having a greater concentration. Indeed, around half of all major Adriatic rivers are in this micro-region. Even when excluding the main branch of the Po, the major waterways of MR 5 are clearly significant (Fig. 6.23). The many branches and tributaries of the Po link the sites across this plain to one another as well as, ultimately, to the Adriatic and the Mediterranean. The importance of the Po is outlined specifically by ancient authors (Pliny, *Naturalis Historia*, 3.117-3.123; Polybius, *Historíai*, 2.16). While the main branch of the Po itself does not directly link many sites in the region, other than Mutina, with the Adriatic, the Po arguably offers the best route between the interior of Transpadana and the Adriatic. Importantly, the northern Adriatic canal network is linked to the Po itself, thus placing the Po in an exceptionally strong position to afford movement between the urban centres of the Adriatic and the interior of northern Italy, where some of the most populous urban centres are located. Indeed, the written sources are very clear about the prominence of the Po in this landscape, and its ability to move goods and people between interior and coast. However, the Po did not exist in isolation in the wider fluvial landscape of MR 5. Strabo describes northern Italy as full of rivers that afford 'wonderful' voyages into the interior, but particularly with the *Padus* (Po) (*Geographica*, 5.1.5). Beginning in the south, the Montone and Ronco rivers meet just south of Ravenna, where they, today, artificially become the Uniti.[629] The Montone and Ronco originally flowed either side of the Roman settlement, and are crossed by the *Via Aemilia*, linking the south and interior of MR 5 with Ravenna. Given these are minor waterways, the roads around Ravenna would likely have been more important for movement and transport than the natural rivers. North of Ravenna, the Lamone is crossed by the *Via Traiana* and the Augustan canal. In this sense, Ravenna, and this portion of the region, stand out as having particularly good infrastructure for movement and transport. Indeed, Strabo describes the city in detail with its harbours, rivers and canals linking it with Rome and the wider Adriatic (Strabo, *Geographica,* 5.1.7). There are no known urban centres between Ravenna and Adria, where the Santerno enters the Adriatic. However, the many tributaries of this major river flow south and are crossed by the *Via Aemilia*, linking the urban centres of southern MR 5 to the Adriatic. More than this, the Santerno is linked to the Augustan Canal, and as such, links these sites with the wider transport network, including the Po, Ravenna and Adria. Indeed, the Santerno, we are told, was used by Claudius in his triumph celebrating the conquest of *Britannia*, on a ship that was more like a 'vast palace' ('*praegrandi domo*') (Pliny, *Naturalis Historia*, 3.119). Clearly the Santerno was navigable, though it is unclear if this was used for transport. Nevertheless, it is taken as

[629] Ciavola *et al.* (2010).

a major river for the current purposes, linking the south of MR 5 with the canal system and wider Adriatic.

The modern Tartaro and its ancient equivalent are difficult to identify. There appears to have been considerable changes to this rivers course over time (much like the Po), and it is difficult to disentangle several named rivers from one another: the Tartarus, the Sagis and the Adrias.[630] The Adrias appears to have later become a tributary of the Tartarus and references to it are scarce after the 1st AD (Strabo, *Geographica*, 5.1.8; 7.5.9; Ptolemy, *Geographica*, 3.1.21). What is clear is that there was a navigable river, roughly where the modern Tartaro is, upon which the city of Adria had a port (Pliny, *Naturalis Historia*, 3.120; Strabo, *Geographica*, 5.1.8). The Adige is a particularly large river, with a basin size over 12,000 $km^2$ and an average discharge of 235 $m^3/s$.[631] Strabo tells us that this river (Atagis) empties into the Adriatic, but again there is some confusion, as he describes it being linked to the Danube, as well as other Alpine rivers (4.6.9-4.6.10; See also Pliny, *Naturalis Historia*, 3.121). Additionally, there is no explicit mention of this waterway being navigable up to any signifcant settlements. Nevertheless, it is assumed that the Adige was a major river in the current context, given its size and frequent references in the textual sources. Given the archaeological evidence, as well as literary sources, the Bacchiglione and Brenta are considered to have been major rivers, and navigable at least as far as Patavium, which we know had a major river port (Pliny, *Naturalis Historia*, 3.121; Strabo, *Geographica*, 5.1.7; Livy, *Ab Urbe Condita Libri*, 10.2.6).[632] The Bacchiglione is again difficult to identify in the written record. Pliny appears to allude to it when he mentions the Aedron (3.121). However, a Roman shipwreck has been discovered along the course of this river, and so, we can take it to have been navigable.[633] On the other hand, Strabo describes the Brenta (Medoacus) as facilitating a journey of some 46 km between Patavium and the sea, though we are offered no information about how long this journey would take (5.1.7). Additionally, Livy explicitly highlights the river as being navigable (10.2.6).

East of Altinum, Pliny offers a fairly confusing list of rivers. The Livenza and Lemene are both described as having ports, and so we may assume that these were readily navigable (Livy, *Naturalis Historia*, 3.126). The greater and lesser Tiliaventum are then highlighted, presumably the Tagliamento, again we are not told explicitly that this river is navigable. Nevertheless, the Tagliamento is much larger than the Livenza and Lemene (a basin of 2,916 $km^2$ and an average discharge of 90 $m^3/s$), and can also be considered a major river, likely acting to connect some of the urban centres of the

[630] Mozzi *et al.* (2020), 82.
[631] Mozzi (2020), 81-82.
[632] Bosio (1991), 243.
[633] Previato and Zara (2014).

surrounding area.[634] Pliny's description becomes more confusing after this, as he describes the Anaxum (Stella) into which flows some combination of the Varanus, the Natiso (Natisone) and Turrus (Torre), it is unclear which Pliny is claiming did or did not flow into the Stella. The modern Natisone and Torre merge to flow into the Isonzo, which in turn empties into the Adriatic, nearby to Aquileia (Pliny, *Naturalis Historia*, 3.126).[635] The dynamic nature of the course of rivers makes identifying ancient rivers with modern ones a particularly complicated undertaking, and the use of modern names throughout this section should not be taken as a suggestion that the ancient rivers all have exact parallels in the modern Adriatic. Importantly, for these admittedly confusing waterways, Strabo explicitly tells us that the Natisone/Torre allowed merchant vessels to sail from the sea into Aquileia, a journey of 11 km (5.1.8). The course of these rivers appears to have changed since Strabo was writing, as the remains of Aquileia are 6 km from the modern Natisone today. We can take them to have been navigable, and Strabo suggests that rivers beyond Nauportus (across the Alps) acted to carry goods from Aquileia into Segestica and Pannonia (4.6.9-4.6.10). These connections highlight that waterways outside and within the Adriatic acted to carry goods from the region to more distant parts of the Empire. In this middle section of the northern Adriatic, the focus of the infrastructure is less on connecting the coast with the interior of the Plain of the Po, and more on connecting the coastal sites with one another and, following the course of the Piave, into the interior beyond the Alps. The canal network acts to connect most of these sites to the Po and provides connections between these sites, the interior of northern Italy and the wider Adriatic.

The ancient sources offer some more detailed information regarding the canal system of MR 5. Strabo describes Scaurus as draining the Plain of the Po by digging a series of navigable canals from the Po to Parma (5.1.11). Pliny describes the Po being diverted into rivers and canals between Ravenna and Altinum, and the section of the canal system linking the Po with Ravenna is explicitly named as the Augustan Canal (3.119). Beyond this, the Flavian Canal, linking the Po to the Tartaro and Adige, and then the Clodian Canal, between the Adige and Bacchiglione/Brenta (3.120-121). This entire area is frequently referred to as the 'Seven Seas', presumably on account of these very canals and the many lagoons (Pliny, *Naturalis Historia*, 3.126; Herodian, 8.7.1; Pomponius Mela, 2.61).[636] Cassiodorus highlights the ease with which one can sail from Istria to Ravenna, in large part due to the waterways, artificial and otherwise, of MR 5 protecting vessels from 'savage winds' (*Varriae*, 12.24).[637] Beyond the Brenta it becomes more difficult to identify precise routes or connections that the canal system took,

634 Tockner *et al.* (2003).
635 See Snoj (2009), 386-387, for some etymological issues with the Isonzo.
636 Bosio (1991), 241.
637 Bjornlie (2019), 491-492 (translation).

though archaeological evidence shows that both Altinum and Aquileia were connected to the wider network by canals.[638]

The transport network of the northern Adriatic is more wide-reaching than anywhere else in the region. In the south, the focus is clearly on the connection between coast and the interior of the Plain of the Po, with the *Via Aemilia* and the many major rivers of the area linking the two. Nevertheless, the *Via Popillia* and the canal system run along the coast, linking coastal sites, not only with one another, but with the wider network leading into the interior. Beyond the Brenta and Patavium, the orientation switches more towards connecting the coast with the interior and the Alps. However, the canal system again links the coastal sites to one another, linking the wider network directly to the Alps and the provinces beyond the Mediterranean. Aquileia appears to have been central in this system, being at the convergence of major roads and the termination point of the canal network. As such, MR 5 can be regarded as being of major importance in the transport network of the region, acting as a link between sites across the entire Adriatic and indeed, the wider Mediterranean, the Transpadana and central Europe. The canal system allows much of these connections to be capitalised on without the need for maritime transport, and the considerable investment required for this system highlights its importance.

*6.2.2.4- Istria (MRs 6-8)*

Beyond MR 5, there is noticeably less information from the written sources about the waterways, and we are forced to rely more on the modern evidence and archaeology, than with those on the Italian side of the Adriatic (Fig. 6.23). The density of all waterways across MRs 6-8 is within the sd range, though MR 6 is a clear outlier for the concentration of *major* rivers, being significantly above the sd range. MR 6 is one of the smallest micro-regions, but much of it is dominated by the Timavo river, which is described as being 'broad and deep' with a harbour (Strabo, *Geographica*, 5.1.8; See also Pliny *Naturalis Historia,* 3.126, for a brief description of the nearby Formio (Rižana)). This, coupled with the concentration of major roads, the CT analysis, and lack of evidence for large scale production in MR 6, further reinforces the idea of this micro-region being primarily one of connection, rather than production or consumption. It is a route between east and west, and by virtue of the Tiamavus, coast to interior. While evidence for production and exchange here is relatively limited, the movement of goods and people across the infrastructure of this micro-region would surely have been considerable.

The Torrente Rosandra, south of Tergestum, flows from the interior of MR 8, with the *Via Gemina* roughly following its course across the interior. To the north and south of Aegida are the

[638] Bosio (1991), 243.

Rižana and the Badaševica respectively. The Rižana flows from the interior of MR 8 and is crossed by the *Via Flavia* as it runs south towards Parentium. Parentium is similarly flanked to its north and south by waterways, though these appear to be minor and I have been unable even to find names for these rivers, modern or ancient. Both flow from the interior to the east. To the south, is another coastal site, Pola, on the bay of Pula. Another minor and seemingly unnamed river flows from the east of the city, before it bends to the north. East of Pola is Nesactium. This city similarly lies along the *Via Flavia* and just north of the Bay of Budava, connected to it by yet another minor unnamed river.

The waterways of MRs 7 and 8 do not seem to have played a major role in the wider infrastructure. There are several smaller rivers, but there is little evidence for these having been used for any large scale transport or movement.[639] Instead, the road network here provided terrestrial connections between sites within the micro-regions, and the coastal urban centres allowed access to the wider region. Indeed, the majority of known oil or wine production sites are coastal, though the few in the interior are located nearby waterways. While grapes and olives from the interior may have been transported down some of these minor rivers to the pressing sites, the primary focus of the micro-regions does appear to be entirely coastal, with connections to the interior afforded by infrastructure remaining minimal.

#### *6.2.2.5- The Dinaric Coasts (MRs 9, 14 and 16)*

The concentration of rivers along the Dinaric coast are of note, as both MRs 9 and 14 are clear outliers, with exceptionally high concentrations of rivers. That being said, there are no major rivers in any of the micro-regions. The rivers of the Dinaric coasts almost exclusively flow from the Dinaric Alps of the interior towards the coast, perpendicular to the road networks of these micro-regions. In this respect, the waterways do not contribute to the same wider connectivity or transport infrastructure. Additionally, there is no evidence for any of these waterways having been used for transport to any significant extent, with the majority being small streams. While we do have very high values for overall length, the contribution towards movement in these micro-regions was likely minimal, with the road and port infrastructure assisting in movement of goods and people along the coast, rather than into the interior. Once again, the Dinaric coasts can be seen as part of the infrastructure of the Adriatic region, acting as routes between the productive micro-regions, rather than as significant locations for specialised production or exchange themselves.

[639] See Soczka Mandac *et al.* (2014), for discussions of Rižana and the Badaševica at Aegida.

*6.2.2.6- The Zadar Plateau (MRs 10-13)*

MRs 10-13 all have average concentrations of waterways, though MR 13 has the highest of any within the sd range, and MR 12 the lowest. Additionally, MRs 11 and 12 have no major rivers. The focal point of the waterways of the Zadar Plateau is the Skradin Bay (Fig. 6.24). Many of the minor waterways across MRs 10-13 flow into this Bay, including the only major river across any of the these, the Krka. Pliny and Strabo both briefly discuss the Titius (Krka) of MR 10, though Pliny offers little information beyond its location (*Naturalis Historia*, 3.140). While Strabo does not name the river, he describes a navigable river in the location of the modern Krka upon which lies the city of Scardona (*Geographica*, 7.5.4). This can only have been the Krka, and as such, we can understand it to have been navigable for some distance inland. Nevertheless, there is little evidence that the waterways of the Zadar Plataeu were particularly signifcant for large scale movement of goods, beyond the likely exception of the Krka and the Skadrin Bay, which would have afforded access to the Adriatic for many of the sites in the area, though with Iader being the primary hub for maritime movement to and from the micro-region, given the nature of the road and port infrastructure.

*6.2.2.7- The Neretva (MR 15)*

MR 15 has the second lowest density of waterways in the Adriatic, though the concentration of major rivers here, is one of the highest. There is only one major river in MR 15, the Neretva, but it is one of the largest anywhere in the Adriatic.[640] In the written sources, the Neretva (Naron) is described in relation to the city of Narona, though there is a clear understanding that commodities reached the interior through the river (Pliny, *Naturalis Historia*, 3.143-3.144, 7.5.9). The Neretva is the main feature of MR 15 and the valley cut by the river is what sets it apart from the mountainous MRs 14 and 16. The road network is not of particular note, and connections between the coast, Narona, and the interior of Dalmatia, would likely have been afforded by this river. Based on the infrastructure, MR 15 can be viewed as an important route connecting the interior of Dalmatia to the wider Adriatic, with Narona acting as a local hub along the fluvial routes.

*6.2.2.8- The South Eastern Coast and the Croatian Islands (MRs 17-20)*

The concentration of rivers in MRs 17 and 18 are within the sd range. However, MR 17 is towards the upper limit of this, and MR 18 is the lowest anywhere in the Adriatic. That being said, both have major rivers. Both Strabo and Pliny highlight the Drin of MR 17 as a navigable river, with Pliny highlighting its

[640] Has-Schön (2006), 546.

importance to the city of Scodra (Pliny, *Naturalis Historia*, 3.144; Strabo, *Geographica*, 7.5.7). A such, we can assume this waterway to have facilitated connections between the sea, the Adriatic cities of MR 17 and the interior of Dalmatia, as well as sites around Lake Shkodër (Fig. 6.25). In this sense, MR 17 can be thought of similarly to MR 15, acting to offer potential connections between the interior of Dalmatia to the wider Adriatic.

The Seman and the Vjosa/Aoös are both within MR 18. Strabo describes Apollonia as being situated upon the Aoüs (Aoös), though also highlights that the city was around 1.8 km from the river and 11 km from the sea (*Geographica*, 7.5.8). The modern measurement between Apollonia and the sea is relatively close to this, at around 9 km. However, the remains of the city are more than 10 km from the modern Aoös, and some 7.5 km from the modern Seman. It is unclear if this is due simply to the rivers changing course, miscalculations from Strabo, or indeed both. Certainly both the Aoös and Seman appear to have shifted considerably further south after the 15th century.[641] On the other hand, Livy simply describes the Apsus (Seman) as being between Dyrrachium and Apollonia (31.27), while the Aoös as being nearby to Apollonia, though no specific measurements are given (3.145). It is unclear exactly what role either of these rivers played in the transport network, but the Aoös appears to have been used as a means of reaching Apollonia, while the Seman remained a signifcant landmark in the area, whether it was utilised often for transport or not. Both are considered to have been major rivers in the current context, and the Aoös in particular was likely the means by which maritime traffic from the Adriatic reached Apollonia.

There appears to be little connection between the rivers and the location of sites across MRs 19 and 20, with the majority of sites being by the coast. Ultimately, it seems very unlikely that the waterways of MRs 19 and 20 would have been used for any specialised exchange, much like the road system. Instead, unsurprisingly, we must look to the port and harbour infrastructure of these islands.

### 6.2.3- Ports and Harbours

The ports and harbours of the Adriatic were likely the main infrastructure by which any specialised large-scale exchange was conducted across or beyond the region. The primary database used to collect the port and harbour data for the Adriatic was that of de Graauw 2019, and supplemented with data from the Ancient Archaeological Sites of Croatia database where possible. In total, 424 individual sites lie within the Adriatic study area, though removing those that were founded after AD 300 or before 750 BC, we are left with 412 sites (this includes 184 that have no founding date in the databases) (See again Appendix H). In this section, the general distribution of ports is discussed, before

[641] Fouache *et al.* (2001).

these are broken down by their density along the coasts of each micro-region. Some specific major ports are discussed in more detail. A rough breakdown of the possible capacities of major ports, as well as some other ports for comparison, can be found in Table 6.7.

A breakdown of the basic distribution of ports and harbours by micro-region can be found in Table 6.8, and Figs. 6.3 and 6.26-29. The prominent position of MR 7 is in line with much of what has been shown about the importance of Istria thus far. The relatively large number of ports on the islands should also not be surprising, given that this would be the only way for these micro-regions to effectively interact with the wider Adriatic and Mediterranean economies, and helps to put the lack of terrestrial infrastructure on these islands into perspective. MR 13, as the only landlocked micro-region, has no port infrastructure. Beyond raw numbers of ports, it is more helpful to consider the density of ports within each micro-region. This can be conducted by total area or, more helpfully, coastal length. By several orders of magnitude, MR 12 has the highest concentration of ports and harbours of any micro-region. This is situation reflects the concentration of the urban population and roads already noted. Interestingly, the islands are towards the lower end of this scale, with only MR 17 having a lower density of ports than MR 19. Though this is likely due to the long coastline of the island micro-regions.

What is clear from the basic distribution of ports and particularly categorised ports, is that MR 12 is of considerable note when it comes to port infrastructure, being almost as obvious an outlier as it was for the density of urban population discussed in Chapter 4. Additionally, MR 7 still appears prominent, while the islands have surprisingly little port infrastructure given the length of coastline, and of relatively small scale. MR 5 is somewhat less prominent with regard to port concentration than might be expected, though having the most major ports of any micro-region suggests that rather than having limited port infrastructure, it was concentrated in fewer specific sites along the northern Adriatic coast.

**Table 6.7- Possible Port Capacities.**

*These estimated capacities are largely my own, and are not intended to represent anything beyond a rough comparative measure, the categorisation was conducted independently of these sizes. The estimates are based on the relative scale of Schörle's estimates for Portus ((2011), 96) and a series of additional factors, including archaeological remains, previous estimates and potential wharfage and natural harbour size derived from Google Earth. See also, Rendina (2018).*

| Port | Possible Ship Capacity | Category |
|---|---:|---|
| **Tarentum** | 50 | Major |
| **Brundisium** | 70 | Major |
| **Ancona** | 65 | Major |
| **Ariminum** | 30 | Major |
| **Ravenna** | 30 | Major |
| **Patavium** | 60 | Major |
| **Altinum** | 50 | Significant* |
| **Aquileia** | 60 | Major |
| **Pula** | 30 | Major |
| **Iader** | 40 | Major |
| **Salona** | 60 | Major |
| **Dyrrachium** | 50 | Significant* |
| | | |
| **Apollonia** | 20 | Significant |
| **Tergestum** | 15 | Significant |
| **Narona** | 20 | Significant |
| **Hydruntum** | 20 | Significant |
| **Barium** | 15 | Significant |
| **Cannae** | 20 | Significant |
| **Loron** | 2 | Small |
| **Medulin** | 10 | Significant |
| **Salvore** | 10 | Significant |
| **Siparis** | 1 | Natural |
| **Soline** | 10 | Significant |
| **Sv. Ivan** | 1 | Small |
| **Umag** | 10 | Natural |
| **Val Catena** | 15 | Significant |
| **Valbandon** | 10 | Significant |
| **Zambrattija** | 1 | Small |
| | | |
| **Portus** | 500 | Major |

** Based on size alone, these could be considered major.*

**Table 6.8- Concentration of ports by Micro-region.**

*These densities are based on the length of the micro-regions coastline. It should be noted that the length of coasts used are all from the same shapefile, and so while the coastline paradox of course affects these raw numbers, the comparative values between micro-regions are not affected. A full breakdown of these details can be found in Appendix I.*

| MR | Ports/1,000 km | Significant Ports/1,000 km | Major Ports/1,000 km |
|---|---|---|---|
| **1** | 51.85 | 15.56 | 2.59 |
| **2** | 79.03 | 13.17 | 0.00 |
| **3** | 59.65 | 23.86 | 0.00 |
| **4** | 79.31 | 26.44 | 4.41 |
| **5** | 17.22 | 7.61 | 1.20 |
| **6** | 166.58 | 95.19 | 0.00 |
| **7** | 123.36 | 64.82 | 2.09 |
| **8** | 63.67 | 18.19 | 0.00 |
| **9** | 45.80 | 14.09 | 0.00 |
| **10** | 28.72 | 4.60 | 1.15 |
| **11** | 28.69 | 5.74 | 0.00 |
| **12** | 206.03 | 14.72 | 14.72 |
| **13** | 0.00 | 0.00 | 0.00 |
| **14** | 37.66 | 7.53 | 0.00 |
| **15** | 46.09 | 7.68 | 0.00 |
| **16** | 31.87 | 5.10 | 0.00 |
| **17** | 5.36 | 1.79 | 0.00 |
| **18** | 18.79 | 9.40 | 0.00 |
| **19** | 16.03 | 2.19 | 0.00 |
| **20** | 33.74 | 5.74 | 0.00 |
| **Total** | **33.47** | **10.15** | **0.81** |

### *6.2.3.1- Salento (MR 1)*

While infrastructure in MR 1 is relatively unimpressive in terms of roads and waterways, there are a significant number (40) of individual port sites in the micro-region (Fig. 6.30). 12 of these are on the Western coast, and technically not on the Adriatic itself. However, all are within this Adriatic micro-region, and would have been used for movement into and out of the Adriatic region. Additionally, there are two major ports in the micro-region, Tarentum and Brundisium, both associated with major urban centres.[642] Due to a lack of archaeological investigation at Tarentum, precise figures for city and harbour size remain elusive, though Strabo specifically points out that the harbour of Brundisium was larger than that of Tarentum by the 1st century BC (*Geographica*, 6.3.6).[643] Again, it is unclear exactly how large the port at Brundisium was, though it seems to have occupied much of the space of the

[642] Trethewey (2018), 12.
[643] Hyatt (2011), 193.

modern inner port of Brindisi (Figs. 6.31 and 6.32).[644] This is comparable to the total area that Schörle calculates for the Puteoli harbours, one of the largest ports on the Tyrrhenian coast, so it is significant that Brundisium appears to have been of a similar scale.[645] This large scale can be viewed in the context of Brundisium's importance as a crossing point between east and west, and the high concentration of ports in this micro-region as reinforcing the importance of this connection, complemented by the road network.

12 ports in MR 1 are considered significant, though the concentration of significant ports is relatively less dense than with major ports. The majority of these significant ports are in the southern extreme of the micro-region, with the port of Hydruntum perhaps being the most important, similarly acting as an east-west crossing point. The more northerly signifcant ports are associated with urban centres, and, based on the literary evidence, were likely used more for north-south travel. These significant ports would have acted as redistribution hubs for the local area, while the major ports to the south, allowed for wider redistribution with the eastern Adriatic and wider Roman world. This is similar to what has been observed in the road network of the area, where the major roads generally run east-west, coast to coast, and minor roads follow the coast itself. Notably, both major roads in MR 1 likely terminated at the major port of Brundisium. Ultimately, the infrastructure suggests that movement in MR 1 was orientated primarily on an east-west basis, with the major infrastructure being orientated towards connecting both coasts of the Italian peninsula with the eastern coast of the Adriatic. Everything discussed thus far, suggests MR 1 was one of the main areas in the Adriatic where this east-west crossing would have been made, and was a well-integrated component of not only the Adriatic economy, but of the wider Roman world.

*6.2.3.2- The Gargano (MRs 2 and 3)*

There are relatively few ports in MRs 2 and 3 (Fig. 6.33). However, both have significant concentrations of ports along their coastlines, as MR 2 has one of the shortest coastlines in the Adriatic. However, the majority across MR 2 are either natural harbours or unclassified ports and are fluvial rather than maritime. As such, MR 2 does not appear to have been a particularly well integrated part of the wider regional economy, rather it was a route linking the Adriatic and Rome, though primarily through terrestrial connections to the major ports of MR 1. However, the significant ports with no associated urban centres along the coast of the Gargano peninsula clearly show a different situation, and suggests there must have been something to gain from investing in infrastructure here. Thus far, there has been little to indicate that the Gargano would have been particularly closely integrated within the

[644] Martino *et al.* (2015), 4; Martino *et al.* (2016), 220.
[645] Schörle (2011), 93, 96; Brandon *et al.* (2008), 376 fig. 1.

wider economy. Yet, MR 3 has one of the highest concentrations of signifcant ports. The concentration of such infrastructure would have been unnecessary simply in order to facilitate the north-south coastal movement passing by the promontory. Instead, it suggests that there must have been some importance to maritime movement into and out of MR 3. The very low agricultural potential and urban population of the micro-region suggests limited economic output, but the location, as the CT analysis suggests, would likely have resulted in relatively high levels of traffic sailing around the Gargano coast. For MR 3, we may view economic integration in a somewhat reversed manner. Rather than local factors resulting in relatively efficient production and encouraging participation in the wider economy, the access to transport routes outweighed the relatively inefficient production potential, resulting in the few, but surprising, productive villas on the peninsula. It is unlikely that MR 3 was a major component of the wider economic network, but it does seem that participation in this network may have allowed the natural limitations of the peninsula to be somewhat overcome. This clearly highlights the different ways in which economic cohesion could have benefited different micro-regions.

*6.2.3.3- The Central Italian Adriatic (MR 4)*

The transport network of MR 4 discussed thus far appears largely to be orientated towards movement between the interior and the coast. There are two major ports in MR 4, both towards the north of the micro-region at Ancona and Ariminum (Fig. 6.34). Moreover, MR 4 has the second highest concentration of major ports, being one of only two micro-regions with greater than 3 major ports per 1,000 km of coast. Despite the relatively large scale of this micro-region, the coast itself is quite featureless, and so the total coastline length is considerably smaller than micro-regions with more undulating coasts, islands and promontories. As the evidence for wine and oil production in MR 4 has already suggested, the concentration of major and significant ports in the micro-region make it a likely candidate for specialised production and exchange. With these concentrations it is likely that some of these ports were engaged in exchange beyond the Adriatic, particularly at Ancona and Ariminum. The remains of the port infrastructure at Ariminum are particularly well understood thanks to modern geomorphological investigation, and modern reconstructions of them relatively detailed (Fig. 6.35).[646] Certainly Ariminum can be viewed as having been a major Adriatic port, though not quite on the same scale as Brundisium to the south. Similarly, the port at Ancona has been relatively well investigated, and a great deal of information about it is available.[647] The scale of the harbour suggests a capacity more akin to Brundisium than Ariminum.

[646] Schörle (2011), 96; Ugolini (2015), 244.
[647] For a very in-depth discussion of the port infrastructure, see Ugolini (2021), especially 18-20, 26-27, 33.

There is a very high concentration of small urban ports in MR 4, second only to MR 12. This reflects the densely urbanised nature of MR 4, which covers much of the coast, but particularly in the north. As such, we might expect that much of the coast of MR 4, beyond the more major ports, acted as more local redistribution or collection hubs, while the small urban ports would have been important consumers and exporters in their own right. MR 4 is particularly well placed to engage in specialised production and exchange, at a crossroads between the Adriatic and the wider Roman world. However, dominance of a single port, like at Brundisium in MR 1, does not appear to have been replicated in MR 4. Instead, a more diverse range of ports, albeit smaller, would have been utilised for moving goods to and from MR 4, though much would presumably have gone through the major northern ports.

*6.2.3.4- The Northern Adriatic (MRs 5 and 6)*

The Northern Adriatic often features heavily in discussions of the Roman Adriatic, indeed, much of what has already been discussed suggests it was an important part of the wider economy. Nevertheless, the density of ports is relatively low across MR 5. Despite having the most major ports of any micro-region, these are relatively sparsely concentrated along the coast, and only MR 10 has a lower concentration of major ports (Fig. 6.36). This is likely due to the length of the coast of MR 5, with the lagoons and bays creating many possible natural harbours where built infrastructure would not be necessary. Indeed, MR 5 has the second largest number of identified natural harbours, though the concentration of these along the coast is still relatively low. However, this should be viewed in the context of the other infrastructure already discussed in MR 5. The length of major rivers and canals in MR 5 is far greater than anywhere else in the Adriatic. This infrastructure, particularly the canals, we are told allowed for safer maritime movement along the northern coast of the Adriatic (Cassiodorus, *Varriae*, 12.24). As such, rather than having many ports along the coast of the micro-region to ensure safe passage of vessels, the canals and navigable rivers would provide this safety in MR 5. This suggests that infrastructure, however, was orientated towards movement along the coast, rather than facilitating direct links between many different consumption locations on the coast of MR 5 itself.

The three major ports represent some of the most likely sites for specialised production and exchange in MR 5. Notably, these three ports, Ravenna, Patavium and Aquileia, are spread equally across the micro-region, with Ravenna on the southernmost coast, Aquileia on the northernmost, and the river port of Patavium in the interior, roughly 120 km from both Ravenna and Aquileia. Each of these ports are directly connected by the waterways of MR 5, with Aquileia and Ravenna being at the two termini of the canal system, and Patavium linked to this artificial system through the Brenta.[648]

[648] Bosio (1991), 243.

Therefore, exchange between these three ports would not require a vessel to enter the Adriatic itself. Additionally, the majority of the 19 significant ports are north of the Po delta and west of Aquileia. Virtually all of these significant ports (excluding Equilium, which has a coastal lighthouse)[649] are associated with major rivers or the canal system. It is clear, more than in any other micro-region, that the waterways and ports/harbours of MR 5 are inextricably linked to one another.

The major port of Classe at Ravenna is particularly well investigated and understood. However, the port and the surrounding urban settlement, reached its peak during the 5th century AD, and so determining the details of the earlier, Augustan facilities is difficult.[650] However, we can use some of the estimates for the later facilities to gauge a rough capacity and size for the major port at Ravenna, with which to compare to the other major ports. Only around one quarter of the area has been excavated, but the capacity of warehouses suggests a minimum capacity of 28 ships, so a total closer to 100 if this is replicated in the unexcavated areas.[651] If the urban expansion (the area covered by the city had increased by around 5 times its early imperial size by the 5th century AD) was replicated in the port infrastructure, we arrive at a capacity of around 22 ships, though given the relative scale of Ravenna itself, this would likely have been closer to 30. [652] Nevertheless, while it does appear that Ravenna was a major port in the early imperial period, it was not on the same scale as many of the contemporary major ports of the Adriatic.

Determining the exact capacity and size of the ports of Patavium and Aquileia is similarly complicated. However, much of the length of the waterways within Patavium show evidence for having been reinforced, presumably as part of dock construction.[653] This would suggest a capacity comparable to that of Brundisium and Ancona at Patavium. The total length of the canal system used for docking ships at Aquileia is unclear.[654] Nevertheless, it appears to have been similar in scale to Patavium, and both are considerably larger than the signifcant port at Altinum.[655]

In contrast to MR 5, MR 6 has the second highest density of ports anywhere in the Adriatic, and while it has no major ports, it has the single highest concentration of significant ports. The road infrastructure in MR 6 is clearly orientated towards movement to and from MRs 5 and 7. The high concentration of signifcant ports suggests direct links with the wider region, and possible involvement in specialised production and exchange. It is likely that many commodities would have been imported

[649] Trethewey (2018), 14.
[650] Manzelli (2000), 230-237.
[651] Augenti and Cirelli (2011), 216.
[652] Manzelli (2000), 234; Augenti and Cirelli (2011), 205.
[653] Mozzi *et al.* (2017), 81.
[654] Capulli (2013), 19.
[655] Tirelli (1987), 302.

into and exported from the signifcant port at Tergestum, to be consumed here or redistributed within the micro-region. However, as this micro-region is at the head of the Adriatic, and along the crossroads between the interior of central Europe and the Balkans, it can similarly be viewed as an important point of extra-regional redistribution, rather than a point of consumption or production.

The general scheme across the northern Adriatic appears to be one utilising the waterways, and to a lesser extent, the road network, to facilitate intra-regional exchange. Rather than an area where huge quantities of goods were directly produced or consumed, much of the infrastructure was used to carry goods across and beyond the micro-regions, rather than for consumption within. Of course, there is evidence for large scale production and consumption within the micro-regions, but when considering the wider trend of specialised production and exchange, the infrastructure of MR 5 and 6 can be viewed a network of redistribution beyond the region, as the CT analysis suggested may be the case for the north-east. In this sense, the entire infrastructure of the northern Adriatic can be viewed as facilitating movement and exchange beyond the Adriatic.

*6.2.3.5- Istria (MR 7)*

The Western coast of Istria has repeatedly been highlighted as an area for potential specialised production and exchange in the Adriatic. In terms of port and harbour infrastructure, this appears to hold true (Fig. 6.37). MR 7 has the single largest number of ports anywhere in the Adriatic, with the third highest density by coastline. This is likely in part due to relatively intensive archaeological investigation along the coast, but the concentration of port infrastructure is striking nonetheless. In terms of major ports, there is only one, at Pula (Fig. 6.38), and the concentration is towards the lower end for those micro-regions that have major ports.[656] However, virtually the entire coast of MR 7 is covered in signifcant ports, the overwhelming majority of which are not associated with urban centres. This suggests that there was relatively little consumption at port sites themselves, at least when compared to those of MRs 4 and 5. Additionally, that commodities were exported from ports all along the coast, rather than from a single or only a few specific emporia like locations. The organisation of this infrastructure is clearly orientated towards maritime export above anything else. The disproportionate concentration of ports on the west of the peninsula clearly points to specialised production and exchange with the north, and west, though the majority of these western connections would likely have been in order to access the infrastructure of MR 5 for further export north. It seems unlikely that Istria can be viewed as a significant area for redistribution like the rest of the northern

[656] Boetto *et al.* (2017), especially 190.

Adriatic, rather, that commodities were exported directly from and to MR 7, particularly with the interior of central Europe through connections with MRs 5 and 6.

*6.2.3.6- The Dinaric Coasts (MRs 9, 14 and 16)*

The thin strips of land between the Adriatic and the Dinaric Alps have relatively well-developed transport infrastructure when compared to the evidence for production in these micro-regions. While MR 14 has the second fewest ports of any micro-region, the concentration of ports along the Dinaric coasts is only slightly below the average of the wider region (Fig. 6.39). However, other than MR 9, all of these micro-regions have considerably lower concentrations of significant ports, with only nine of the 43 total ports being signifcant, all nine of which are associated with urban centres. The distribution of natural harbours along these coasts is relatively uniform, suggesting that there was no 'central' redistribution for any of these micro-regions. Rather, it appears likely that movement along the coast here would have been small scale local movement, rather than specialised exchange sailing to or from specific locations within these micro-regions.

The concentration of signifcant ports across MRs 9, 15 and 16 should be further discussed. The urban centres of these micro-regions are almost all on the very small side, yet, most of them have evidence for signifcant port infrastructure, rather than the smaller infrastructure we see at similarly sized urban centres elsewhere. It is likely that the urban centres and their ports acted as local redistribution hubs along the coasts, yet the scale of infrastructure suggests larger quantities of exchange than local populations/production would necessitate. We can view this in relation to the presumably significant movement to and from the interior beyond the Dinaric Alps themselves. It seems likely that the greater quantity of goods coming into and leaving these micro-regions did so through the ports of the relatively small urban centres of the coast, with the terrestrial infrastructure allowing for local redistribution, and likely more significantly, for the goods to be further transported to and from the interior of Dalmatia. These micro-regions should be viewed similarly to MR 3, as being along important routes more than being important destinations themselves. That being said, the port infrastructure both along the Dinaric Coasts and in MR 3 makes clear they were components of wider networks of specialised exchange, if not production. MR 9 in particular would have been an important aspect of this extra-regional exchange, as the CT analysis suggests, and as is expanded upon in Chapter 7.

*6.2.3.7- Zadar Plateau (MRs 10 and 11)*

There are a total of 21 known ports/harbours in MR 10. However, the concentration of ports along the coast is relatively sparse, with only five MRs having less concentrated port distributions (Fig. 6.39). Only one of these, at Iader, is considered a major port, which gives MR 10 the lowest concentration of major ports of any micro-region. Compared to the concentration of urban centres in MR 10, the concentration of port infrastructure is limited. The road network of the micro-region is orientated towards linking the urban centres of the interior, and notably, multiple routes lead to Iader. It seems very likely that the majority of maritime exchange in the micro-region would have taken place at the urban centres of Scardona, Aenona and especially the major port at Iader.[657] From here, the road network would allow redistribution across the urban centres of the interior and the interior of the province. Other than perhaps the small urban ports associated Blandona and Nedinum, it is unlikely that the ports or harbours along the rest of the coast would have been used commonly for specialised exchange on a regional scale. In this sense, we can view Iader as an especially important port, more than the size of the city itself would suggest, as it acted as an important point of redistribution for the wider micro-region and province.[658]

*6.2.3.8- Salona (MR 12)*

The micro-region around Salona is quite exceptional in terms of port infrastructure. It is the smallest micro-region, in terms of coast and area. However, with 14 known ports, it has the highest concentration anywhere in the region (Fig. 6.39). This is also true for major ports, small urban ports and MR 12 has the second highest concentration of natural harbours. This infrastructure of ports is centred around the major port at Salona itself, as well as the significant ports to the West at Tragurium. Using the estimated urban area covered by Salona, and the coastal and fluvial areas this would cover, there would have been over 1,500 m of potential wharfage.[659] This would suggest a ship capacity of up to 60 vessels, comparable to the larger ports of the Adriatic, such as Aquileia. This might have been unexpected, as while Salona itself is one of the largest Adriatic urban centres, the evidence for production and potential mobility in this micro-region is relatively limited. The position of Salona as the provincial capital has been used to explain the size of the city thus far. Clearly the majority of the goods consumed at Salona came from across the sea. The road network further permitted connection with the interior of the Dalmatia. As has been suggested, it is unlikely that a significant proportion of

[657] On the importance of Iader, see Wilkes (1969), 206-210; Brusić (2001), 46; (2007), 21.
[658] There is very little evidence for significant port infrastructure in MR 11 by the Roman period, see Herakleia and Stari Trogir- Loranum. Katić (1994); Bibić (2019); de Graauw (2019); Paraman *et al.* (2020), 260-261.
[659] Based on basic Google Earth measurements.

the commodities consumed at Salona were produced locally, and more so, that any significant number of exports were produced locally. Instead, we can view MR 12 as benefitting from its position as the seat of the provincial capital. This permitted considerable expenditure on port infrastructure, allowing for a high level of exchange at Salona, without the requirement for large scale specialised production in the immediate area itself. Rather, this micro-region should be viewed, ultimately, as the provincial capital, with disproportionately close regional and extra-regional connections afforded by the sea, and the road network linking these wider destinations to the riches of the interior of Dalmatia through The ports and harbours of MR 12. In this sense, MR 12 should be considered as a major point of redistribution and consumption across and beyond the Adriatic, much like MRs 5 and 7, though without the large scale local production evidenced in MR 7.

*6.2.3.9- The Neretva Valley (MR 15)*

There are very few ports around Narona, the once centre of Roman control in Dalmatia (Fig. 6.40).[660] Of these, only the river port of Narona, can be considered signifcant. This does not suggest that there was particularly significant investment in the port infrastructure of MR 15. Nevertheless, the coast is relatively small, and so, while the concentration of ports is not particularly dense, it is not quite as sparse as the raw numbers might suggest. This can be viewed in the context of Narona and the Neretva's position in the wider Adriatic. The Pelješac peninsula requires a signifcant detour in order to be circumnavigated and to allow movement between the south and Narona. As such, maritime traffic sailing out of or into the Adriatic would not have been naturally funnelled towards the coast of MR 15, and so this infrastructure would represent movement specifically into and out of MR 15 rather than any wider redistribution patterns. Other than two natural harbours on the Adriatic coast itself, all ports, including Narona's, are associated with the Neretva River. Exchange of commodities would have been conducted along the river, and redistributed from Narona to the other urban centres of the micro-region, which were reasonably well connected with minor roads. Additionally, Narona would have acted as a point of exchange for commodities between the interior of Dalmatia as well as the wider Adriatic region, through the Neretva. However, it is unlikely that the importance of the port at Narona could have been comparable to those to the north, which lay directly along the main routes into and out of the Adriatic.[661] Nevertheless, MR 15 should be viewed as an important route connecting the interior of Dalmatia with the Adriatic.

[660] Wilkes (1969), 245-248.
[661] See Wilkes (1969), 251-252, for precisely this sentiment.

*6.2.3.10- South Eastern Coast (MRs 17 and 18)*

In many ways, MRs 17 and 18 are more similar to the micro-regions of the opposite Italian coast, rather than their terrestrial neighbours. MR 17 has the fewest ports of any micro-region (Fig. 6.41). The relatively limited archaeological investigation in this area likely explains some of this scarcity, but it is striking nonetheless. The significant port, the so-called Nymphaeum of Calypso's isle, is on the very border between MRs 17 and 18. MR 17 also has the lowest concentration of ports anywhere in the Adriatic. This is in part due to the presence of Lake Shkodër, which gives the micro-region a particularly long 'coast'. However, the lake does not seem to have been particularly well utilised, despite being connected to the sea through the Drin. Movement to or from Scodra, the largest site in the micro-region, would have been south along the river and out towards the sea, or north or east overland, towards the interior of the province. The small port at Scodra was likely primarily to facilitate direct exchange between larger coastal sites such as Dyrrachium or possibly Brundisium, importing commodities from across the Adriatic and beyond at these regional hubs, in exchange for commodities acquired over land from the interior of Dalmatia.

The focus on the opposite coast across the Adriatic is yet more pronounced in MR 18, though there is still relatively little port infrastructure in this micro-region. The river port of Lissus would have afforded some possible movement from the hinterlands of MR 17 down through Lissus, either using the road or river network, and on towards the wider region. [662] In this sense, Lissus can be viewed as a local redistribution hub, with good links between MRs 17 and 18 by land as well as by sea. The remaining four significant ports are all further south, with three being concentrated around Apollonia. The focus of these ports would be on movement east-west. The ports of Dyrrachium and Apollonia are frequently mentioned in connection with links to the ports of Brudnisium and Hydruntum on the opposite coast.[663] Additionally, the terrestrial infrastructure, particularly the road network, connects the eastern Adriatic coast with the interior of Greece and Macedonia and on towards the Aegean. There is little evidence for large scale production or dense urban populations in MRs 17 and 18. Nevertheless, the importance of these micro-regions as links between east and west, within and beyond the Adriatic region, should not be underestimated. Whether or not there was large scale specialised production in the micro-regions themselves, it is extremely well positioned to take advantage of this crossroads between east and west, and, as the CT analysis shows, in a relatively poor position for movement north or south.

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[662] Wilkes (1969), 256-257.
[663] See 5.1.1 above.

*6.2.3.11- Croatian Islands (MRs 19 and 20)*

Only MR 7 has more port infrastructure than either MRs 19 or 20 (Fig. 6.39). As such, over 20% of the known ports in the Adriatic are in just these two micro-regions. That being said, they, along with MR 5, do have exceptionally long coastlines. And so the concentration of these ports is relatively low. Neither of these micro-regions have any major ports, but both MR 19 and 20 have seven signifcant ports. All but two of the significant ports in MR 19 are associated with the larger islands in the north of the micro-region, Krk, Cres and Pag. Notably, these are evenly spread out, with one signifcant port on the northern coast of Krk and one on the southern. As such, we might view these ports as redistribution points for their respective islands. Commodities produced across the island would be sent to one of these ports and then sent to the mainland, where goods, particularly Istrian oil, could have been exchanged and taken back to be redistributed. This is in line with what has been shown thus far regarding the islands of MR 19, with relatively little evidence for large scale specialised production, as the huge amounts being produced in Istria, discussed in Chapter 5, would mean that it could be relatively cheaply imported.

The smaller islands in the south of MR 19 have two signifcant ports, one on Pašman the other the nearby Murter. Notably these ports are both very close to the small urban ports associated with Blandona and Nedinum in MR 11. There is also evidence for a non-villa production site on Murter, though, to my knowledge, nothing significant on Pašman. However, it would seem likely that production on these islands was sufficient enough to warrant maritime infrastructure to exchange these goods with the urban centres of the mainland nearby. This is a case where we might view these two islands as more closely linked with the urban centres of MR 11 than with those in their own micro-region. Certainly, the ports of Blandona and Nedinum are closer to these islands and their ports, than they are to the cities with which they are typically associated. It is further notable that the most significant production site in MR 19, Muline on Ugljan, has its own small port which is only around 12 km from the major port of Iader. While there might not be the intensively concentrated population, specialised production or infrastructure on the islands of MR 19 that we see elsewhere on the mainland, it is clear that many of these islands could have been deeply integrated within the wider economy of the region, with many potentially acting more like the hinterlands of major mainland settlements than their immediately adjacent territory.

The situation is somewhat similar in MR 20. Each of the major islands of MR 20, Brač, Hvar, Vis, Korčula and Šolta have a significant port. Additionally, the smaller islands Lastovo and Šćedro also have significant ports. Excluding Lastovo and Šćedro, all of these ports are on the northern coast of their associated islands. The provincial capital of Salona and MR 12 are also to towards the north of these islands. Unlike in MR 19, the evidence for specialised production of wine and oil in MR 20 is significant. As such, it seems reasonable to suggest that much of the production on these islands was orientated towards creating a surplus for export across the sea, to Salona, using the port infrastructure of both MR 12 and 20. Rather than the immediate hinterland of Salona being used for specialised production, the islands, which were practically closer to Salona due to the mobility offered by the Adriatic and port infrastructure, could supply the provincial capital with many of its populations' requirements, as well as commodities for wider export and redistribution.

## 6.3- Infrastructure and Circuit Theory

Now that the transport infrastructure of the Adriatic has been discussed, it can be applied to the Circuit Theory (CT) analysis of the region. A discussion of the methodology is provided before the results are discussed and analysed. This allows the earlier CT analysis to be compared with new analysis accounting for infrastructure. This comparison reveals in quantitative terms, the possible impact of the network of infrastructure.

### 6.3.1- Methodology

In order to assess the impact of infrastructure on the CT model, new cost surface maps are generated. The basic process for this follows the same methodology as outlined in Chapter 3, but with additional steps to account for the infrastructure. In addition, the shapefiles for the coast, roads, waterways and ports are converted into raster format, where the presence of any of these features returns a cell with a numerical value, and the absence of any infrastructure, an NA value. The coastline shapefile of the Adriatic is simplified, in order to correspond to the raster resolution of 250 m. Each cell of coastline is assigned a prohibitively costly value, in this case 5,000.[664] As detailed above, the presence of well-engineered roads can reduce travel times by a factor of two. For the current iteration, it was determined that a factor of 1.5 for major roads and 1.25 for minor, would more accurately reflect the average across the region, as the quality of even major roads is unlikely to have been universally high across the entire Adriatic. The model then compares the base cost surface terrestrial map and the road raster, dividing the cost surface time by a factor of 1.5 or 1.25 where a major or minor road is present.

For the waterways, only the major rivers and the canal system are included in the model, as the rest of the waterways are unlikely to have been navigable for vessels of any considerable scale.

[664] See Casson (1995), 369; Wilson *et al.* (2013) table 2; Rendina (2018), 34; Rice (2013); Rice (2020); for the importance of built harbour infrastructure.

Before being rasterised, the shapefile of major rivers can be simplified as with the coastline. Additionally, the minor branches can be removed. Sailing upstream or downstream along a river would have very different travel times, and for this reason, the direction of the waterways were spilt into four distinct categories, north, east, south and west. With this, four distinct terrestrial cost surface maps are necessary. This is in line with the maritime cost surface maps, and, as is outlined above, it is assumed that movement downriver averaged 2.035 m/s (or around 122 seconds to cross 250 m) and upriver 0.509 m/s (or 490 seconds cross 250 m).[665] These represent raw values, rather than factors. As such, a terrestrial cell where a major river is present, will have a cost value of 122 if the direction of the river is the same as the direction of travel, and 490 if these directions are opposite. For crossing a waterway without the presence of a road/bridge, a prohibitively expensive value of 1,000 is used. Additionally, the canals are given a value of 122 regardless of direction of travel. Where roads and waterways intersect, the road value is used for any direction, the assumption being that there would have been a bridge somewhere around this area of the waterway.

Different categories of ports are not differentiated between in this process. This is for multiple reasons. Most practically, that quantification of the differentiation of these ports is currently very rough, estimates for scale are simply not reliable in a manner that would provide meaningful quantifiable results. Additionally, the CT analysis shows basic potential mobility based on cost surfaces in time, the quantity of commodities has generally not been taken into account for cost surface maps, and so adding it specifically for ports would not add to the model. As is discussed above, ports are primarily for safety, rather than speed, so ports represent access points rather than efficient routes, like roads or waterways. A flat value of 490 was used to represent ports. This is based purely on the relative cost of sailing upstream, as the time required to load and unload would not prevent movement between land and sea, but would still be a relatively costly process. Additionally, this is more than 10 times 'cheaper' than crossing between land and sea without port infrastructure.

Once these cost surface maps are generated, they can be merged with the base terrestrial cost surface as well as the maritime cost surface. In all cases, the presence of infrastructure overwrites the base cell value. Where roads and rivers intersect, the road value is used, for coast and port, the port value is used, and where ports and roads or rivers occasionally intersect, the port value is given precedence, so as to not create an artificially low cost route between land and sea. These cost surfaces are then used in the CT analysis as normal.

[665] Malmberg (2015); De Soto (2019), 282.

### 6.3.2- Results and Discussion

The full CT results can be found in Appendix B, but by comparing the region-wide results with and without infrastructure, it appears that the impact of infrastructure was relatively minor (Figs. 6.42 and 5.43). Suggesting that at this regional scale, potential mobility is dictated primarily by geographic factors. However, by comparing the total mean values for each scenario with and without infrastructure, we can understand its impact more clearly. For all 48 scenarios, the total current mean value (tcmv) is greater with the addition of infrastructure (Table 6.9). The difference values between different scenarios clearly show that infrastructure impacted the region disproportionately month to month and dependent on the direction of travel. One of the most striking comparisons is that the smallest difference values are for movement south and west. This might seem to suggest that movement south or west was not impacted as significantly by the infrastructure, however, looking at these as a percentage (Table 6.10), this does not hold up, and even movement west seems to have been impacted relatively positively by the infrastructure of the region.

**Table 6.9- Circuit Theory Infrastructure tmcv Difference.**

*These difference values are calculated by subtracting the total mean current value (tmcv) of the infrastructure CT analysis from the base CT analysis. Though the differences are very small, they are positive difference values without exception. This suggests the infrastructure increased potential mobility across the region.*

| | North | East | South | West |
|---|---|---|---|---|
| **Jan** | 0.0001282 | 0.0004150 | 0.0001351 | 0.0000537 |
| **Feb** | 0.0002829 | 0.0006171 | 0.0000446 | 0.0000324 |
| **Mar** | 0.0004201 | 0.0002860 | 0.0000629 | 0.0000546 |
| **Apr** | 0.0002021 | 0.0003238 | 0.0001382 | 0.0000872 |
| **May** | 0.0002218 | 0.0002452 | 0.0001783 | 0.0000502 |
| **Jun** | 0.0002316 | 0.0005083 | 0.0001672 | 0.0000594 |
| **Jul** | 0.0002807 | 0.0001065 | 0.0000238 | 0.0000678 |
| **Aug** | 0.0003278 | 0.0003780 | 0.0000640 | 0.0000594 |
| **Sep** | 0.0003239 | 0.0005868 | 0.0001631 | 0.0000470 |
| **Oct** | 0.0002913 | 0.0006111 | 0.0001864 | 0.0000753 |
| **Nov** | 0.0003073 | 0.0006064 | 0.0001186 | 0.0000534 |
| **Dec** | 0.0002972 | 0.0002531 | 0.0001052 | 0.0000989 |

Yet more meaningful comparisons can be made by comparing the city mean current values for each scenario (cmcv). Including infrastructure, both the tmcv and cmcv difference values are positive, indicating that cities are again consistently located in areas of higher potential mobility, much like was shown before infrastructure was accounted for. However, if this cmcv difference value *without* infrastructure is subtracted from the cmcv difference value *with* infrastructure, every resultant value is negative. As such, with or without infrastructure, the urban centres of the Adriatic are located in areas of high potential mobility, but this is less pronounced when infrastructure is included. This suggests that the infrastructure of the region was more orientated towards improving potential mobility and connectivity beyond the cities themselves.

**Table 6.10- Circuit Theory Infrastructure tmcv Difference as a percentage.**

*These difference values are calculated as above, but then converted into a percentage of the original base CT analysis, before infrastructure was included. The results as a percentage offer a significantly different picture to the raw numbers.*

| | North | East | South | West |
|---|---|---|---|---|
| **Jan** | 0.0337 | 0.0827 | 0.0301 | 0.0454 |
| **Feb** | 0.0754 | 0.1216 | 0.0099 | 0.0272 |
| **Mar** | 0.1125 | 0.0543 | 0.0143 | 0.0463 |
| **Apr** | 0.0537 | 0.0647 | 0.0308 | 0.0734 |
| **May** | 0.0592 | 0.0476 | 0.0400 | 0.0425 |
| **Jun** | 0.0619 | 0.1002 | 0.0373 | 0.0500 |
| **Jul** | 0.0753 | 0.0213 | 0.0053 | 0.0565 |
| **Aug** | 0.0882 | 0.0752 | 0.0143 | 0.0504 |
| **Sep** | 0.0871 | 0.1158 | 0.0365 | 0.0396 |
| **Oct** | 0.0783 | 0.1205 | 0.0416 | 0.0629 |
| **Nov** | 0.0829 | 0.1204 | 0.0267 | 0.0436 |
| **Dec** | 0.0795 | 0.0510 | 0.0236 | 0.0823 |

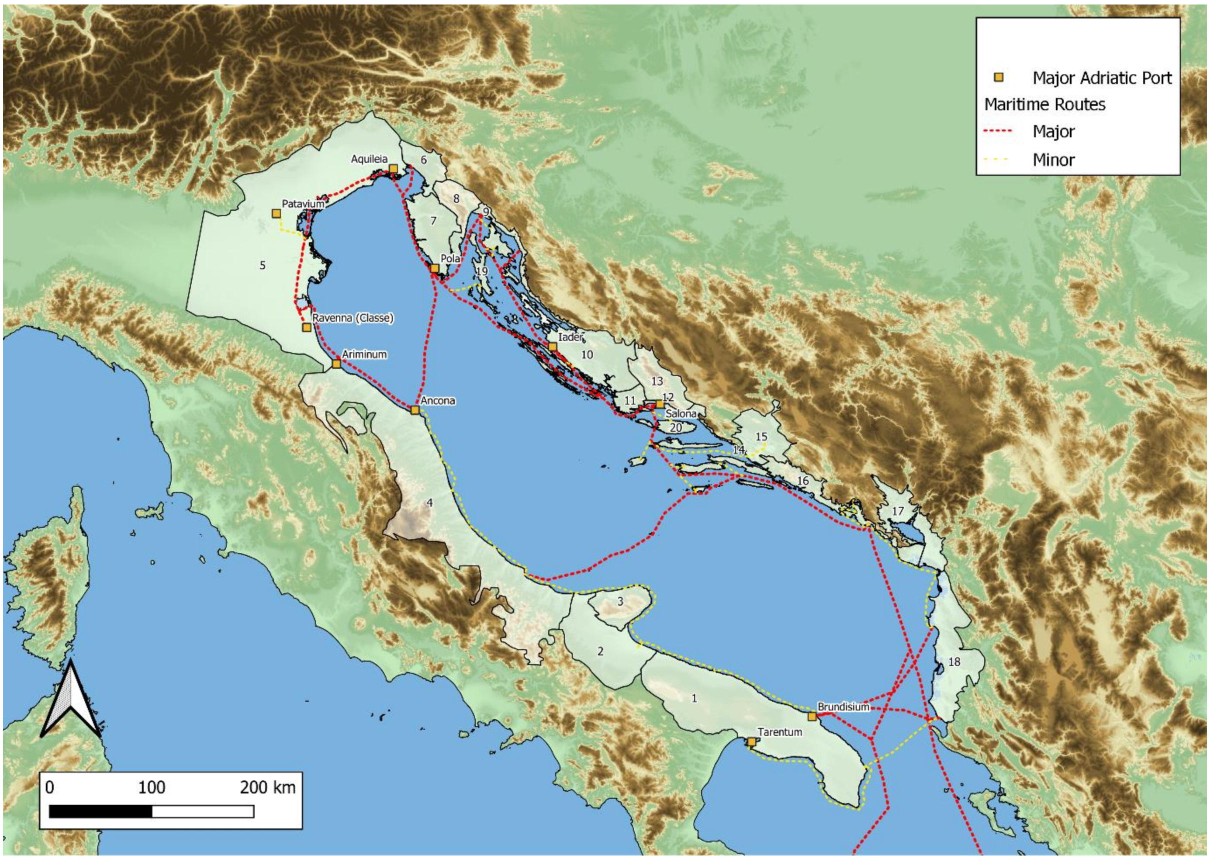
Comparing the different cmcvs also reveals some interesting patterns. Most striking is that the scenarios for moving west are the only ones *below* the sd range for the cmcv, but some of the few scenarios *above* the sd range for the difference as a percentage between the cmcv with and without infrastructure (Figure 6.44). This suggests that while movement west still appears significantly less prominent with infrastructure, the impact of infrastructure on movement west was more positive than for other directions, other than east. It is significant than east and west are the only directions with cmcv infrastructure differences above the sd range, suggesting infrastructure was more orientated towards improving movement east-west rather than north-south, at least where the urban centres are concerned. This would suggest a considerable level of investment in improving connections across the Adriatic, as opposed to movement north or south out of the region. The impact of directional movement appears less significant, with there being no obvious pattern, other than the highest values generally being colder, wetter months. Possibly suggesting that infrastructure acted to improve movement during what were presumably more dangerous sailing months more than during the drier safer sailing months. This would play in well with the idea port infrastructure primarily being concerned with safety as opposed to speed.

Other than cmcvs, we can also look at individual current mean values of urban centres (imcv) in order to better understand the hierarchy of sites across the region. These are much the same as the imcv without infrastructure, with all urban centres having positive imcv difference values. However, if we subtract the original imcv without infrastructure from those with, some new trends can again be observed (Fig. 6.45). More than half (53%) of these resultant values are negative, suggesting that many sites were negatively impacted by the presence of infrastructure. However, it should be kept in mind that the addition of infrastructure in this model required the addition of very high costs for transitioning between maritime and terrestrial movement. As such, these negative results more correctly indicate that transitioning between maritime and terrestrial movement was of greater importance in these sites. The negative values could also be a reflection of the prominence of east-west movement in the infrastructure analysis, with those sites where movement north or south was of greater concern having negative values. Moreover, it allows for a comparison of which sites were most impacted by the addition of infrastructure. Once again, there does not appear to be a straightforward correlation between population and these imcv infrastructure difference values, though the sites with the highest populations are generally above or within the sd range. Particularly interesting is the seeming reversal of the hierarchy of the largest sites. While Aquileia had the largest raw imcv value with or without infrastructure, the difference between these two is one of the most negative, being the only large site below the sd range. On the other hand, Dyrrachium and Iguvium are the only two large sites above the sd range (compare with Fig. 4.16). This would point to the infrastructure of the region acting to disproportionately improve the potential mobility of sites where the natural values were lower.

This can be applied to the micro-regions. As a proportion of the number of cities in each micro-region, several micro-regions have significantly negative overall values, particularly MRs 5 and 6 (Fig. 6.46). Again, these are two micro-regions where exchange north and south beyond the Adriatic appears to have been particularly important, and these negative values appear to reflect the importance of east-west movement in the infrastructure. Notably, two of the highest overall imcv by micro-region are in MRs 18 and 1, where the east-west connections between both have repeatedly been highlighted as signifcant. The fact these micro-regions are disproportionately positively impacted by the inclusion of infrastructure emphasises the importance of this east-west movement, and likely connection between these micro-regions, afforded by the regional infrastructure. It is also interesting that the two island micro-regions have very different results here, with MR 19 a large negative value, and MR 20 a signifcant positive value. The two island micro-regions have been distinct thus far, with the production of oil and especially wine in MR 20 being more apparent in MR 20 than MR 19. This appears to be reinforced by the inclusion of infrastructure. Moreover, this may hint at closer connections with the east and west in MR 20 than had been identified previously. It was suggested that the primary location of exchange for MR 20 would be north in MR 12. However, with this positive value which consistently favours east-west movement, we might expect the connections with the coasts to the east and west to have been more pronounced than we may at first have assumed. Indeed, as is discussed in Chapter 7, the islands of MR 20 represent an important crossing point east-west, much like MRs 1 and 18 to the south. The importance of exchange between MR 19 and Istria to the north, appears to be reinforced by this analysis.

By analysing the infrastructure of the Adriatic, the complex picture of potential mobility and connectivity has been expanded. It is clear that infrastructure disproportionately positively impacted potential movement east and west, and acted to improve the potential mobility of areas where this was naturally lacking, rather than reinforcing the natural trends already observed in Chapters 2 and 3. Certain micro-regions were in better positions for the natural mobility and agricultural potential of the landscape to be capitalised upon. Even if infrastructure appears to have lessened the divide between those micro-regions with high natural potential mobility and those with low, the same micro-regions and sites remain dominant overall, with the potential of MRs 4, 5, 7 and 12 to engage in specialised production and exchange remaining particularly likely. However, the infrastructure points to other micro-regions having engaged in similar practices, though likely on a more inter-regional scale, especially in MRs 1, 18 and 20.

# Section C: The Connecting Adriatic




This section combines the previous two, considering the physical as well as archaeological data, and ultimately analysing how far the Adriatic Sea can be seen to have connected the region. This is achieved through analysis of *amphorae* distributions and the shipwreck evidence.

# Chapter 7: Modelling Maritime Exchange: Shipwrecks and *Amphorae* Distributions

*'A man has had a successful voyage if he reaches the port for which he set out.'*- Seneca*, De Beneficiis, 2.31.3*

In order to understand complex economic systems, it is necessary to analyse patterns of exchange within the system. In the case of the Roman Adriatic, maritime exchange is of particular importance. The coastal waters of the Adriatic, like much of the Mediterranean, are littered with the wrecks and cargoes of what were, ultimately, failed voyages of exchange. The distribution of these (un)exchanged commodities, and the likely destination and origin of the vessels upon which they were stowed, provides a great deal of insight into the nature of the regional economy. With the provenance of so many *amphorae* forms being relatively well understood, we can use these archaeological remains to model patterns of exchange. In this chapter, a model for exchange across the Adriatic is proposed, with close reference to shipwrecks and their cargo of *amphorae*. The literary sources and the distribution of different amphora forms are first discussed, covering both the benefit and short comings of both types of evidence. Following this, the Adriatic shipwrecks themselves are analysed in detail, and finally the qualitative analysis is compared to the quantitative Circuit Theory outputs, and the model itself outlined. All of this builds on previous chapters to provide the basis of a complex but robust system of exchange that was focused on the Adriatic region.

## 7.1- Literary Sources and *Amphorae* Forms

The evidence for ancient patterns of exchange is diverse and often problematic. Frequently we must rely on incomplete proxy data. Nevertheless, by understanding the limits of the available data, we can develop considerable insight into these patterns. In what follows the limited amount of literary evidence for exchange is first outlined, before the different *amphorae* forms, produced within and beyond the region, are discussed.

### 7.1.1- Ancient Sources

The maritime routes discussed in the ancient sources are briefly outlined in Chapter 6. However, it is helpful to consider the implications of these in the specific context of maritime exchange. It is clear that a variety of different products were produced across the region (see Table 7.1). A variety of wines, mainly from the Italian coast, but stretching from the south through central Italy and the northern Adriatic, are described as amongst the best in the Roman world (Pliny, *Naturalis Historia*, 14.8). Additionally, Adriatic oil is known from across the region, though rarely do we get precise points of origins beyond Tarentum and Liburnia, notably on opposite sides of the region (Apicius, *De Re Coquinaria*, 1.7).[666] A variety of foodstuffs were also produced, and seemingly exchanged, across the region, including cheeses from both sides of the sea, and honey and fish. Textiles, particularly dyed wool, are also well known; primarily from the Italian Adriatic, and especially at Tarentum and across Apulia, which the ancient sources appear to agree are amongst the best anywhere. There is evidence for Adriatic trees being used for ship construction at Rome, the areas around Faventia and Lopsica appearing to have been particularly well forested, and it has also been suggested that there were stone masons at Narona in Dalmatia.[667] While the focus of this work is on Adriatic wine and oil, this very brief overview shows that other Adriatic products should be kept in mind, and would have made up a signifcant part of maritime cargo crossing the region.

**Table 7.1- Adriatic Commodities.**

*These commodities are mentioned in the ancient sources, with a rough location given where possible.*

| Name | Commodity | Location | Source |
|---|---|---|---|
| **Pizzino** | Wine | Timavus | Pliny, *Naturalis Historia*, 14.8 |
| **Praetunian** | Wine | Adriatic/Ionian | Pliny, *Naturalis Historia*, 14.8 |
| **Anconan** | Wine | Ancona | Pliny, *Naturalis Historia*, 14.8 |
| **Sprig-Vines** | Wine | Adriatic/Ionian | Pliny, *Naturalis Historia*, 14.8 |
| **Cezana** | Wine | Interior | Pliny, *Naturalis Historia*, 14.8 |
| **Maecenas** | Wine | Interior | Pliny, *Naturalis Historia*, 14.8 |
| **Tyroll** | Wine | Verona | Pliny, *Naturalis Historia*, 14.8 |
| **Adrian** | Wine | Adria | Pliny, *Naturalis Historia*, 14.8 |
| **Latiniensian** | Wine | Lower Sea | Pliny, *Naturalis Historia*, 14.8 |
| **Graviscan** | Wine | Lower Sea | Pliny, *Naturalis Historia*, 14.8 |
| **Statoniensian** | Wine | Lower Sea | Pliny, *Naturalis Historia*, 14.8 |
| **Adriatic Peach** | Fruit | Samnium | Pliny, *Naturalis Historia*, 15.11 |
| **Sardine** | Fish | Adriatic | Pliny, *Naturalis Historia*, 9.20 |
| **Fir Trees** | Wood | Adriatic Coast | Pliny, *Naturalis Historia*, 16.76 |
| **Marble Polish** | Sand | Adriatic Coast | Pliny, *Naturalis Historia*, 36.9, 36.51 |
| **Illyrian Salt** | Minerals | Lake Shkoder | Strabo, *Geographica*, 7.5.11 |
| **Tarentine Wool** | Textile | Tarentum | Pliny, *Naturalis Historia*, 29.2.9; Varro, *Res Rusticae*, 2.2.18; Collumella, 7.2.3 |
| **Taretine Honey** | Foodstuffs | Tarentum | Horace, *Carm.* 2.6; Varro, *Macrob. Sat.* 2.12 |
| **Taretine Wine** | Wine | Aulon | Martial, 13.125; Pliny, *Naturalis Historia*, 14.6 |
| **Taretine Oil** | Oil | Tarentum | Martial, 13.125; Pliny, *Naturalis Historia*, 14.6 |

[666] Glicksman (2007), 47-48.
[667] Wilkes (1969), 237-238.

| Name | Commodity | Location | Source |
|---|---|---|---|
| **Brundisium Wool** | Textile | Brundisium | Strabo, *Geographica*, 6.3.6 |
| **Brundisium Honey** | Foodstuffs | Brundisium | Strabo, *Geographica*, 6.3.6 |
| **Brundisium Fruits** | Fruit | Brundisium | Strabo, *Geographica*, 6.3.6 |
| **Apulian Wool** | Textile | Canusium | Strabo, *Geographica*, 6.3.10 |
| **Apulian Wool** | Textile | Luceria | Horrace, *Carm*. 3.15.14; Pliny, *Naturalis Historia*, 8.48 |
| **Meat, cheese and milk** | Foodstuffs | Sarsinia | Martial, 1.43.7, 3.58.35; Pliny, *Naturalis Historia*, 11.241 |
| **Sarsinian Wool** | Textile | Sarsinia | Martial, 1.43.7, 3.58.35; Pliny, *Naturalis Historia*, 11.241 |
| **Pottery** | Ceramic | Ariminum | Stillwell and Mcallister (1976), Ariminum, http://www.perseus.tufts.edu/hopper/text?doc=Perseus:text:1999.04.0006:entry=ariminum accessed 03/03/22 |
| **Wine *Amphorae*** | Ceramic | Forum Popili | Pliny, *Naturalis Historia*, 3.20 |
| **Faventian** | Wine | Faventia | Varro, *Res Rusticae*, 1.2.7; Collumella, 3.3.2; Silius Italicus, 8.598; Pliny, *Naturalis Historia*, 19.1 |
| **Faventian Linen** | Textile | Faventia | Varro, *Res Rusticae*, 1.2.7; Collumella, 3.3.2; Silius Italicus, 8.598; Pliny, *Naturalis Historia*, 19.1 |
| **Trees** | Wood | Faventia | Varro, *Res Rusticae*, 1.2.7; Collumella, 3.3.2; Silius Italicus, 8.598; Pliny, *Naturalis Historia*, 19.1 |
| **Stone Workshops** | Stone | Bononia | Stillwell and Mcallister (1976), Bononia, http://www.perseus.tufts.edu/hopper/text?doc=Perseus:text:1999.04.0006:entry=bononia accessed 03/03/22 |
| **Pottery** | Ceramic | Mutina | Pliny, *Naturalis Historia*, 35.46 |
| **Mutinan Wool** | Textile | Mutina | Pliny, *Naturalis Historia*, 35.46 |
| **Worked Bronze** | Minerals | Atteste | Pliny, *Naturalis Historia*, 3.23 |
| **Patavium Wool** | Textile | Patavium | Strabo, *Geographica*, 5.1.7; 5.1.12 |
| **Altinum Wool** | Textile | Altinum | Martial, 14.155; Pliny, *Naturalis Historia*, 32.11; Cassiodorus, *Variae*, 12.22 |
| **Shellfish** | Fish | Altinum | Martial, 14.155; Pliny, *Naturalis Historia*, 32.11; Cassiodorus, *Variae*, 12.22 |
| **Istrian Corn** | Foodstuffs | Istria | Cassiodorus, *Variae*, 12.23-24 |
| **Istrian Wine** | Wine | Istria | Cassiodorus, *Variae*, 12.23-24 |
| **Istrian Oil** | Oil | Istria | Cassiodorus, *Variae*, 12.23-24 |
| **Lopsica Lumber** | Wood | Lopsica | Wilkes (1969); Pliny, *Naturalis Historia*, 3.25 |

| Name | Commodity | Location | Source |
|---|---|---|---|
| **Dalmatian Wine** | Wine | Coastal, exported from Salona | Wilkes (1969), 237-238 |
| **Dalmatian Oil** | Oil | Coastal, exported from Salona | Wilkes (1969), 237-238 |
| **Stone Workshops** | Stone | Narona | Wilkes (1969) |
| **Doclea Cheese** | Foodstuffs | Doclea | Pliny, *Naturalis Historia*, 11.97 |
| **Liburnian Oil** | Oil | Liburnia | Apicius, *De Re Coquinaria*, 1.7 |

### 7.1.2- *Amphorae*

A combination of ancient sources, primarily the geographers, and *amphorae* typologies have been used in the past to suggest possible patterns of exchange in the Adriatic. For example, Canusium was a centre for Lamboglia 2 wine *amphorae* production, and the rise of wool from Canusium appears to coincide very closely with the decline of Lamboglia 2 circulation (Strabo, *Geographica*, 6.3.10).[668] As such, it has been suggested that production at Canusium was market orientated, with the proliferation of exchange in Apulian wool being a response to a decreasing market for Adriatic wine.[669] Other sites have been singled out as not only exporters, but centres of exchange, acting as *emporia*. This includes large sites already well discussed such as Aquileia, Salona and Narona, but also lesser known sites, such as Anxanum, Senia, Vegium and Tarsatica.[670] Indeed, it has long been suggested that some sites in the region were reliant on local centres of exchange, whether these were large, populous and far reaching centres, or the smaller, more local.[671] Even from a cursory examination of the ancient evidence, it is clear that there existed across the Adriatic large extra-regional commercial centres, as well as more local centres, facilitating exchange within the region and micro-regions, with market orientated specialised production reliant on maritime exchange. In this section, the *amphorae* evidence is discussed in more detail, with reference to the inherent issues in analysing *amphorae* produced in the Adriatic region, before discussing the varying forms of *amphorae* found in the Adriatic, wherever they may have been produced.

[668] Gofreddo (2015).
[669] Roe (1992), 92-97.
[670] See the epigraphic evidence for Anxanum in Romanelli (1817), 204; Wilkes (1969) 200-202 and Pliny, *Naturalis Historia*, 3.25 for Senia, Tarsatica and Vegium.
[671] See, for example, Wilkes on Nedinum's reliance on Iader (1969), 212-214.

*7.1.2.1- Amphorae from the Adriatic*

The issues with understanding the *amphorae* evidence have been discussed in Chapter 5. However, it is again helpful to consider these issues in relation to maritime exchange. First of all, the forms of Adriatic *amphorae* are not particularly well documented. While there certainly appear to be distinct forms that can be linked to the region, and even specific sites within the region, this is a relatively recent development, with forms now considered distinct, having been conflated for decades.[672] The main Adriatic forms are the Dressel 6A/6B, Forlimpopoli, Lamboglia 2 and the Adriatic iterations of Dressel 2-4 and Greco-Italic *amphorae* (See Fig. 5.7 and Table 5.1). These are produced across the Adriatic, north to south and along both coasts, and identifying specific production sites is largely impossible.[673] It is beyond the scope of this work to expand significantly on the understanding of the extra-regional distribution of Adriatic *amphorae* forms. However, it is clear that Lamboglia 2 were widely distributed across the Mediterranean, in particular along the coasts of Gaul and southern Spain, but also north Africa, Sicily and the Aegean.[674] The distribution of Dressel 6A *amphorae* is less widespread with some examples in Gaul, the Aegean, Egypt and Cyprus, and the majority being in northern Italy.[675] Dressel 6B have similar distributions, mainly in northern Italy, but extending east along the Danube, and north beyond the Alps.[676] While we have clear evidence for maritime export of Adriatic wine and oil beyond the region, it appears to have been relatively limited, and to have reduced in scale by the Imperial period, with the Republican Lamboglia 2 and Dressel 6A having the widest extra-regional scope. Additionally, of the 1,718 non-Adriatic sites in the OXREP shipwreck database, there are only 16 which mention any of the main Adriatic *amphorae* forms, and one additional wreck site which Strauss suggested as having a cargo with a likely Adriatic origin (Table 7.2).[677] This likely reflects the difficulty in identifying the Adriatic forms of *amphorae* outlined above. Nevertheless, it is striking that there is such an apparent dearth of evidence for Adriatic maritime exports of wine or oil beyond the region.

[672] See especially Van Limbergen (2018), 201-206.
[673] For an exception to this, see the Laecanius amphorae stamps from the Birjuni islands, Istria, in Bezeczky (1998).
[674] Jurišić (2000), 105; Van Limbergen (2018), 206-209.
[675] Jurišić (2000), 107; Van Limbergen (2018), 210-212;
[676] Marion and Tassaux (2020), 31-33.
[677] See Strauss (2013) for full details of these 17 sites.

**Table 7.2- Non-Adriatic Sites.**

*Submerged sites that have cargoes with a likely Adriatic origin, but were found beyond the region itself. After Strauss (2013).*

| Name | Place of origin | Place of destination |
|---|---|---|
| **La Fourmigue C** | Aegean via Cosa | France |
| **Areopolis** | Adriatic | Aegean |
| **Alexandria A** | Adriatic | Alexandria |
| **Antikythera A** | Alex/ Pergamum/ Aegean | Rome |
| **Paros B** | Adriatic? | |
| **La TradeliŠre** | Aegean via southern Italy | France |
| **Cape Kiti B** | Adriatic? | Cyprus/Levant? |
| **CavaliŠre** | General Mediterranean? | France |
| **Valle Ponti** | Spain, Aegean, Adriatic | Northern Italy |
| **Albenga** | | |
| **Aragnon** | | |
| **Arles IV** | Baetica | |
| **Pointe Cacalu** | Campania | |
| **Calanque Devenson 1** | | |
| **Punta Licosa 2** | | |
| **Cala del Diavolo** | | |
| **Thasos B** | Adriatic | Aegean? |

### *7.1.2.2- Amphorae in the Adriatic*

There are 54 identified *amphorae* forms from submerged contexts in the region. These include the Adriatic forms as well as forms that must have been imported from beyond the region (See Table 7.3 and Fig. 7.1).[678] The most common origin for these forms is the Adriatic itself, with around 31% of all occurrences having an Adriatic origin. The Aegean and Spain are the next most common, with 20% and 11% of occurrences respectively. While this analysis does not take into account cargo sizes or number of vessels at each site, simply understanding the frequency with which certain forms were a component of the cargoes moving across the Adriatic provides important insights into the mechanisms under which any regional economy may have been organised. Of the forms with identified regions of

[678] It should be noted that some sites have multiple amphorae forms, hence a total of 164 occurrences at 145 sites.

origin, the Adriatic and Aegean are the only with occurrences more than one standard deviation (sd) above the mean, i.e., are above the sd range, and none are below the sd range. This suggests that cargoes with an Adriatic and Aegean component to them are significantly more common than those containing *amphorae* with different regions of origin. This might indicate that the connections with the eastern Mediterranean were more important than those of the western. That being said, if we combine the region of origins in order to indicate only an Adriatic or eastern or western Mediterranean origin, this eastern prominence is less compelling. This gives 35 occurrences with eastern origins, 49 with western and 51 with Adriatic. It is apparent that inter-regional maritime exchange was a major component of the Adriatic economy, while extra-regional exchange with the Aegean and much of the western Mediterranean were important aspects of this wider economic system. While this system was undoubtedly complex, by simply analysing the frequency with which certain forms occur, we can begin to intuitively understand basic aspects of this system, before the more complex facets are modelled. More complex analysis requires understanding of the submerged sites themselves, rather than the occurrences of *amphorae* forms alone.

**Table 7.3- *Amphorae* Forms in the Adriatic.**

*The amphorae forms from the submerged sites in the Adriatic. A single site can have multiple amphorae forms, so the total sum of occurrences here is greater than the total sites. See also Fig. 7.1.*

| Form | Occurrences | Region of Origin |
|---|---|---|
| **Aegean** | 2 | Aegean |
| **Aegean ER1** | 1 | Aegean |
| **African** | 2 | North Africa |
| **African 2** | 1 | North Africa |
| **African 2A-C** | 1 | North Africa |
| **African 1** | 1 | North Africa |
| **Baldacci 2A** | 1 | Adriatic |
| **Bel.2A** | 4 | Spain |
| **Bel.2B** | 1 | Spain |
| **Brindisi** | 1 | Adriatic |
| **Central Italian** | 1 | Central Italy |
| **Coan** | 3 | Aegean |
| **Cretan AC4** | 1 | Aegean |
| **Dr.10** | 2 | Spain |
| **Dr.1A** | 1 | Tyrrhenian Italy |
| **Dr.1C** | 1 | Spain |
| **Dr.2-4 (Greek/Coan)** | 10 | Aegean |
| **Dr.2-4 (Spanish)** | 1 | Spain |
| **Dr.2-4 (Italian)** | 2 | Italy |
| **Dr.2-4 (Unconfirmed)** | 15 | Uncertain |
| **Dr.20** | 7 | Spain |
| **Dr.21-22** | 1 | Italy |

| Form | Occurrences | Region of Origin |
|---|---|---|
| **Dr.28** | 1 | Western Mediterranean |
| **Dr.29** | 1 | Uncertain |
| **Dr.35-36** | 1 | Aegean |
| **Dr.43** | 1 | Aegean |
| **Dr.6A** | 13 | Adriatic |
| **Dr.6B** | 1 | Adriatic |
| **Dr.7-11** | 1 | Spain |
| **Egyptian** | 3 | North Africa |
| **Form.** | 13 | Adriatic |
| **G4** | 2 | Gaul |
| **Grado 1** | 1 | Adriatic |
| **Greco-Italic** | 2 | Italy |
| **Haltern 70** | 1 | Spain |
| **Keay 25** | 1 | North Africa |
| **Keay16** | 1 | Lusitania |
| **La.2** | 18 | Adriatic |
| **La.2/Dr.6** | 2 | Adriatic |
| **La.2/Dr.6A** | 1 | Adriatic |
| **Late Graeco-Italic** | 1 | Italy |
| **Late Roman** | 1 | Uncertain |
| **MR4** | 2 | Eastern Mediterranean |
| **Portorecanato** | 2 | Northern Italy |
| **Punic/Imperial African** | 1 | North Africa |
| **Rhodian** | 9 | Aegean |
| **Rhodian imperial** | 4 | Aegean |
| **Richborough 527** | 3 | Southern Italy |
| **Sicilian** | 1 | Southern Italy |
| **Tripolitanian** | 2 | North Africa |
| **African 3** | 1 | North Africa |
| **Knidian** | 1 | Aegean |
| **3 handled ovoid vessel** | 1 | Uncertain |
| **atypical horn handled** | 1 | Uncertain |
| **horn-handled** | 1 | Uncertain |
| **Unidentified** | 9 | Uncertain |

## 7.2- Adriatic Shipwrecks

Now that the basic information from ancient sources and *amphorae* forms has been outlined, we can begin to analyse the submerged archaeological landscape of the Roman Adriatic. The database of sites can be found in Appendix J. These data are mainly drawn directly from Strauss (2013) and supplemented by various sources where appropriate, particularly Jurišić (2000), with the cargo region of origins and ship destinations altered and expanded through my own interpretations. It may be more accurate to consider the data used as 'submerged sites'. While most of the 145 sites are suspected shipwrecks, some ports with *amphorae* finds are also included, as they presumably represent cargo for maritime exchange. Additionally, some sites identified as shipwrecks may in fact simply be flotsam or jetsam, or indeed submerged coastal sites. Nevertheless, as most sites are quite clearly shipwrecks, I will typically refer to these data collectively as shipwrecks sites. In what follows, the issues with shipwreck data are first outlined and the Adriatic data itself explained and analysed broadly, before the imports and exports and the possible destinations and origins of the ships and associated cargoes are addressed more specifically. Finally, the overall pattern of inter-regional exchange within the region is examined. This provides a general scheme for how exchange across the Adriatic was conducted, before the circuit theory outputs of previous chapters are used to build upon this in a more quantitative manner.

### 7.2.1- Limitations of Shipwreck Data

While shipwreck data undoubtedly represent a rich source of information, they are not without their biases. First of all, as with any collection of archaeological data, this database cannot be anything like complete. The majority of these sites were discovered due to the presence of *amphorae*, rather than the perishable wooden hulls of the vessels themselves.[679] Furthermore, it must be kept in mind that wrecks represent failed voyages, whether due to adverse weather conditions or scuttling.[680] As such, even if we had access to all of the ships that had ever sunk in the Adriatic, their cargoes would represent only a fraction of what was transported across the sea successfully. One compelling example of this is the lack of grain ships we have evidence for anywhere across the Mediterranean. These were some of the largest and most important cargo vessels during the Roman period, yet we have no archaeological evidence for any such ships on the sea floor.[681] This could be due to multiple factors, one being that grain is a highly perishable material, unlike *amphorae*, and another being that the ships carrying these vital cargoes appear to have followed very direct, highly controlled routes, likely avoiding the harsher sailing conditions of certain seasons, where other smaller, more independent enterprises would be more willing to risk poorer conditions for a quick profit, thus, making their ships more likely to sink.[682]

The coastal nature of shipwreck data is also problematic. For many years, it was assumed that coastal tramping was the main modus by which ancient maritime exchange was conducted.[683] This

[679] Several sites in the northern Adriatic are the opposite of this, *i.e.* have well preserved hulls but no cargo. However, these represent the exceptions. See Beltrame and Gaddi (2013).
[680] See Rossi and Boetto (2020) for scuttled Adriatic ships near Caska.
[681] For example, the Isis described in Lucian, *Navigium*, 14.
[682] Bevan (2013), 3-4.
[683] See especially Nieto (1997), 156-158. For more recent discussions around this, Russell (2011); Rice (2016); Leidwanger (2017).

appears to make sense when the distribution of wreck sites is considered, as they cluster overwhelmingly along the coasts (Fig. 7.2). However, this can be explained more pragmatically in two main ways. First of all, most ships sink because they collide with something, and so are far more likely to sink leaving or entering a harbour, or when sailing by rocks, than they are when sailing on open waters.[684] As such, we would expect more coastal wrecks, whether there were more coastal voyages or not.[685] Additionally, archaeological bias comes into play. Finding wrecks on the seabed in areas of open water (with the Mediterranean having a maximum depth of 5,200 m and the Adriatic 1,200 m) is an expensive and painstaking undertaking, requiring specialist equipment and researchers.[686] The discovery of coastal wrecks, on the other hand, is, more often than not, made by private recreational divers. This is further emphasised by the seeming scarcity of wrecks along the north African coast, where recreational diving is less common than on the Mediterranean coast of France or the Adriatic.

Nevertheless, despite all of these complex issues, the wealth of insight which is offered by the shipwreck data is considerable. Shipwreck data have been used to model patterns of exchange across the ancient Mediterranean ranging from small scale cabotage/tramping to the more direct and organised systems indicative of economic specialisation and cohesion.[687] As is shown, despite the issues with analysing shipwrecks, these data allow for a complex system of multiple scales to be reconstructed in the Adriatic.

### 7.2.2- The Adriatic Database

The database is made up of a total of 145 sites, a summary of which can be found in Fig. 7.3 and Appendix J. While this study is largely non-chronological, focusing on a relative snapshot in time as opposed to developments or changes over time, the period and date range, where possible, of each site is provided. The majority of these sites have relatively large possible date ranges, and for some, precision beyond the general Roman period cannot be provided (see Fig. 7.4). Nevertheless, the available data does suggest that the majority of submerged Adriatic sites are imperial, most dating somewhere between the end of the 1st century BC and the end of the 4th AD.

The origin of the cargo and the destination of the ship are also included in the data (see Figs. 7.5 and 7.6). These origins and destinations build upon the work of Strauss. Cargo origins are fairly straight forward, simply being the place region of origin for the bulk of the cargo. It is often difficult to be any more precise than the regions highlighted, and in some cases the origin remains uncertain. The

[684] Although for today at least, mortality rates are lower closer to the coast, Weng and Yang (2015).
[685] See Robinson *et al.* (2020), for more detailed discussion of the correlation between wrecks and safety safety.
[686] See, for example, Ballard *et al.* (2000).
[687] See especially Berti (1990); Nieto (1997); Arnaud (2005); Russell (2011), 148-151; Beresford (2013); Russell (2013), 110-140; Rice (2016); Leidwanger (2017); (2020); Robinson *et al.* (2020).

destination of the ship is somewhat more complicated. This is often based on the cargo origin. If, for example, the cargo was clearly produced in Rhodes, it is unlikely that the ship carrying this Rhodian cargo would be in the Adriatic unless the destination of the vessel (which is not necessarily the same as the ultimate destination of the cargo itself) was somewhere within the Adriatic. Of course, this might represent a vessel collecting a Rhodian cargo previously exchanged in the Adriatic, for consumption beyond the region. However, this would still be indicative of exchange between Rhodes and the Adriatic, whether the cargo was consumed in the Adriatic region or not. The location of the wrecks can also help to inform the possible destination. If the Rhodian cargo was discovered along the south-western coast of the region, this might indicate that it did indeed represent secondary exchange, as a ship sailing from the east into the Adriatic would most likely use the eastern coast, as has been shown throughout this study. Specific examples of particular note or representative value discussed below, but it is important to highlight from the offset that 'origin' here refers to the general region of origin of the cargoes, and 'destination' to the likely destination of the ships carrying the cargo, wherever the cargo was ultimately to be consumed.

Looking first at distributions across the region, most immediately striking is the concentration of sites along the eastern coast, as compared to the western coast. This might be due to less actual maritime traffic and exchange along the western coast. However, as has been highlighted, this could similarly be a reflection only of wreck sites rather than actual traffic. Indeed, the many craggy islands and inlets of the eastern coast, while often providing safe harbour, also offer far more opportunity for wreckages than the relatively uniform, sloping beaches of the opposing coast. Moreover, recent maritime survey projects have focused specifically on the Illyrian coast, and have brought to light numerous new submerged sites in the eastern Adriatic, in a way which has not been mirrored on the Italian coast to date.[688] Additionally, much of the recreational diving in the Adriatic appears to be undertaken from the Croatian coast, while Italian diving sites are more typically located on the Tyrrhenian rather than the Adriatic coasts.[689] As such, we would expect to have more known wreck sites on the eastern coast than on the western coast, whether there was more actual exchange taking place on either coast or not. Nevertheless, the difference is striking, and as has been discussed and will be expanded upon below, the evidence for this representing an actual disparity in the level of maritime exchange on each coast is quite convincing.

An additional apparent gap in the data points can be found along the southern coast of Montenegro and the northern coast of Albania, corresponding roughly to the coasts of MRs 17 and

[688] See especially Royal (2018).
[689] This is largely anecdotal, but when searching 'Adriatic Diving' the top results are all Croatian, while 'Italian Diving' provides Tyrrhenian results as opposed to Adriatic.

18. As has been highlighted throughout, this is generally a relative blank spot when it comes to archaeological evidence. This is not necessarily because there was little production or exchange occurring across these micro-regions, but rather a result of the relative lack of research focused on these areas. The adjoining areas north and south of these coasts are far better researched, published and understood. However, while the majority of the Illyrian Coastal Exploration program (ICEP) focuses north of MR 17, recent publications have alluded to traffic, if not actual points of exchange, along this coast.[690] The exact locations of these sites have not been published, to my knowledge, but a breakdown of the *amphorae* found can be found in Table 7.4. These contain most of the common Adriatic forms, as well as some that are not documented elsewhere at submerged Adriatic sites.[691] While, like much of the Dalmatian coast, there are a large number of eastern Mediterranean *amphorae* from this Albanian subsample, these are generally forms identified elsewhere across the Adriatic, i.e. Late Roman *amphorae*. On the other hand, the western Mediterranean and north African *amphorae* identified here by ICEP are far rarer, or entirely absent, elsewhere in the Adriatic. This would suggest that the east-west exchange in the south of the Adriatic included commodities that were generally not exported further north, instead either being consumed along the Albanian coast, or traded further inland to Macedonia, along the *Via Egnatia*.[692] Given the limited shipwreck evidence for this, it might be that this exchange was relatively minor, but again, the nature of shipwreck evidence has to be considered. The coast of northern Albania is far more like that of Adriatic Italy, than of Croatia, with few islands, and so wrecks here are less likely either to occur or be discovered, particularly with recreational diving in Albania primarily being focused on the southern coast rather than this far north.[693] Furthermore, this stretch of coast can be thought of as a large bay, bowing in from the coast to the north. For vessels sailing towards the northern Adriatic, or south out of the region, it may have been more efficient to sail directly south from Olcinum or Butua, rather than hugging the northern Albanian coast here. All of this would again result in fewer shipwrecks being discovered along this stretch of coast, even if there were high levels of traffic. Finally, as the primary pattern of exchange in this area of the region is between the east and west, and thus relatively short journeys, we may again expect fewer wrecks. This small subsample of data represents a very interesting insight into a part of the region that is largely understudied, but does appear to suggest that a distinct pattern of exchange was present here, involving both coasts of the Adriatic and the wider Mediterranean, and representing a complex wider economy of multiple scales.

[690] See Royal (2018), especially 28-30.
[691] Royal (2015).
[692] Karivieri (2008).
[693] Fir example Sarandë, near Butrint.

**Table 7.4- *Amphorae* Forms from the Albanian Coast.**

*Subset of amphorae forms documented through ICEP, after Royal (2018).*

| Form | Occurrences | Region of Origin |
|---|---|---|
| **La.2** | 20 | Adriatic |
| **Dr.1A** | 2 | Tyrrhenian Italy |
| **Dr.1B** | 1 | Tyrrhenian Italy |
| **Pascual 1** | 1 | Spain |
| **Dr.6A** | 4 | Adriatic |
| **Rhodian** | 6 | Aegean |
| **Dr.5** | 1 | Aegean |
| **Dr.2-4** | 11 | Italy |
| **Form.** | 15 | Adriatic |
| **Dr.9/10** | 1 | Spain |
| **Dr.28** | 2 | Spain |
| **Dr.20** | 4 | Spain |
| **Dr.24** | 1 | Asia Minor |
| **African 1** | 4 | North Africa |
| **Empoli** | 3 | Adriatic |
| **Dr.30** | 1 | North Africa |
| **Cretan 1** | 1 | Aegean |
| **LRA 4** | 20 | Eastern Mediterranean |
| **African 3** | 4 | North Africa |
| **African 2D** | 1 | North Africa |
| **Beltran 72** | 4 | Spain |
| **Dr.23** | 1 | Spain |
| **LRA 1** | 32 | Eastern Mediterranean |

The cluster of sites around the Salento peninsula, visible on Fig. 7.2 again, offers some insight into the wider mechanisms of exchange. The large concentration here can be explained relatively simply. These wrecks may represent voyages and exchange between the wider Mediterranean world and the Adriatic, as well as exchange that did not have the Adriatic as a destination or an origin. Some of the cargoes here may have been destined for an Adriatic location, but others may simply represent exchange east to west, having ended up in the Adriatic region after being blown off course while sailing across the Ionian. Indeed, the concentration of sites around the Salento peninsula is quite remarkable even beyond an Adriatic context, attracting frequent reanalysis with new and innovative techniques.[694] These Adriatic sites around the south of the region are unique in this respect, and the large number of sites should be understood with the greater volume of traffic and exchange that would surely have been traversing this area when compared to the Adriatic alone.

[694] For example at the Torre Santa Sabina, Calantropio *et al.* (2021).

A relative lack of sites can also be observed in the northern Adriatic. This area of the region has featured very prominently in the discussion so far, and so the lack or wreck sites may seem surprising. There is an extremely large concentration around the Istrian peninsula, but the rest of the northern Adriatic is quite sparse. This can be viewed, in the first instance, in terms of the infrastructure of this area discussed in Chapter 6. The canal system made this a particularly safe stretch of coast to traverse, as is pointed out explicitly by Cassiodorus (*Variae*, 12.24).[695] As such, once again, fewer wreck sites need not suggest less actual maritime exchange or traffic. Furthermore, the only fluvial wrecks discovered in the region are from this area; indeed, most of the northern Adriatic submerged sites are fluvial rather than maritime. As the majority of 'maritime' traffic along this coast presumably used the very safe canal system and lagoons, we would expect relatively more fluvial wrecks from this area.[696] Beyond this, the lagoons and marshy landscape of the northern Adriatic are particularly well suited to the preservation of organic material, and more than elsewhere, the shipwrecks here include well preserved wooden remains, with several having no known cargoes, and only the remains of the ship's hull surviving. With all of this, we once again should not take the lack of wreck sites in the northern Adriatic as directly correlating to less exchange, rather a different system of exchange and archaeological bias.

### 7.2.3 Cargo Origins and Ship Destinations

As has been highlighted, the majority of sites represented in the study area appear to have had ship destinations or cargo origins within the Adriatic (See Figs. 7.7 and 7.8). This is not unexpected, as for virtually all sites discussed, the origin or destination must have been somewhere in the Adriatic, otherwise there would be no reason to enter the Adriatic at all. While this Adriatic prominence is true for cargo origins, it is more pronounced when looking at the likely destination of the ships. This would seem to be in line with the basic analysis of *amphorae* forms, suggesting higher levels of maritime import into the region than export, with much export being terrestrial or fluvial, and with inter-regional exchange being particularly important in this maritime setting. The difference between destination and origin may be explained simply by the fact that determining specific destinations is generally more difficult than determining cargo origins. If a cargo with an origin outside of the Adriatic is discovered in the Adriatic, it is easy to conclude that the ships destination must have been in the Adriatic, whether the cargo would ultimately be consumed in the region or not. In any case, the origin and destination discussed here are not definitive, but are based on a combination of factors, some of examples of which are discussed below.

[695] Bjornlie (2019), 491-492.
[696] Uggeri (1997); D'Agostino and Medas (2010), 288.

*7.2.3.1- Ship Destinations*

Despite the variety of possible destinations for the Adriatic ships, the overwhelming majority likely had Adriatic destinations. Of the 145 sites, 111 (76%) have likely Adriatic destinations (Fig. 7.6). These generally appear to be destined for the major ports of the northern Adriatic, or the Dalmatian coast (more detail can again be found in Appendix J). This is important, as these sites in particular could represent intermediary emporia like sites, from which wider export to the interior of the central European provinces or into Dalmatia and along the Danube could be conducted. Imports from the wider Mediterranean primarily entered the region through maritime exchange. However, these would not all have been consumed within the region. Instead, some would be exported over land from Adriatic hubs. Exchange of these commodities would bring imports from the provinces beyond the Alps, which would be both consumed within the region, and, importantly, exported from Adriatic ports to the wider Mediterranean. This begins to point to inter-regional exchange being a major component of the system of maritime in the region, even if the commodities themselves came from or were destined for extra-regional consumption locations.

Of those few ships which appear to have had destinations beyond the region (11), there are slightly more western Mediterranean (seven) than eastern (four). This is again largely in line with the *amphorae* form occurrences, possibly suggesting somewhat more exchange with the west than the east. However, the seeming preference for western export should be understood in the context in which the sites were discovered. All of these cargoes with likely western destinations are around the Salento peninsula (nos. 3, 5, 6, 7, 9, 10 and 13, Fig. 7.3). It is difficult to tell whether wrecks on the eastern Adriatic coast were sailing along this coast before heading west or east at the mouth of the sea, as there is a clear preference for using the eastern coast for movement north and south. On the other hand, wrecks around the Salento peninsula, at the mouth of the Adriatic, are unlikely to have been leaving the Adriatic with intended destinations in the east. Moreover, for six of these Salento sites the origin of the cargo was likely the south of the Italian Adriatic.[697] For voyages such as these, sailing along the more efficient and safer eastern coast would be unnecessary given the western origin and destination. For voyages beginning further north in the region, this may have been worth the extra step of crossing back and forwards east to west across the sea. The concentration of wrecks around the Salento peninsula may in part even be due to the relatively high risk associated with sailing along the western coast as opposed to the east. On the other hand, the cargoes with likely eastern destinations are spread more evenly along the entire eastern coast but, once again, all have Adriatic

[697] For the production sites of the Adriatic amphorae forms in these cargoes, see Carre *et al.* (2014) and Van Limbergen (2018) and 4.2.3 above.

Italian origins (nos. 11, 32, 44, and 62, Figs. 7.3 and 7.3a). The Sason 1 wreck (no.11) represents a cargo of Lamboglia 2 *amphorae*, produced in the Adriatic, likely in central Italy (see Chapter 5).[698] This cargo was found off the island of Sason, which is south of any of the eastern Adriatic centres. It may be that this cargo represents a voyage between Brundisium and Appollonia, however, there is more evidence for Lamboglia 2 production in the central Italian Adriatic, and so the position of this cargo in the south-eastern extreme of the region, suggests an intended destination in the eastern Mediterranean.

While the occurrence of *amphorae* forms from the Aegean is significant, there is only a single cargo that appears to have been destined for the Aegean. The main component of the Lastovska wreck's cargo was Adriatic Lamboglia2/Dressel 6A transitional vessels, but included multiple Rhodian *amphorae* on board.[699] This suggests a return trip between the Aegean and the Adriatic. The Aegean cargo had been unloaded, likely somewhere in the central Italian Adriatic, and the Adriatic cargo loaded for export back to the Aegean. The position of this wreck in particular suggests that it may represent something of a rare occurrence, movement west to east across the open sea. It is possible that the Adriatic origin was in fact along the eastern coast, possibly at Vis, but central Adriatic Italy was a hub for Lamboglia2/Dressel 6A *amphorae* production, and the position along the coast of Miljet would be in keeping with a voyage from the Italian coast using the Croatian islands wherever possible for safe harbour and landmarks before sailing south out of the region along the eastern coast. Indeed, there appears to be an east west route just north of the Gargano peninsula, where a series of islands would provide harbour and landmarks for sailors to make the crossing.[700]

Analysing the few extra-regional destinations suggests that the apparent greater number of ships with western destinations as opposed to eastern, may not be quite as significant as it first appeared. The prominence of western destinations does not seem to be supported, with the number of ships with such destinations likely reflecting the danger of circumnavigating the Salento peninsula rather than much greater levels of western export or traffic. Additionally, the eastern coast being the primary route across the Adriatic appears to be reinforced, with those wrecks found along the western coast mainly having likely destinations in the west of the region, and those on the eastern coast having more varied likely inter-regional and extra-regional destinations. Indeed, I would suggest that the preference for the eastern coast would likely make exchange with the east at least as common as exchange with the west.[701]

[698] Royal (2018).
[699] Vrsalović (1974), 53, 240; Jurišić (2000), 69; Strauss (2013).
[700] See Kirigin *et al.* (2009) for the importance of some of these islands.
[701] See Bekić and Pešić (2015); Royal (2015); Bekić and Royal (2016) for detailed discussions of these eastern connections in the Adriatic.

*7.2.3.2- Origin*

As has been noted, the prominence of cargoes from the Adriatic is slightly less marked than that of ships destined for the Adriatic. 76 of the 145 cargoes have likely Adriatic origins, 52% compared to the 76% ships with Adriatic destinations (Fig. 7.5). The imbalance between east and west is somewhat reduced when looking at the origins. Of those that can be identified, 28 were likely from the eastern Mediterranean, primarily the Aegean, while 24 were likely from the west. It is notable that this appears to be the inverse of what the cargo destinations suggested. This makes sense when we consider the nature of entering the Adriatic from east or west. As has been highlighted, many of the wrecks with likely western destinations were only identified as such due to their position along the Salento peninsula, not through the composition of their cargo. While it is difficult to determine ship destination based on cargo alone, it is more straightforward to identify origins based on the cargo, whatever the location of the wreck. As such, we would expect somewhat more evidence for ships with western destinations than eastern, but a more complete picture for cargo origins. As such, the prominence of eastern cargoes seems to further question the concept that there were stronger connections between the Adriatic and the west, perhaps even indicating more imports from the east.

The Aegean is the second most common likely origin for cargo, representing 15% of the total identified. These wrecks are primarily on the eastern coast (Fig. 7.6), with the furthest north being the Kvarner Gulf wreck near Nesactium, Istria (no. 125, Fig. 7.3b).[702] These cargoes appear to represent frequent exchange between the Aegean and primarily the ports of the northern Adriatic, though the major ports of the Dalmatian coast were surely also a major component of this.[703] It is notable that the concentration of sites in the north east, near Tarsatica/Lopsica, does not include any of these cargoes of Aegean origin, perhaps suggesting that exchange with the Aegean was conducted primarily at relatively few emporia sites on the eastern or northern coasts, such as Aquileia, or Salona.[704] The Ancona 1 wreck (no. 77) is an exception to this, as it is likely the destination of this ship with a primarily Rhodian cargo was on the western coast at Ancona, likely having sunk while crossing east to west after entering the region along the eastern coast. Additionally, there are two Aegean cargoes in the southern Adriatic, at Torre Chianca (no. 9) and Punta del Serrone (no. 12). These two sites are the only that likely did not have either Adriatic origins or destinations. The Torre Chianca had a cargo of five *cipollino* marble columns, likely bound for Rome but sunk in the Gulf of Taranto.[705] The Punta del

[702] Parker (1992), 561; Strauss (2013).
[703] Royal (2015).
[704] See Arnaud (2005) for a discussion of such ports in the Adriatic, with Aquileia and Salona being prominent, especially 196-199.
[705] Russell (2013), 119.

Serrone had a cargo consisting of bronze statuary that was likewise most probably destined for Rome.[706] However, this wreck was found near Brundisium, and so the possibility that it was destined for somewhere in the Adriatic (eg. Brundisium itself) remains, though, in all likelihood, the ultimate destination would have been Rome in any case. Even with these sites, the ships may have been destined for Adriatic sites, or were only in the region incidentally, having been blown off course. This highlights one important aspect of the Adriatic being a semi-closed sea, that engagement with wider maritime exchange would have been relatively direct, that is, maritime voyages would not pass through the Adriatic, unless they originated or were destined for an Adriatic port. Nevertheless, with the varied origin of the cargoes discussed, it is clear that the Adriatic was an important part of a wider system of maritime exchange, acting often as a link between origin and ultimate destination, but also as direct exporter and producer.

### 7.2.4- Inter-Regional Exchange

Of the 145 wrecks, 143 had likely Adriatic destinations or cargo origins, and 58 (40%) had both Adriatic destinations and cargo origins. It should be noted that sites with uncertain origins or destinations all must have had either an Adriatic destination or origin, and that many likely had both, but this section will focus on the more certain 58 cargoes. By isolating only these inter-regional cargoes (Fig. 7.9) the northern Adriatic is a very obvious concentration of sites. This would appear to reinforce the concept that the major ports of the northern Adriatic acted as regional redistribution centres for imports from and exports to the north and south. Furthermore, the fluvial cargo sites are all located in the northern Adriatic, again reinforcing the importance of the fluvial network to this part of the region in particular.[707] The other most obvious concentration of inter-regional cargoes is along the coasts and islands of MRs 9 and 19. Being located so far east of Istria suggests that an origin or destination in the northern Adriatic and MR 5 or 6 is unlikely, instead, these cargoes were likely primarily derived from or destined for the ports along this coast itself, such as Tarsatica or Lopsica.[708] Several of these cargoes consisted of tiles, likely for ballast, while Adriatic *amphorae* were a component of many, and one having a particularly large cargo of worked stone at Margarina Point (no. 91, Fig. 7.3b).[709] The origin and destination of these can be difficult to interpret, but there is considerable evidence for the exchange of tiles from northern Italy into Dalmatia.[710] As such, what this concentration of sites may represent, is a three part pattern of exchange. Tiles and other commodities from the northern Adriatic

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[706] Beltrame (2002), 547; Strauss (2013).
[707] Uggeri (1990).
[708] See Wilkes (1969), 201, on the importance of these sites.
[709] Vrsalović (1974), 25; Jurišić (2000), 69; Russell (2011); Strauss (2013)
[710] Wilkes (1979).

were shipped to the east of Istria, at Tarsatica,[711] for example, where some cargo was unloaded, primarily for consumption in the interior, and additional cargo from the interior (such as worked stone) loaded onto the ship.[712] This then sailed to central Dalmatia, where the tiles, as well as any other commodities from the north or interior of Dalmatia, including worked stone, were exchanged for more local products, or extra-regional commodities acquired from one of the major Dalmatian ports. The final journey would then return to the northern Adriatic ports, where the process would begin again. Though the micro-regions around this concentration of wrecks represent neither particularly large markets for consumption or production, the position at the convergence of the coastal Dalmatian, northern Italian and Dalmatian interior markets, evidently made this a particularly busy inter-regional shipping route.

Another key component of inter-regional exchange appears to have been the relatively rare journeys between east and west. The nature of the three part exchange detailed above would mean that exchange between the Italian Adriatic and the eastern coast would not necessitate direct exchange, or making an east-west crossing over open sea. Instead, the infrastructure and redistribution centres of the northern Adriatic would have been used to connect east and west more indirectly. This may also explain the lack of shipwreck evidence along the Italian coast, if most journeys utilised the infrastructure of the north, we would expect less wrecks, if not less traffic overall. Exceptions to this can be seen in a few locations, around Ancona, the Gargano, and to a lesser extent, Brundisium and the south. Movement south or north would primarily have been conducted along the eastern coast, even for many cargoes with destinations or origins along the western coast. Moving to the east from the west would likely have taken place as soon as possible from the port of origin, while moving west from the east would be more strictly at one of these crossing points, and likely the port opposite, Ancona, Brundisium, would have been the final destination of this voyage, whether subsequent more local redistribution took place or not.

Maritime exchange within the region was clearly a major component of the wider Adriatic economy, representing the majority of maritime exchange. This primarily appears to have been redistribution utilising, above all else, the infrastructure of the northern Adriatic. The primacy of the eastern coast is highlighted quite starkly through this analysis, and it is clear that movement between east and west was conducted only at a few crossing points, with much of the exchange between east and west likely taking place indirectly through the redistribution centres in the north of the region. With all of this, we have a rough model for what the system of exchange and distribution of *amphorae*

[711] Notably, Tarsatica is one of the few sites with an imcv difference above the sd range, see Chapter 3 and Fig. 3.16.
[712] See Russell (2013), 73-75 for Dalmatian interior quarries.

cargoes across the Adriatic looked like; a complex network of both extra- and inter-regional exchange, between east, west, north and south.

## 7.3 Circuit Theory and Shipwrecks

With this basic analysis of *amphorae* and cargo distributions across the Adriatic, a basic model for exchange across and beyond the region has been constructed. This has been based almost entirely on qualitative data thus far, but by utilising the Circuit Theory (CT) outputs of Chapters 2 and 5, we can begin to apply more quantitative analysis to these data. In this section, the current values around submerged sites are analysed generally, in order to provide comparative data between direction and season of travel. Following this, some specific sites are discussed in more detail, highlighting the varied and complex nature of maritime exchange across the region.

In order to analyse the current values for wreck sites, a similar process to that taken for the urban centres in Chapters 3 and 5 is undertaken. First buffers are created around the wreck locations using the buffer function in QGIS; the mean CT; values of each of these buffers are extracted using the r package terra; the total raster mean values can be compared against the buffer mean values. As the location of these submerged sites is generally less exact than those of the urban centres, a larger buffer was used to get the mean current values. As some of the locations are accurate only to 10 minutes of arc (10\`), a buffer of 18.5 km was used (1\` of arc being roughly equivalent to 1,850 m).[713] The mean current value for each buffer was calculated for every scenario and site. Comparison between different sites is less useful here, as some are very close to the coast and others are in open water, not to mention that sites at opposite ends of the region may have been on the same route, so comparing raw current values between sites does not provide a great deal of insight. However, comparing the differences for current values between scenarios allows a better understanding of probable sailing directions and seasons for maritime exchange. Additionally, the difference between directional and seasonal current values for each site allows us to gauge how probable certain directions or seasons of sailing were for specific wrecks. In this section, the wider wreck mean current values (wmcv) are outlined and discussed, before more specific analysis of the directional and seasonal wmcv is conducted, all with reference to the cost surfaces with and without infrastructure. Finally, the probabilities for specific scenarios tied to specific sites are calculated and discussed, before a model of exchange, based on these data, is proposed. This reinforces the idea of a north and south directional preference, a wide ranging sailing season and shows the significant impact infrastructure appears to have had on patterns of maritime exchange.

[713] 'OpenDEM' website https://opendem.info/arc2meters.html (accessed 06/01/22).

### 7.3.1 Wreck Mean Current Values (wmcv)

The wmcv were calculated in the same way in which the cmcv (city mean current values) were calculated for Chapter 4. Raw values are provided in Appendix K, but it is again most useful to consider the difference values, which are derived by subtracting the wmcv from the total mean current value (tmcv) of each respective circuit theory output. Throughout this section, wmcv will be used to refer to this difference value, an overview of which can be found in Table 7.5 and Fig. 7.10. It is notable that once again, for all scenarios, the wmcv is positive, indicating that the wreck sites were all located in areas of higher than expected potential mobility. The highest single wcmv is for sailing north in April. All of the higher values are relatively evenly spread between north, east and south, with movement west again seeming to have been of significantly less concern for maritime exchange. Likewise, the seasonal variation appears to have been relatively evenly spread, with both Summer and Winter months accounted for in the upper half of wmcv. All of this suggests that sailing west was a less significant component of maritime exchange than for sailing in other directions. Furthermore, the seasonal nature of ancient sailing does not seem to be supported by this analysis, with no clear sailing season which has particularly high wcmv for the wreck sites that we have evidenced in the Adriatic.[714]

When the infrastructure is added to the scenarios, the situation is changed markedly, far more than was observed for the fixed point urban centres in Chapter 6. For wmcv including infrastructure, nine scenarios have negative values, all for sailing west, with only sailing west in November, October and December having positive wcmv. The largest wmcv in this case is for sailing east in December, with all those scenarios above the standard deviation (sd) range being for the Winter months, and all but one for sailing north or east. Clearly the overall picture is quite different when we include infrastructure for analysing maritime exchange. If the original wcmv is subtracted from that including infrastructure, we can begin to understand the impact of this infrastructure even more clearly (TTable 7.5 and Fig. 7.11). Those months most positively impacted by the infrastructure are October, November and December. Additionally, the directions north, east and south are all similarly impacted by this, with only movement west seeming to have been less well affected by the inclusion of infrastructure. Like with the terrestrial analysis, this does not indicate that movement west was made less efficient by the inclusion of infrastructure, simply that movement in other directions was improved disproportionately, and so movement west becomes, relatively, even less efficient. Or rather, that the wreck sites we do have evidence for, appear to be in areas of particularly low current

[714] See changing views between Casson (1995); Jurišić (2000), 9 for limited sailing seasons and Horden and Purcell (2000), 143; Tammuz (2005), 145; Beresford (2013), 1-4 for models using much more frequent sailing throughout the year.

for movement west, likely indicating that these vessels were in fact not travelling west at all when they sank (these probabilities are discussed below).

**Table 7.5- wcmv Differences Values**

*The wcmv difference values for each scenario. The values including infrastructure are also provided as well as the difference between the original wcmv and the infrastructure wcmv, as a raw value and as a percentage. These differences are discussed below.*

| Scenario | wcmv Difference Value | wcmv Difference Value Infrastructure | Infrastructure Minus wcmv | Percentage Difference |
|---|---|---|---|---|
| **Jan E** | 0.862 | 0.982 | 0.120 | 13.939 |
| **Jan N** | 0.362 | 0.336 | -0.025 | -7.009 |
| **Jan S** | 1.000 | 1.039 | 0.040 | 3.979 |
| **Jan W** | 0.224 | -0.037 | -0.260 | -116.387 |
| **Feb E** | 0.889 | 1.014 | 0.125 | 14.024 |
| **Feb N** | 0.736 | 0.705 | -0.031 | -4.177 |
| **Feb S** | 0.786 | 0.835 | 0.048 | 6.159 |
| **Feb W** | 0.238 | -0.018 | -0.256 | -107.639 |
| **Mar E** | 0.683 | 0.829 | 0.146 | 21.422 |
| **Mar N** | 0.816 | 0.783 | -0.033 | -3.998 |
| **Mar S** | 0.560 | 0.599 | 0.039 | 6.995 |
| **Mar W** | 0.246 | -0.013 | -0.259 | -105.325 |
| **Apr E** | 0.715 | 0.701 | -0.015 | -2.042 |
| **Apr N** | 1.154 | 0.985 | -0.168 | -14.599 |
| **Apr S** | 0.419 | 0.319 | -0.100 | -23.921 |
| **Apr W** | 0.260 | -0.124 | -0.384 | -147.818 |
| **May E** | 0.763 | 0.758 | -0.005 | -0.627 |
| **May N** | 0.813 | 0.641 | -0.172 | -21.132 |
| **May S** | 0.756 | 0.669 | -0.087 | -11.550 |
| **May W** | 0.247 | -0.141 | -0.388 | -156.867 |
| **Jun E** | 0.852 | 0.841 | -0.010 | -1.211 |
| **Jun N** | 0.645 | 0.479 | -0.165 | -25.614 |
| **Jun S** | 0.699 | 0.615 | -0.084 | -12.047 |
| **Jun W** | 0.212 | -0.168 | -0.380 | -179.334 |
| **Jul E** | 0.969 | 1.003 | 0.035 | 3.582 |
| **Jul N** | 0.737 | 0.628 | -0.109 | -14.838 |
| **Jul S** | 0.620 | 0.597 | -0.024 | -3.800 |
| **Jul W** | 0.202 | -0.128 | -0.331 | -163.390 |
| **Aug E** | 0.758 | 0.806 | 0.049 | 6.405 |
| **Aug N** | 0.882 | 0.772 | -0.110 | -12.490 |
| **Aug S** | 0.398 | 0.371 | -0.027 | -6.671 |
| **Aug W** | 0.236 | -0.097 | -0.333 | -141.248 |
| **Sep E** | 0.887 | 0.936 | 0.050 | 5.602 |
| **Sep N** | 0.927 | 0.820 | -0.108 | -11.601 |
| **Sep S** | 0.500 | 0.475 | -0.025 | -4.911 |
| **Sep W** | 0.227 | -0.103 | -0.330 | -145.372 |
| **Oct E** | 0.885 | 1.263 | 0.378 | 42.777 |

| Scenario | wcmv Difference Value | wcmv Difference Value Infrastructure | Infrastructure Minus wcmv | Percentage Difference |
|---|---|---|---|---|
| **Oct N** | 0.955 | 1.172 | 0.217 | 22.705 |
| **Oct S** | 0.501 | 0.808 | 0.306 | 61.113 |
| **Oct W** | 0.215 | 0.214 | -0.002 | -0.825 |
| **Nov E** | 0.913 | 1.288 | 0.374 | 40.988 |
| **Nov N** | 0.880 | 1.099 | 0.219 | 24.857 |
| **Nov S** | 0.523 | 0.821 | 0.297 | 56.769 |
| **Nov W** | 0.229 | 0.230 | 0.001 | 0.323 |
| **Dec E** | 0.929 | 1.292 | 0.363 | 39.107 |
| **Dec N** | 0.599 | 0.824 | 0.224 | 37.411 |
| **Dec S** | 0.672 | 0.965 | 0.293 | 43.566 |
| **Dec W** | 0.216 | 0.213 | -0.003 | -1.300 |

Analysing the directional wmcv more specifically provides deeper insight into the directional scheme of maritime exchange across the region. While the higher wmcv appear to be relatively evenly spread out, dividing these according to deviation from the mean value is more telling (Table 7.5 and Fig. 7.10). Of the seven values above the wmcv sd range, three each are for movement north and east and only one for movement south. All of the scenarios for sailing west are below the wmcv sd range. Adding infrastructure, this is not quite so pronounced. Only six scenarios are above the sd range, three for sailing east, two for north and one for south. Additionally, while all those scenarios below the sd range are for sailing west, sailing west in October, November and December are within this range. This would appear to suggest that the infrastructure of the region acted to increase the disparity between directional maritime exchange somewhat. To understand this more clearly, we can again look at the infrastructure difference, obtained by subtracting the original wmcv difference values from the wmcv difference values with infrastructure (Table 7.5 and Fig. 7.11). While the raw values are often larger for east than south, for example 0.378 for east in October and 0.306 for south in the same month, as a percentage this is often reversed (43% for east in October and 61% for south in the same month). Certainly the directional differences as a percentage is far less pronounced than with the raw values. This is highlighted by comparing the clear correlation between wcmv with and without infrastructure (the linear Fig. 7.10), as opposed to the wcmv without infrastructure against the infrastructure difference (the more cluttered Fig. 7.11), which shows little to no correlation. With all of this, the inclusion of infrastructure would appear to reinforce the disparity between directional maritime exchange somewhat, but had a greater impact, as a percentage, on the scenarios which started with relatively low wcmv without infrastructure.

The monthly wmcv allow us to more clearly understand the seasonal differences in the shipwreck sites we have. While there are Winter and Summer months above the sd range for the original wmcv difference value (Fig. 7.10, x axis), there is only one Summer, one Spring and the remaining four are Winter or Autumn. This suggests that wrecks appear to be in locations with higher current values for colder months. This is reinforced when considering the infrastructure, for which all scenarios above the sd range are January, October, November or December. Likewise, the three scenarios for sailing west that are not more than one standard deviation below the mean are for the same months, excluding January. This suggests not only that we appear to have more shipwrecks for Winter sailing in areas with higher current values, but that the infrastructure disproportionately positively impacted exchange during these Winter months. Considering the infrastructure difference, this fact is made even more obvious (Fig. 7.10 y axis). Scenarios during the Winter are consistently amongst those most positively affected by the inclusion of infrastructure.

The general scheme outlined qualitatively above can now begin to be expanded upon with this qualitative data. We have very few wrecks with high current values for exchange towards the west. This may suggest that there was limited maritime exchange towards the west, which would seem to be in line with the analysis for the urban centres. However, it should also be kept in mind that much of the exchange towards the west was likely conducted more indirectly, utilising the safer infrastructure of the northern Adriatic, or one of the few points crossing open water outlined above. In the first instance, we would expect fewer wrecks, with the canals being relatively safe. In the second, there is an archaeological bias for coastal sites as opposed to those in open water.[715] As such, while maritime exchange towards the west was likely less important than other directions, this is unlikely to be quite as pronounced as suggested by the CT wreck analysis. Additionally, it remains the case that the cargoes being carried by ships sailing west, and possibly south, are generally less archaeologically visible than the cargoes being carried north. This could partially explain these CT outputs, and is in line with what has been suggested of Adriatic imports and exports previously, with many of the exports being perishable materials such as timber or textiles. Furthermore, while it may at first appear that maritime exchange during Winter months was more favourable, this likely reflects that more ships were wrecked during Winter months. While sailing was possible and could be relatively efficient during the Winter months, the more frequent wreckage of vessels likely results in the high wmcv we have for maritime exchange over these Winters months. This reinforces the fact that significant exchange was taking place year round, though was more risky during the Winter. Additionally, the infrastructure appears to have reinforced much of the disparity between directional exchange. More interestingly, infrastructure clearly acted to increase current values for exchange during Winter months more than for others. A complex pattern of maritime exchange is beginning to

[715] See 6.2.1 above.

emerge, with movement north and east clearly being of particular significance and the infrastructure of the region acting to disproportionately make Winter sailing more efficient.

### 7.3.2 Individual Wreck Mean Current Values (iwmcv) and Probabilities

While comparing individual sites wmcv is less helpful than for urban centres, by understanding the differences between the seasonal and directional iwmcv, we can begin to assign probability values for the direction and month of sailing for individual wrecks. The iwcmv are derived in the same way as the imcv outlined in Chapter 4. In order to transform these into probabilities, the percentage that each scenario's current value makes up of the sites total iwmcv is calculated. The results of this can be found in Figs. 7.12 and 7.13 (See also Appendices L and M for more detail). While these basic probabilities should not be used to predict the direction and season of travel of indivudal wrecks, they do provide an insight into general trends across the datset, from which we can draw useful concluisons. It should be noted that for no scenario or site does this 'probability' exceed 15%. As such, and unsurprisingly, we cannot say that a specific voyage was sailing north in April, for example, with any real certainty based on these numbers alone. However, looking at the occurrences of the highest probability scenarios across all 145 sites can be quite revealing (Tables 6.6 and 6.7). 46 total sites have the highest probability of exchange towards the north in April, 37 for sailing east in July. Of course, this does not mean that almost 60% of Adriatic wrecks were under one of these scenarios, rather that these two scenarios clearly represent the most likely scenario for most of the sites. Adding infrastructure again has a significant impact. North in April and east in July are reduced to five and 11 sites respectively for the most probable scenario. East in December and north in October appear to be the most frequently occurring, at 35 and 27 respectively. This again reinforces the impact infrastructure had on Winter sailing, with the current values along the routes of exchange suggested by these wreck sites being consistently higher with the inclusion of the infrastructure. Similarly, the seeming importance of eastern and northern exchange is further reinforced.

**Table 7.6- Highest Probability Scenarios**

*The number of sites that have a specific scenario as their highest probability. All months are represented at least once, as with every direction except west, which is never the most likely scenario. See also Figure 7.12.*

| | North | East | South | West |
|---|---|---|---|---|
| Jan | 0 | 0 | 6 | 0 |
| Feb | 1 | 0 | 0 | 0 |
| Mar | 7 | 7 | 0 | 0 |
| Apr | 46 | 3 | 0 | 0 |
| May | 3 | 3 | 0 | 0 |
| Jun | 0 | 0 | 6 | 0 |
| Jul | 0 | 37 | 0 | 0 |
| Aug | 0 | 5 | 0 | 0 |
| Sep | 0 | 0 | 2 | 0 |
| Oct | 0 | 0 | 8 | 0 |
| Nov | 0 | 0 | 3 | 0 |
| Dec | 2 | 6 | 0 | 0 |

**Table 7.7- Highest Probability Scenarios (With Infrastructure)**

*The number of sites that have a specific scenario as their highest probability. All months are represented at least once, as with every direction except west, which is never the most likely scenario. See also Figure 7.13.*

| | North | East | South | West |
|---|---|---|---|---|
| Jan | 0 | 1 | 8 | 0 |
| Feb | 1 | 0 | 0 | 0 |
| Mar | 0 | 7 | 0 | 0 |
| Apr | 5 | 1 | 0 | 0 |
| May | 0 | 3 | 0 | 0 |
| Jun | 0 | 0 | 1 | 0 |
| Jul | 0 | 11 | 0 | 0 |
| Aug | 0 | 5 | 0 | 0 |
| Sep | 0 | 0 | 2 | 0 |
| Oct | 27 | 0 | 11 | 0 |
| Nov | 0 | 19 | 5 | 0 |
| Dec | 3 | 35 | 0 | 0 |

In order to get a better idea of actual probability, we can analyse the number of scenarios that are required to be summed in order to reach a greater than 50% probability for each site. The fewest number of scenarios needed to be included are for the Joni wreck (no. 8), with only five, all of which are for sailing north. This is particularly interesting as the cargo of this wreck appears to suggest a north African origin, with an Adriatic destination somewhere in the north.[716] This provides quantitative

[716] Stratton (2015); Royal (2018), 13-16.

data to support what had been gathered from the purely qualitative study of the site. The single most likely scenario for the Joni wreck is sailing north in April, and the spread of months is generally within the wetter, colder months of Winter and late spring. As such, it seems very likely that this vessel represents exchange between the Adriatic and north Africa outside of the prohibitive sailing season (May-September) proposed by Jurišić for the Adriatic.[717] This indicates that even long distance extra-regional exchange was likely not strictly seasonal, with imports arriving throughout the year, particularly into the imperial period.[718] This speaks of a regular flow of cargo from across the wider Mediterranean world north into the Adriatic region. Adding infrastructure to this does not significantly impact the situation, with the Joni wreck still requiring the fewest scenarios to reach over 50% probability, and all being the same scenarios again.

Looking to the site with the second fewest scenarios required, we have the Sason 1 wreck (no. 11). Interestingly, seven scenarios are required to reach 50% without infrastructure, but only six with. Excluding infrastructure, all scenarios are again for sailing north, except one, sailing south in February. This is the same with infrastructure, but sailing north in May is no longer required to reach the 50% probability threshold. Interestingly, in this case, the qualitative data appears to suggest that this vessel was sailing south, out of the Adriatic towards the east.[719] However, with this quantitative data, we may reconsider this, perhaps instead suggesting that this was a return voyage, similarly between the Adriatic and the eastern Mediterranean, but when this ship was wrecked, it would seem more likely that it was sailing north into the Adriatic, with the Adriatic objects representing some shipboard equipment and personal belongings of the crew as opposed to cargo. Regardless, the idea that this cargo represents exchange between the Adriatic and the wider Mediterranean appears to be reinforced through the CT analysis; with movement south out of or north into the region being the most likely scenarios.

While this approach cannot provide definitive asnwers to sailing directionality and seasonality, it does build significantly on the qualitative analyses. With it, a probabilistic landscape of maritime movement can be created. While the level of uncertainty remains high, quantifying this uncertainty allows for a far more nuanced and informative understanding of the landscape of movement to be formed. Combining these probabilities with more traditional qualitative analyses offers insight which would be impossible without a combined approach such as this.

[717] Jurišić (2000), 9.
[718] See Beresford (2013), especially 1-18, for improvements in sailing technology allowing for longer sailing seasons.
[719] Royal (2018).

### 7.3.3 A Model for Adriatic Maritime Exchange

With everything discussed thus far, a more complex model of maritime can now be outlined. A basic scheme of this can be found in Fig. 7.14. This was constructed manually based on a combination of all of the data analysed, quantitatively and qualitatively, throughout this thesis, but primarily from the current chapter. These are not meant to represent exact routes, rather; offer a visualisation of the proposed model of exchange.

At the crossroads between east and west, it is unsurprising that the Adriatic has two main points of entry, from the east, and from the west.[720] This east west divide, qualitatively argued for, is replicated convincingly using the computational models above. This speaks to the robustness of the model, and in this case, acts as predicted. Most of the traffic sailing into the region would have sailed towards the area around Lake Shkodër, either directly, after entering from the east, or after crossing to the east prior to rounding the heel of Italy from the west.[721] From here, the most obvious destination would be Salona, sailing south of the Pelješac peninsula at the mouth of the Neretva, though it is unclear if there would have been a preferred route between the islands of MR 20 to or from Salona.[722] From Salona, there are an additional two major routes, one more easterly towards Iader, and the interior of northern Dalmatia through ports like Tarsatica, and a more westerly route passing the ports of western Istria and onto Aquileia.[723] From here, the entire northern Italian Adriatic is linked primarily by the canal system, with the scale of maritime exchange on the open waters here likely being relatively minimal.[724] The majority of traffic between the north-east at the major ports at Ancona and Ariminum would likely have utilised this system through Ravenna, though there is evidence for direct connections between Ancona and Pola, on towards Aquileia.[725] This crossing represents one of the few direct east-west connections. An additional major crossing must have been located somewhere in the middle Adriatic, north of the Gargano peninsula and utilising the islands of the Palagruža archipelago as landmarks and safe harbour during this crossing.[726] It is unclear if there was a main port of call on the west for this crossing, or if more local redistribution occurred before crossing for voyages to Salona, the northern Adriatic and the south beyond the region. Finally, the crossing points at the mouth of the Adriatic, though poorly documented in the shipwreck data, must

[720] Bekić and Royal (2016); Royal (2018); Auriemma (2015).
[721] Much like what Jurišić has previously suggested, Jurišić (2000), 48-51.
[722] See Gaffney and Kirign (2006) for discussions of these islands and their role in wider exchange.
[723] Carre (2008); Carre and Pesavento Mattioli (2009).
[724] Bosio (1991), 243.
[725] See Pliny, *Naturalis Historia*, 3.129 describing distances between Ancona and Pola, as well as the Ancona wrecks Strauss (2013).
[726] Kirigin *et al*. (2009).

have been of considerable significance.[727] This would primarily have been between Brundisium and the ports at Appollonia and Dyrrachium, though presumably many of these crossings sailed north from Brundisium towards the Dalmatian coast and the north.

The more minor routes act to redistribute commodities from major ports along the coasts. The traffic along the Italian coast would likely have been fairly minimal, mainly comprising of such local redistribution towards or from one of the major crossing points to the east. Similarly, much of the coasts of MRs 17 and 18 would have seen relatively minimal maritime traffic, again acting to redistribute commodities from more major sites to the south and north, across the coastal sites and on towards the interior. Likewise, there must have been a considerable amount of traffic between the islands of MR 20 and the Dalmatian coast at Salona. Likely fairly small scale exchanges, but conducted frequently to supply the provincial capital. A similar situation can be observed for MR 19, where the major routes of the north east could be utilised in order to participate in the wider regional economy.

All of this points to a complex system on multiple scales. Major sites and routes acted to connect not only the region with the wider Mediterranean, but exchange between the disparate micro-regions within the wider whole appears likely to have been the main component of maritime exchange in the region. Much of this intra-regional exchange would have been to redistribute commodities for consumption within the region, but similarly, much must have been to exchange extra-regional goods for wider export, either south to the Mediterranean, north across the Alps and up the Po, or east into the interior of Dalmatia and Macedonia. With this in mind, and drawing on the data from previous chapters, an outline for the wider economic system, of which this maritime exchange was a single component, can be provided, with reference to economic cohesion and specialisation.

[727] See Royal (2018), especially 28-30.

# Chapter 8: Discussion

The central questions posed in this thesis centred on how far the Roman Adriatic can be considered to have been a cohesive economic whole, the presence or absence of economic specialisation in the region and the potential of Circuit Theory as a methodology for modelling mobility and connectivity in the ancient world. In attempting to address these questions, the production and exchange of wine and oil across the region were considered, shining a light on the often mirky and daunting ancient economy; not only in the Adriatic region, but across the wider Roman world. As with most questions in the field, the answer is not straightforward, but seeking it, is certainly illuminating.

Chapter 1 highlighted the issues with the current state of research in the field. With regard to studying the ancient economy, it is clear that while progress has been made to move beyond the binary arguments between primitivist and modernist, there is still scope to improve the discourse. Much of the conclusions drawn throughout suggest neither a primitivist or modernist model to be a helpful view of the Roman economy. Indeed, in studying the Roman economy of the Adriatic, it has been made clear that it is far more helpful to think of the Roman economy as just that; a Roman economy. It is unique in its organisation, function and scale, and some aspects are so far removed from our modern perceptions of economics, that trying to gauge how far the Roman economy adheres to either of these models is unhelpful. Ultimately, the quantitative approaches taken throughout this study allow us to attempt to reconstruct a Roman economy based on real data rather than determining how far the economy resembled any specific model or another.

Beyond approaches to the ancient economy, Chapter 1 also discussed the issues with scholarship studying the ancient Adriatic. The primary issue is the disconnect between the coasts, whether it be lack of engagement between different scholarly traditions, countries or languages, or more practically, the unequal availability of archaeological data and publications across the region. These are all difficult problems to overcome, but by considering the Adriatic as a distinct region, it is possible to overcome some of these issues. Beginning with a purely geographical study of the region removes many of these human biases, and allows real differences in the region to be observed, highlighting that far more appears to connect the region than to separate it, when the wider roman world is considered. While the scholarship might not reflect this, it has been made clear through the current research, that the geography of the Adriatic was well suited to allowing for the emergence of a distinct economic entity with access to the wider economy beyond. Furthermore, by considering the whole region, micro-regions can be more readily identified and studied, again showing that the differences within the region were well suited for the emergence of specialised production and exchange, on both a regional and inter-regional scale.

In Chapter 2, a consciously non-archaeological approach was undertaken. Through this, it has been shown that the Adriatic region is physically distinct from the surrounding landscape, despite crossing multiple modern and ancient borders, polities and economic systems. Further, the Adriatic can be divided into 20 micro-regions, each of which was distinct and with varying ecological and agricultural suitabilities. These micro-regions define the study area for addressing the question of economic cohesion more directly. While some of the micro-regions showed significant ecological potential for wine or olive production as well as archaeological evidence for the exploitation of this potential (especially MRs 4 and 7), the most interesting analysis comes where the archaeological and ecological evidence do not align so neatly. Through this chapter, it is made clear that the diversity of the ecologies and geographies of the Adriatic micro-regions were well-suited for the emergence of a system of strong economic cohesion, built upon specialised wine and oil production and exchange. A key takeaway should be that, in order to understand the wider ancient economy, we must first understand the basic physical environment from which the economic system ultimately emerged.

Chapter 3 continued with a non-archaeological approach, and outlined the core quantitative model of the thesis, the application of Circuit Theory (CT). The use of CT is central to understanding potential mobility and connectivity in this thesis, and addressing these concepts is vital to answering any questions of economic cohesion and specialisation. One of the most significant benefits of CT analysis is the amount of quantitative data produced through the analysis. The data produced through the methods outlined in Chapter 3 were analysed repeatedly in different ways throughout the rest of the thesis, yet there are numerous more analyses that could be conducted on the data. Even before the data is compared to the archaeological evidence, it is clear that the patterns of mobility across the Adriatic were a complex combination of land- and seascapes; considering either the terrestrial or maritime context in isolation does not provide anything like a complete picture of the ancient economy. The importance of maritime movement is made very apparent through the CT analysis, with the direction and season of movement changing not only the potential mobility across the sea itself significantly, but having a huge knock on effect on the potential patterns of movement and connectivity across the entire regional landscape.

The direct archaeological analysis begins with Chapter 4 and the patterns of urbanism across the Roman Adriatic. Nuanced approaches for quantifying ancient populations and consumption were utilised, highlighting that the varied agricultural potential of the region would likely have necessitated signifcant levels of exchange, not only within the region itself, but also engaging with the wider economy of the Roman world. Drawing upon the CT data, it was shown that urban centres are consistently located in areas of particularly high potential mobility, further highlighting the importance of connectivity and exchange for the urban populations of the region. In particular, the cities of the northern Adriatic, and especially Aquileia, emerge as likely candidates for hubs of regional and extra-regional exchange. While many of the largest urban centres were in areas of especially signifcant potential mobility, the correlation between settlement size and potential mobility is not straightforward. Instead, explanations of the regional population hierarchy must be addressed through understanding the archaeological and civic factors. While potential mobility is undeniably important for any urban centre, the relative ecological potential and civic status of the site must have had a significant impact on settlement size. Showcasing this, perhaps most emphatically, is Salona, which was one of the largest Adriatic cities, in by far the most densely populated micro-region (12), yet being in an area of relatively middling to unimpressive potential mobility. This must surely be explained by the status of the city as provincial capital. Indeed, the rank size rule analysis highlights Salona and MR 12 as likely having disproportionate access to the wider economic networks, which many of the other centres of the region would access only indirectly through Salona itself. The analysis of Chapter 4 begins to highlight that while the geography of a region is vital to understanding economic cohesion, more ephemeral factors had a huge impact on ancient patterns of consumption and exchange within the restraints dictated by geographic and ecological realities.

With Chapter 5, the economic production of wine and oil is addressed. The gaps in the archaeological data become quite pronounced here, but convincing micro-regional trends begin to emerge. The significance of wine and oil production in MRs 4 and 7, Central Adriatic Italy and western Istria respectively, become very clear, and is in line with the ecological potential outlined in Chapter 2. MR 5, lying between MRs 4 and 7 in the northern Adriatic, emerges as a particularly complex micro-region in this respect. The literary and ecological evidence for wine production is simply not reflected in the archaeological data. While this can partially be explained by archaeological issues, much like with the apparent gap across MR 18, this can also be explained by considering MR 5’s relative position, as opposed to its ecological situation in isolation. MR 5 is flanked by the two micro-regions with the greatest evidence for wine and oil production in the region, and so would have had quite a significant comparative disadvantage for the production of these commodities. Nevertheless, the micro-region was particularly well placed to tap into wider patterns of exchange within the wider region, as well as beyond the Adriatic and Mediterranean worlds into transalpine Europe. In order to understand any ancient economic system, a region or micro-region cannot be considered in isolation. The relative economic potential is as, if not more, important to understand than the raw potential alone.

The infrastructure of the region was discussed at length in Chapter 6. This outlined the roads, waterways and ports of the Adriatic, building upon the natural mobility and potential connectivity afforded by the regional geography. While the impact of infrastructure on the landscape of potential mobility was clearly less significant than that of geography, the areas which were most affected by this infrastructure are extremely interesting. Some of the urban centres with the highest potential mobility values become less prominent with the addition of infrastructure. Indeed, Aquileia, with one of the highest natural potential mobility values, becomes less dominant through the addition of infrastructure, while the likes of Dyrrachium, with one of the lowest potential mobility values, being very positively affected by the addition of infrastructure. This all suggests that the infrastructure of the Adriatic, while by no means reversing the potential mobility afforded by the natural geography, was, in part, an attempt to reduce the disparity of potential mobility between some of the larger settlements. Furthermore, MR 12 and Salona are again prominent in this analysis, with MR 12 having a vastly disproportionate concentration of port and road infrastructure compared to the micro-regions size and coast. This highlights the way in which geographic realities could be somewhat overcome by political, civic or economic concerns. Perhaps the most pertinent conclusion to draw from this chapter, is the importance of the extensive canal network of the northern Adriatic. The investment here, not necessarily a direct attempt to increase mobility, but to increase the safety and reliability of maritime movement was hugely signifcant. The northern Adriatic, here, becomes a yet more important vector of exchange for the inter-regional and extra-regional economies.

The fixed archaeological points of Chapters 5 and 6 are followed by more transitory archaeological remains in Chapter 7, with the analysis of the shipwrecks and *amphorae*. The difficulty of understanding *amphorae* typologies and distributions in the Adriatic is clear. However, this does not mean that signifcant conclusions cannot be drawn. Most obvious from this analysis, is the significant role which inter-regional economies played in the maritime exchange of the Adriatic. The majority of exchange across the sea appears to have been inter-regional in nature, with extra-regional exchange being conducted through one of relatively few centres of redistribution. The major port cities of the northern Adriatic and Salona, in MRs 5 and 12, emerge as obvious candidates for centres of exchange on a regional scale. Notably, the evidence for production in both of these micro regions is limited. However, both would have had preferential access to the wider economic system; MR 5 across the plain of the Po and beyond the Alps, MR 12 the interior of Dalmatia and wider connections afforded by the position of Salona as the provincial capital. On the other hand, MRs 4 and 7, while having convincing evidence for specialised wine and oil production, do not appear to have been such prominent locations in terms of wider maritime exchange or redistribution. Indeed, both MRs 4 and 7 would likely have been reliant on the redistribution centres of the northern Adriatic and MR 12 in order to exchange the surplus commodities that were clearly being produced in these micro-regions. Indeed, for MR 4, the interior and especially Rome might be more likely destinations. By applying the CT data to the submerged sites of the region, we can begin to shed more light on patterns of sailing in the ancient world. This evidence clearly shows the importance of movement north and east across the region, with movement south and especially west, being far less apparent. This likely reflects the importance of the safe canal network of the northern Adriatic for movement west, and the fact that much of the cargo carried across the Adriatic would be on ships sailing north along the eastern coast, while movement east or west was conducted at only a select few crossing points, and ships sailing south may have been carrying less archaeologically visible cargoes, exported from the region. Moreover, the limited sailing season suggested by some and challenged by more recent scholarship, is simply not supported in this analysis.[728] The CT analysis of the shipwreck data highlights quite clearly, that while sailing during wetter, colder months may have been more dangerous than Summer sailing, it was an important component not only of small-scale inter-regional exchange, but of long distance extra-regional exchange. Exchange in the ancient world was perfectly capable of persisting through unfavourable and even dangerous conditions. The danger associated with such travel should not be downplayed, indeed much infrastructure was directed at combating this danger. However, exchange, other than possibly the state-run grain import, would not have been halted during Winter months; though would have likely reduced. Indeed, the impact of infrastructure on patterns of sailing was clearly significant. This is especially true of the Winter sailing months, which are consistently amongst the scenarios most positively affected by the inclusion of infrastructure. This again points to the importance of Winter sailing, as well as the danger associated with it.

With this overview, we can now consider the wider implications of the research. Beyond the deeper understanding of the Adriatic region, these implications can be viewed in two main areas. First the contribution to the study of the ancient economy, and second, the potential of CT for archaeological studies. The economy of the Roman Adriatic was without a doubt a complex system of many different producers and consumers. The scale of production and export/import between micro-regions in the wider region highlight the presence of some level of economic rationalism; an awareness of relatively distant markets and the profitability of specific commodities. Nevertheless, it would be stretch to argue that the entire system was dictated and organised around profit incentives and maximising efficiency. This can be viewed as a microcosm for the wider ancient economy. We can see instances of something akin to a modern economy, with targeted production and export beyond local regions, but this has very strict limits, being restricted by the relatively primitive understanding

[728] Casson (1995); Jurišić (2000), 9; Horden and Purcell (2000), 143; Tammuz (2005), 145; Beresford (2013), 1-4.

of economics and especially the ability for communication. While it might be helpful in the first instance to seek aspects of the primitivist and modernist models in the ancient economy, it is clear that these models can, at best, only offer a general scheme for how different parts of the economy were organised. Beyond a fist analysis, we must move beyond these models, and analyse ancient economies individually and uniquely. The Roman economy is the Roman economy, trying to argue how far that resembles a modern or primitive model obscures its unique nature. A good example of this can be found in the shipwreck evidence. While the limits of ancient technology clearly made winter sailing problematic, it definitively did not stop winter sailing and long-distance, large-scale exchange of goods across the winter months. Rather than arguing that the ancient economy was one thing or another, it is instead, far more helpful to understand the limits of the world in which that economy functioned, and then to analyse how, where and when these limits were pushed. The restrictions of technology, economic rationalism and communication across the ancient world did not stop large scale targeted exchange across and beyond the Mediterranean. Going forward, this approach will add to our understanding of the Roman and ancient economy more broadly. The quantitative approaches used throughout this study allow us to more objectively model and understand the ancient economy. However, unless we begin applying these to more nuanced aspects of the economy, and move beyond tired old arguments and on to more open ended questions where the nature of the ancient economy is no longer a choice between limited pre-determined options, new methodologies would be limited in their scope. New methodologies must be combined with new questions and approaches to understanding the ancient economy.

The application of Circuit Theory throughout this work revealed a promising and innovative methodology for understanding the Roman economy. The limits of least cost path analysis are well discussed but this method continues to be the primary means by which archaeologists study movement, mobility and connectivity of past societies. This study has shown CT to be a viable and important step towards improving the methodology available for archaeologists. CT is less immediately intuitive to learn and interpret than fairly straightforward LCP analysis. However, it has far greater scope for more detailed control of the model and, importantly, can be readily implemented without the need for known archaeological sites to be used as points between which actors move. Using advanced methods for running CT also supersedes the need for pairwise modelling, which very quickly becomes computationally demanding to the point of impracticality.[729] The clearest benefit of CT as a methodology is the sheer amount of data produced through the analysis. The outputs are directly comparable across different scenarios, allowing for meaningful quantitative analysis. In this

[729] See the travelling salesman problem, where as few as 16 points requires "653,837,184,000 distinct routes" to be modelled, Hoffman *et al.* (2016), 1573.

study alone, CT has allowed the distribution of Roman urban centres, the impact of infrastructure and the seasonality of ancient sailing to be approached quantitatively in a way which has not been undertaken before, and which would be prohibitively complex to model using LCP analysis only. That being said, the data produced through this study can still be analysed in even greater detail for each of these aspects, with only some of the most immediately apparent results discussed at length here. Furthermore, the application of CT to archaeology more broadly, not only for different locations or time periods, but for different questions. For example, the seasonality of river transport, movement across frontiers or the relationship between potential mobility and agricultural suitability. While the application of CT in archaeological contexts still requires refinement, this innovative methodology has wide-reaching potential and a number of exciting possible applications beyond the analyses and questions of this study.

This study has addressed each of the research aims outlined above. It has been shown that the Adriatic can, in many ways, be viewed as a distinct economic system within the Roman world. However, it is also a system which was built upon providing access to the wider roman economy, whether this was through the ports of the north connecting the sites of the Adriatic with the Mediterranean beyond, or by providing a low cost means by which the Mediterranean and central European provinces beyond the Alps could exchange commodities. Furthermore, it is clear that there were micro-regions within the region that engaged in specialised production and exchange, particularly along the central Adriatic coast of Italy, the western coast of Istria and, to a lesser extent, the southern Croatian islands. This specialisation was an integral part of, and itself reliant on, the distinct and connected nature of the Adriatic economy. Finally, Circuit Theory analysis has been shown to be an innovative, quantitative approach, able to produce huge quantities of comparable data, the analysis of which, can directly lead to the conclusions posed in this study. The implications for archaeological studies, and especially our understanding of the Roman economy and methodological approaches to modelling past societies, are hugely significant.

# Conclusion

A complex picture of the ancient Adriatic economy has emerged. In many ways it can be considered to have been a cohesive economic whole, existing as a distinct economic entity within the wider network. This can be seen most obviously in the high level of inter-regional maritime exchange and the prominence of sites, such as Salona and Aquileia, which have been shown to have had disproportionate access to the wider economic system, and upon which other sites may have been reliant for extra-regional exchange. In this system, highly productive areas like MR 4, MR 7 and to a lesser extent, MR 20, exploited the comparative advantage afforded by the geography, ecology, population and potential mobility of the micro-regions, and invested in specialised production with exchange with the regional market in mind. This production was conducted on a large scale, but not under any wider centralised mechanism. Surplus would then have been sent to the major ports across MRs 5 and 12 through relatively small-scale but numerous exchanges. From which, the wider extra-regional markets could be reached by more direct and large-scale exchange. All of this suggests a cohesive, economic whole. On the other hand, there is an element of incoherence in the regional economy. This can largely be viewed as a north-south divide, with the micro-regions south of MRs 4 and 16 on the western and eastern coasts respectively showing far more cohesion between themselves than with the system of redistribution and extra-regional exchange of the north. In the south, exchange across the Adriatic and with the interiors of central and southern Italy and Macedonia/Greece, would appear to have been of greater significance than with the rest of the Adriatic region towards the north. MR 4 can be thought of as something of a transitionary area in this regard, with the south of the micro-region being more involved in the southern network, the north more with the northern network, and the centre entangled between the two. This is reflected in the production and urban population in the north of the large micro-region. The geographic barrier of the Pelješac peninsula of MR 16 offers a more solid border for this north-south divide on the eastern coast. Ultimately, all of this can be understood through the connecting nature of the Adriatic Sea itself. The opposing coasts were brought together by the potential mobility afforded by the sea, to the detriment of the terrestrial connections between the north and south. Ultimately, the economy of the Roman Adriatic was a distinct economic whole, but a complex one with many internal moving parts, several of which engaged in what can only be described as regional specialised production and exchange. Importantly, this distinct whole was an integral part of the wider economy, and, particularly with the large ports of the north, could not have functioned as it did without close economic ties with the wider Mediterranean and central European provinces. Internal exchange within the region was a major component of the economy, but perhaps the most distinctive feature was the huge quantity of exchange conducted through the region, utilising the central position of the region and the natural and man-made infrastructure facilitating particularly efficient movement between the Mediterranean and central European parts of the Roman economy.

Understanding economic cohesion and specialisation in this Adriatic study has implications for the wider ancient economy. In terms of results, it is clear, first and foremost, that understanding economies through isolated terrestrial or maritime approaches offers at best, a limited understanding, and at worst, a misleading view of the economic system. Maritime patterns of mobility and exchange directly impacted terrestrial exchange, and the terrestrial geographies, ecologies and populations in turn impacted how the patterns of potential mobility could be exploited. Furthermore, combined terrestrial and maritime potential mobility has a signifcant impact on the population and emergent economic system of any region. In terms of methodology, the importance of an initial non-archaeological and quantitative approach is central. By considering the region first as a purely geographic and ecological region, constructing micro-regions based purely on this, we begin to combat some of the inherent archaeological biases. While it may be impossible to completely overcome these archaeological limitations, by considering the geography and ecology in an initial step, we can very intuitively and simply lessen the impact of these biases. While some of the conclusions drawn in this thesis have been suggested previously, this has largely been through qualitative studies, and such studies do not provide directly comparable data or significant scope for moving the study of the ancient economy forward. The CT analysis in particular, has wide-reaching potential applications, being limited neither by the spatial nor temporal restraints of this thesis. CT analysis represents the next step in understanding ancient mobility and connectivity, complimenting and moving beyond more traditional analyses.

Moving forward, there are a number of promising areas in which this research can be expanded and re-directed. The impact of scale has been of particular interest throughout the study, but it has not been possible to engage with this directly through the course of this thesis. Applying mathematical concepts such as the Fourier transform to regional studies of the ancient economy could help to pinpoint at which scale the division between different regions and micro-regions become and cease to be signifcant. While these are relatively advanced concepts, being able to quantitatively define regions and micro-regions would be extremely helpful for future regional economic studies. Furthermore, the relatively extensive nature of this study has prevented more intensive analysis of sites than would have been possible on a smaller scale study. Closer analysis and quantification of the sites discussed, for example quantifying the scale of output at pressing sites beyond the number of presses, would add more quantifiable analysis to patterns of consumption. Nevertheless, without the large regional scale of this study, the wider inter- and extra-regional patterns of exchange would have been far more difficult to identify and outline in any meaningful way. This thesis has also largely avoided developments and changes over time, instead, considering fairly general patterns across the early imperial period. This ensured that the complex concepts and patterns of exchange outlined throughout could be presented in a more manageable way. However, the manner in which these generalised patterns emerged and changed over time would offer a great deal of additional insight into not only the nature of this economic system, but go some way to explaining and even helping to identify other examples of similar patterns. Indeed, the long, relatively stable span of Roman history may be unique in allowing these complex patterns of exchange to develop over time, and approaching this question directly would undoubtedly be informative. Finally, the scope of CT analysis for understanding the ancient economy is something which has only just started to be understood. It has been impossible to address every aspect of the CT results for any of the factors to which the analysis was applied. Closer analysis of how the quantified potential mobility impacted site distribution beyond urban centres, especially at rural press sites, would be extremely interesting, and build our understanding of ancient economies and patterns of production. Beyond this, CT analysis on patterns of mobility has potential beyond economic studies, with the impact of potential mobility on army movements at the frontiers, being just one such other application. While this thesis has gone some way to answering how far the ancient Adriatic can be considered to have been an cohesive economic whole, the conclusions drawn and, in particular, the methods used have wider significance to not only studies of the ancient economy, but of archaeology, classics and the humanities more widely. While methods of data collection have greatly improved in recent years, the data analysis has only just begun to catch up; it is vital that this keeps pace, as the complex web of the ancient economy slowly begins to be untangled.

# Bibliography

Abulafia, D. (2005). ‘Mediterraneans’, in W.V. Harris (ed.), *Rethinking the Mediterranean*. Oxford; New York, 64-93.

ʿAd, U. and Frankel, R. (2012). ‘Lever-and-Drum Presses at Moshav Habonim and Ḥorvat ʿAqav (Ramat Hanadiv)’, *Israel Exploration Journal* 62.1: 101-112.

Adams, C. (2004). ‘Roman Communications; A. Kolb: Transport und Nachrichtentransfer im Römischen Reich’, *The Classical Review* 54.2: 493-494.

Aldenderfer, M. (1998). ‘Quantitative methods in archaeology: A review of recent trends and developments’, *Journal of Archaeological Research* 6.2: 91–120.

Aldini, T. (1978). ‘Anfore Foropopiliensi’, *Archeologia Classica* 30: 236–245.

— (1996). ‘Elementi per una più coretta classificazione delle anfore forlimpopolensi’, *Atti e memorie. Nuova Serie.* 46: 11-22.

— (2000). ‘Archeologia Bertinorense Forlimpopoli’, *Documenti e studi* 11: 23-66.

Alka, D.K. (1990). ‘Lika u rimsko doba / Karl Patsch ; Gospić : Biblioteka “Ličke župe”, 1990.’, *Obavijesti Hrvatskog arheološkog društva* XXII.3: 51-51.

Amouretti, M.C. and Brun, J.P. (1993). *La production du vin et de l’huile en Méditerranée* (BCH, Suppl. 26). Paris.

Ando, C. (2006). ‘The Administration of the Provinces’, in D.S. Potter (ed.), *A companion to the Roman Empire* (Blackwell companions to the ancient world). Malden, MA, 177-192.

Antognozzi, M., Lopreite, E., and Massoni, M. (2014). ‘Lo scavo archeologico di Marino del Tronto (AP): testimonianze di continuità insediativa fra età romana e altomedievale’, in E. Cirelli, E. Giorgi, and G. Lepore (eds.), *Economia e territorio nell’Adriatico centrale tra Tarda Antichità e Alto Medioevo, Ravenna 28 febbraio - 1 marzo*. Ravenna.

Antolini, P. (1986). *Il libro dell’ulivo e dell’olio d’oliva*. Genova.

Apollonio, C., Balacco, G., Novelli, A., Tarantino, E., and Apollonio et al., A.F. (2016). ‘Land Use Change Impact on Flooding Areas: The Case Study of Cervaro Basin (Italy)’, *Sustainability* 8.10: 996.

Arcenas, S. (2015). ‘ORBIS and the Sea: a model for maritime transportation under the Roman Empire’, *Stanford ORBIS Project*.

Arnaud, P. (2005). *Les routes de la navigation antique Itinéraires en Méditerranée*. Paris.

— (2007). ‘Diocletian’s Prices Edict: the prices of seaborne transport and the average duration of maritime travel’, *Journal of Roman Archaeology* 20: 321-336.

— (2016). ‘Entre mer et rivière : les ports fluvio-maritimes de Méditerranée ancienne. Modèles et solutions’, in C. Sanchez and M.P. Jézégou (eds.), *Les ports dans l’espace Méditerranéen antique. Narbonne et lessystèmes portuaires fluvio-lagunaires. Actes du colloque international tenu à Montpellier du 22 au 24 mai 2014, Montpellier-Lattes, (Revue Archéologique de Narbonnaise, Supplément 44)* (Revue Archéologique de Narbonnaise).

Ashby, T. and Gardner, R. (1916). ‘The Via Traiana’, *Papers of the British School at Rome* 8: 104-171.

Attema, P. (2017). ‘Landscape Archaeology in Italy: Past Questions, Current State and Future Directions’, in T. de Haas and G. Tol (eds.), *The Economic Integration of Roman Italy: Rural Communities in a Globalizing World*. Leiden, 426–435.

Augenti, A. and Cirelli, E. (2011). ‘From suburb to port: the rise (and fall) of Classe as a centre of trade and redistribution’, in S. Keay (ed.), *Rome, Portus and the Mediterranean*. London, 205-211.

Auriemma, R. (2015). ‘Fish and ships: la filiera del pesce nell’alto Adriatico in età romana’, *Antichità Altoadriatiche* 84: 475-497.

Auriemma, R. and Degrassi, V. (2015). ‘Flussi di circolazione e redistribuzione in Adriatico tra tarda Repubblica e Impero: anfore da contesti terrestrie subacquei’, in *AdriAtlas et l’histoire de l’espace adriatique du VIe s. a.C. au VIIIe s. p.C. : actes du colloque international de Rome (4-6 novembre 2013)*. Bordeaux, 453–478.

Atti Inch. Agr. (1884), *Atti della Giunta per I.a Inchiesta agraria e sulle condizioni dell.a cl.asse agrico/.a (1884) vol. XI, t 11-111 (Province di Perugia, Ascoli-Piceno, Ancona, Macerata e Pesaro)*. Rome.

Babić, L., Crnjaković, M., and Asmerom, Y. (2012). ‘Uplifted Pleistocene marine sediments of the Central Adriatic Island of Brusnik’, *1* 65.2: 223-232.

Bairoch, P. (1988). *Cities and economic development: from the dawn of history to the present*. Chicago.

Baldacci, P. (1967). 'Alcuni aspetti dei commerci nei territori cisalpini', *Atti del Centro Studi e Documentazione sull'Italia Romana* 1: 7-50.

Ballard, R.D., McCann, A.M., Yoerger, D., Whitcomb, L., Mindell, D., Oleson, J., Singh, H., Foley, B., Adams, J., Piechota, D., and Giangrande, C. (2000). 'The discovery of ancient history in the deep sea using advanced deep submergence technology', *Deep Sea Research Part I: Oceanographic Research Papers* 47.9: 1591-1620.

Bang, P.F. (2008). 'Trade and Empire In Search of Organizing Concepts for the Roman Economy', *Past & Present* 195.1: 3-54.

Baratta, G. (1997). 'Le botti: dati e questioni', in *Techniques et économie antiques et médiévales: le temps de l'innovation, colloque international (C.N.R.S.), Aix-en-Provence 21-23 mai 1996*. Paris, 109-112.

Basić, F. (2013). *The soils of Croatia*. New York.

Baxter, M.J. (2008). 'Mathematics, Statistics and Archaeometry: The Past 50 Years or so', *Archaeometry* 50.6: 968–982.

Begović, V. and Schrunk, I. (2010). 'Villa Rustica u Uvali Dobrika (Madona) na Otoćju Brijuni', *Prilozi Instituta za arheologiju u Zagrebu* 27: 249-266.

Bekić, L. and Pešić, M. (2015). 'Pokateleji Pomorkse Trgovine na IstoČnoj Obali Jarana na Osnovu Nalaza Amfora iz Dvije Rimske Luke/ Evidence of Maritime Trade on the Eastern Adriatic Coact Based on Underwater Finds From Two Roman Ports in Croatia', *Histria archaeologica* 45: 95-112.

Bekić, L. and Royal, J. (2016). 'The Croatia Coastal Survey: 2012-2014 field seasons: The Croatia Coastal Survey: 2012-2014', *International Journal of Nautical Archaeology* 45: 267-282.

Beltrame, C. (2002). *Vita di bordo in età romana, Roma, Istituto Poligrafico e Zecca dello Stato, 2002 Life aboard Ships in Roman Age*. Viterbo.

Beltrame, C. and Costa, E. (2016). 'A 5th-Century-AD Sewn-Plank River Barge at St Mariain Padovetere (Comacchio-FE), Italy: an interim report', *The International Journal of Nautical Archaeology* 45.2: 253-266.

Beltrame, C. and Gaddi, D. (2013). ‘Fragments of Boats from the Canale Anfora of Aquileia, Italy, and Comparison of Sewn-Plank Ships in the Roman Era’, *International Journal of Nautical Archaeology* 42.2: 296-304.

Benito, G., Macklin, M.G., Zielhofer, C., Jones, A.F., and Machado, M.J. (2015). ‘Holocene flooding and climate change in the Mediterranean’, *CATENA* 130: 13-33.

Beresford, J. (2013). *The ancient sailing season* (Mnemosyne, supplements 351). Leiden and Boston.

Berti, F. (1990). *Fortuna maris: la nave romana di Comacchio*. Bologna.

Bevan, A. (2011). ‘Computational Models for Understanding Movement and Territory’, in V. Mayoral Herrera and S. Celestino Pérez (eds.), *Tecnologías de Información Geográfica y Análisis Arqueológico del territorio: Actas del V Simposio Internacional de Arqueología de Mérida*. Mérida, 383–394.

— (2013). ‘Travel and interaction in the Greek and Roman World. A review of some computational modelling approaches’,Dunn, S. and Mahony, S. (eds.) *Bulletin of the Institute of Classical Studies: Supplement* 122: 3-24.

— (2014). ‘Mediterranean Containerization’, *Current Anthropology* 55.4: 387-418.

Bezeczky, T. (1998). *The Laecanius Amphora Stamps and the Villas of Brijuni* (Denkschriften/Österreichische Akademie der Wissenschaften. Philosophisch-Historische Klasse 261 Bd). Wien.

— (2010). ‘Trade Connections Between Ephesus and the Adriatic Region’, *Histria antiqua* 19.19: 351-358.

Bezeczky, T. and Pavletié, M. (1996). ‘New objects from the figlina of C. Laecanius Bassus,’ *JÖAI* 65: 143-163.

Bidovec, F. and Zavod, H. (1967). ‘The Hydrosystem of Karstic Springs in the Timavo Basin’, *Geology* 263.1: 263–274.

Bilić, T. (2012). ‘Wind direction as one of the problems in navigation on the Adriatic in Greek and roman period’, *Pomorstvo* 26: 81-93.

Boetto, G., Koncani Uhač, I., and Uhač, M. (2017). ‘Sewn Ships from Istria (Croatia): the shipwrecks of Zambratija and Pula’, in J. Litwin (ed.), *Baltic and beyond. Change and continuity in shipbuilding.*

*Proceedings of the fourteenth international symposium on boat and ship archaeology, Gdansk.* 189-198.

Book, J.W., Signell, R.P., and Perkins, H. (2007). ‘Measurements of storm and nonstorm circulation in the northern Adriatic: October 2002 Through April 2003’, *Journal of Geophysical Research* 112.C11:

Boschian, G. and Montagnari-Kokelj, E. (2000). ‘Prehistoric shepherds and caves in the Trieste Karst (Northeastern Italy)’, *Geoarchaeology* 15.4: 331-371.

Bosi, G., Labate, D., Rinaldi, R., Montecchi, M.C., Mazzanti, M., Torri, P., Riso, F.M., and Mercuri, A.M. (2019). ‘A survey of the Late Roman period (3 rd -6th century AD): Pollen, NPPs and seeds/fruits for reconstructing environmental and cultural changes after the floods in Northern Italy’, *Quaternary International* 499.A: 3-23.

Bosina, E. and Weidmann, U. (2017). ‘Estimating pedestrian speed using aggregated literature data’, *Physica A* 468: 1-29.

Bosio, L. (1991). *Le strade romane della Venetia e dell’Histria* (Il Mito e la storia 4). Padova.

Botte, E. (2009). ‘Le Dressel 21-22: Anfore da Pesce Tirrenich del’Alto Impero’, in S. Pesavento Mattioli and M.-B. Carre (eds.), *Olio e Pesce in Epoca Romana: Produzione e Commercio nelle Regioni dell’Alto Adriatico: Atti del Convegno (Padova 16 febbraio 2007)*. Rome, 149–171.

Botte, E., Bertrand, A., and Jelinčić, K. (2016). ‘Bunje (Novo Selo, Croatie). Campagne de fouilles 2015’, *Chronique des activités archéologiques de l’École française de Rome.* DOI: 10.4000/cefr.4606 .

Bowden, W., Përzhita, L., Moorhead, S., and Reynolds, P. (2004). ‘Archaeology in the landscape of Roman Epirus: Preliminary report on the Diaporit excavations, 2002-3’, *Journal of Roman Archaeology* 17: 413-433.

Buosi, A., Tomio, Y., Juhmani, A.-S., and Sfriso, A. (2021). ‘Ecosystem Organic Carbon Stock Estimations in the Sile River, North Eastern Italy’, *Water* 13.1: 80.

Buxeda i Garrigós, J., Cau Ontiveros, M.A., and Kilikoglou, V. (2003). ‘Chemical variability in clays and pottery from a traditional cooking pot production village: testing assumptions in Pereruela’, *Archaeometry* 45: 1–17.

Bragato, G., Sladonja, B., and Peršurić, Đ. (2004). 'The soil environment for Tuber magnatum growth in Motovun Forest, Istria', *Natura Croatica : Periodicum Musei Historiae Naturalis Croatici* 13.2: 171-185.

Brander, J.A. and Spencer, B.J. (1985). 'Export Subsidies and International Market Share Rivalry', *Journal of International Economics* 18: 83–100.

Brandon, C., Hohlfelder, R., and Oleson, J. (2008). 'The concrete construction of the Roman harbours of Baiae and Portus Iulius, Italy: The ROMACONS 2006 field season', *International Journal of Nautical Archaeology* 37: 374-379.

Brandt, R., Groenewoudt, B.J., and Kvamme, K.L. (1992). 'An experiment in archaeological site location: Modeling in the Netherlands using GIS techniques', *World Archaeology* 24.2: 268–282.

Brecciaroli Taborelli, L. (1984). 'Una Produzione di Anfore Picene ed il Vino Palmense', *PICUS: Studi e Ricerche Sulle Marche nell'Antichità* 4: 55–94.

Breslin, S. and Higgott, R. (2000). 'Studying Regions: Learning from the Old, Constructing the New', *New Political Economy* 5.3: 333-352.

Brodie, J.F., Mohd-Azlan, J., and Schnell, J.K. (2016). 'How individual links affect network stability in a large-scale, heterogeneous metacommunity', *Ecology* 97.7: 1658-1667.

Brughmans, T. and Poblome, J. (2016a). 'MERCURY: an Agent-Based Model of Tableware Trade in the Roman East', *JASSS* 19.1: 3.

— (2016b). 'Roman Bazaar or Market Economy? Explaining Tableware Distributions Through Computational Modelling', *Antiquity* 90.350: 393–408.

— (2017). 'The Case for Computational Modelling of the Roman Economy: A Reply to Van Oyen', *Antiquity* 91.359: 1364–1366.

Brun, J.-P. (1986). L'oléiculture Antique en Provence: Les Huileries du Département du Var. *Paris.*

— (1993). 'La production du vin et de l'huile en Méditerranée. Actes du symposium international organisé par le Centre Camille Jullian et le Centre archéologique du Var, Aix-en-Provence et Toulon 20-22 novembre 1991', *Bulletin de correspondance hellénique. Suppléments.* 26: 511-537.

— (2003). *Le vin et L’ huile dans La Mediterranee antique. Viticulture, oleiculture et procedes de transformation*. Paris.

— (2004). *Archéologie du vin et de l’huile dans l’Empire romain*. Paris.

Brun, J.P., Garnier, N., and Olcese, G. (2020). ‘A. Making Wine in Western-Mediterranean. B. Production and the Trade of *Amphorae*: some new data from Italy- International Congress of Classical Archaeology - Panel 3.5’, *Proceedings of the 19th International Congress of Classical Archaeology (Cologne-Bonn 22-26 May 2018)*.

Brunović, D., Miko, S., Ilijanić, N., Peh, Z., Hasan, O., Kolar, T., Miko, M.Š., and Razum, I. (2019). ‘Holocene foraminiferal and geochemical records in the coastal karst dolines of Cres Island, Croatia’, *1* 72.1: 19-42.

Brunšmid, J. (1895). ‘Arheološke bilješke iz Dalmacije i Panonije’, *Vjesnik Arheološkog muzeja u Zagrebu* 1.1: 148-183.

Brusić, Z. (2000). ‘Nekropola Gradine kod Dragišića’, *Radovi Filozofskog fakulteta u Zadru* 38: 1-15.

Brusic, Z. (2001). ‘Rezultati prapovijesnih istraživanja na Relji u sklopu izgradnje trgovinskog centra’, *Iskoni bê slovo - Zbornik radova o glagoljici i glagoljašima zadarskog kraja i crkve svetog Ivana Krstitelja* 45-49.

Brusić, Z. (2007). ‘Pakoštanska Luka I Druga Priobalina Liburnska Naselja u Pašmanskom Kanalu u Odnosu na Gradinska Naselja u Zaleđu I Aseriju’, *Asseria* 5.5: 11-37.

Buchi, E. (1973). ‘Banchi di anfore romane a Verona. Note sui commerci cisalpini’, in *Il territorio veronese in età romana, Atti del Convegno (Verona, 22-24 ottobre 1971)*. Verona, 531-637.

— (1996). ‘*La vitivinicultura cisalpina in età romana, in 2500 anni di cultura della vite nell’ambito alpino e cisalpino*’, in G. Forni and A. Scienza (eds.), ‘Confraternita della vite e del vino di Trento’. Trento, 373-389.

Bulić, D. (2015). *Rimska ruralna arhitektura Istre u kontekstu ekonomske i socijalne povijesti*, Doctorate, Sveučilište Jurja Dobrile u Puli.

Buol, S.W., Southard, R.J., Graham, R.C., and McDaniel, P.A. (2011). *Soil Genesis and Classification*. New York.

Buonopane, A. (2009). ‘La produzione olearia e la lavorazione del pesce lungo il medio e l’alto adriatico: le fonti letterarie’, in S. Pesavento Mattioli and M.B. Carre (eds.), *Olio e pesce in epoca romana. Produzione e commercio nelle regioni dell’alto adriatico, Atti del Convegno, Roma 2009*

Buonopane, A. and Pesavento Mattioli, S. (2007). ‘Puntualizzazioni epigrafiche e tipologiche sulle anfore prodotte nei possedimenti imperiali dell’Histria’, in D. Pupillo (ed.), *Le proprietà imperiali nell’Italia romana. Economia, produzione, amministrazione, Atti del Convegno Internazionale*. Ferrara, 293-310.

Buora, M. (1995). ‘Presenze di anfore tipo Dressel 6A con il marchio M. Her. Picen.’, *Quaderni Friulani di Archeologia* 5: 183-189.

Buršić-Matijašić, K. (2001). ‘Najranija prošlost Svetvinčenta i okolice’, *Vjesnik Istarskog arhiva* 6-7.(1996.-1997.): 55-66.

Burton, P. and Lewit, T. (2019). ‘Pliny’s Presses: the True Story of the First Century Wine Press’, *Klio* 101.2: 543-598.

Busana, M.S. (2003). ‘La produzione vinaria dalle fonti archeologiche nella Valpolicella di età romana’, *Annuario Storico della Valpolicella* 19.0: 117-132.

Busana, M.S., D’Inca, C., and Forti, S. (2009). ‘Olio e pesce in epoca romana nell’alto e medio Adriatico’, in S. Pesavento Mattioli and M.-B. Carre (eds.), *Olio e Pesce in Epoca Romana: Produzione e Commercio nelle Regioni dell’Alto Adriatico: Atti del Convegno (Padova 16 febbraio 2007)*35-79.

Cafini, M.I. and D’Alessandro, L. (2010). ‘Anfore adriatiche a Roma. Rinvenimenti dall’area del Nuovo Mercato Testaccio’, *Rei Cretariae Romanae Fautores Acta* 41: 93-100.

Calantropio, A., Chiabrando, F., and Auriemma, R. (2021). ‘Photogrametric underwater and UAS Surveys of Archaeological Sites: The Case Study of the Roman Shipwreck of Torre Santa Sabina’, *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* XLIII-B2-2021: 643-650.

Callender, M.H. (1970). *Roman Amphorae with Index of Stamps*. Oxford.

Calzolari, M. (2007). ‘Il Delta Padano in Età romana idrografia, viabilità, insediamenti’, in F. Berti (ed.), *Genti nel Delta da Spina e Comacchio: Uomini, Territorio e Culto dall’Antichita all’Alto Medioevo*. Ferrara, 153-172.

Cambi, N. (1989). ‘Anfore Romane in Dalmazia’, in *Amphores romaines et histoire économique. Dix ans de recherche. Actes du colloque de Sienne (22-24 mai 1986)* 311-337.

Campanale, C., Stock, F., Massarelli, C., Kochleus, C., Bagnuolo, G., Reifferscheid, G., and Uricchio, V.F. (2020). ‘Microplastics and their possible sources: The example of Ofanto river in southeast Italy’, *Environmental Pollution* 258: 113284.

Campbell, B.M.S. (2000). *English Seigniorial Agriculture 1250-1450*. Cambridge.

Canosa-Betés, J. (2016). ‘Border surveillance: Testing the territorial control of the Andalusian defense network in center-south Iberia through GIS’, *Journal of Archaeological Science: Reports* 9: 416–426.

Capedri, S., Grandi, R., and Venturelli, G. (2003). ‘Trachytes Used for Paving Roman Roads in the Po Plain: Characterization by Petrographic and Chemical Parameters and Provenance of Flagstones’, *Journal of Archaeological Science* 30.4: 491-509.

Capelli, C., Cabella, R., and Piazza, M. (2009). ‘Appendice Analisi in Sezione Sottile di Anfore Dressel 21-22’, in S. Pesavento Mattioli and M.-B. Carre (eds.), *Olio e Pesce in Epoca Romana: Produzione e Commercio nelle Regioni dell’Alto Adriatico: Atti del Convegno (Padova 16 febbraio 2007)*. Rome, 164–171.

Capulli, M. (2013). ‘Ships of Aquileia. Underwater Archaeological Research for the Study of Marine and Inside Routes in the Upper Adriatic Sea’, *Skyllis* 13: 18-24.

Carandini, A. and Settis, S. (1979). *Schiavi e Padroni nell’Etruria Romana La Villa di Sette inestre dallo Scavo alla Mostra*. Bari.

Carballo, D.M. and Pluckhahn, T. (2007). ‘Transportation corridors and political evolution in highland Mesoamerica: Settlement analyses incorporating GIS for northern Tlaxcala, Mexico’, *Journal of Anthropological Archaeology* 26.4: 607-629.

Carre, M.-B. (1985). ‘Les Amphores de la Cisalpine et de l’Adriatique au Début de l’Empire’, *Mélanges de l’École française de Rome. Antiquité* 97.1: 207-245.

— (2008). ‘Les Fouilles du Port Fluvial d’Aquilee’, *Revue Archéologique, Nouvelle Série* 1: 193-198.

Carre, M.B., Kovačić, V., Marchiori, A., Rosada, G., Tassaux, F., and Zabeo, M. (2006). 'Loron/Lorun, Parenzo/Poreč, Istria. Una villa maritima nell'agro parentino: la campagna di ricerca 2004', *Histria Antiqua* 14: 261-280.

Carre, M.-B., Monsieur, P., and Pesavento Mattioli, S. (2014). 'Transport *amphorae* Lamboglia 2 and Dressel 6A: Italy and/or Dalmatia? Some clarifications', *Journal of Roman Archaeology* 27: 417-428.

Carre, M.-B. and Pesavento Mattioli, S. (2003). 'Tentativo di Classificazion delle Anfore Olearie Adriatiche', *Aquileia Nostra* 74: 453-475.

Carreras, C. and De Soto, P. (2013). 'The Roman Transport Network: A Precedent for the Integration of the European Mobility', *Historical Methods: A Journal of Quantitative and Interdisciplinary History* 46.3: 117-133.

Casson, L. (1950). 'The Isis and Her Voyage', *Transactions of the American Philological Association* 81: 43-56.

Casson, L. (1995). *Ships and Seamanship in the Ancient World*. Baltimore and London.

Caudullo, G., Welk, E., and San-Miguel-Ayanz, J. (2017). 'Chorological maps for the main European woody species', *Data in Brief* 12: 662-666.

Cerva, M. (1997). 'Oleum Liburnicum', *L'evidenza del paradosso, Atti e Memorie della Società Istriana di Archeologia e Storia Patria* 97: 39-45.

Chandler, T. (1974). *Three Thousand Years of Urban Growth*. New York.

Charbonnier, M.-C. and Cammas, C. (2018). 'Characterization of Gallo-Roman roads in northern France using micromorphological methods', *Quaternary International* 483: 194-210.

Charlin, G., Gassend, J.-M., and Lequément, R. (1978). 'L'épave antique de la baie de Cavalière (Le Lavandou, Var)', *Archaeonautica* 2.1: 9-93.

Chevallier, R. (1976). *Roman Roads*. London.

Ciarrocchi, G. (1999). *Cupra Maritima: La Campagna e la Citta, ritrovamenti, schizzi e annotazioni sulle strutture antiche, (1969 - 1999)*. Grottamare.

Ciavola, P., Salemi, E., and Billi, P. (2010). '*Sediment supply and morphological evolution of a small river mouth (fiumi uniti, ravenna, italy): should river management be storm-driven?*', in . Bologna.

Cioffi, R. (2016). *Travel in the Roman World (Oxford Handbooks Online)*. Oxford.

Cipriano, S. (2009). 'Le Anfore Olearie Dressel 6b', in S. Pesavento Mattioli and M.-B. Carre (eds.), *Olio e Pesce in Epoca Romana: Produzione e Commercio nelle Regioni dell'Alto Adriatico: Atti del Convegno (Padova 16 febbraio 2007)*. Rome, 178.

Cipriano, M.T. and Carre, M.-B. (1989). 'Production et Typologie des Amphores sur la Côte Adriatique de l'Italie', in *Amphores romaines et histoire économique. Dix ans de recherche. Actes du colloque de Sienne (22-24 mai 1986)*. Rome, 67-104.

Cipriano, S., Mazzocchin, S., Maritan, L., and Mazzoli, C. (2020). 'Le anfore Dressel 6B prodotte in area nord adriatica: Studio archeologico e archeometrico di materiali da contesti datati', in P. Machut, Y. Marion, A. Ben Amara, and F. Tassaux (eds.), *Adriatlas 3. Recent multidisciplinary research on North Adriatic amphorae in Roman times*Ausonius editions. Bordeaux.

Cipriano, S. and Mazzochin, S. (2002). 'Analisi di alcune serie bollate di anfore Dressel 6B (AP. PVLCRI, FLAV.FONTAN/FONTANI, L.IVNI.PAETINI, L.TRE.OPTATI)', *Aquileia Nostra* 73: 305-340.

Costantini, E.A.C. and Dazzi, C. (eds.) (2013). *The soils of Italy* (World soils book series). Dordrecht and New York.

Cowgill, G.L. (1977). 'The Trouble with Significance Tests and What We can do about It', *American Antiquity* 42.3: 350–368.

Cukrov, N., Cmuk, P., Mlakar, M., and Omanović, D. (2008). 'Spatial distribution of trace metals in the Krka River, Croatia: an example of the self-purification', *Chemosphere* 72.10: 1559–1566.

Cushman-Roisin, B., Korotenko, K.A., Galos, C.E., and Dietrich, D.E. (2007). 'Simulation and characterization of the Adriatic Sea mesoscale variability', *Journal of Geophysical Research* 112.C3: 13.

Crawford, M. (2017). 'Where Were the Coins We Find Actually Used?', in T. de Haas and G. Tol (eds.), *The Economic Integration of Roman Italy: Rural Communities in a Globalizing World*. Leiden, 407–415.

Cristofori, A. (2004). *Non arma virumque: Le occupazioni nell'epigrafia del Piceno*, 2nd edition. Bologna.

Crowe, F., Sperduti, A., O'Connell, T.C., Craig, O.E., Kirsanow, K., Germoni, P., Macchiarelli, R., Garnsey, P., and Bondioli, L. (2010). 'Water-Related Occupations and Diet in Two Roman Coastal Communities

(Italy, First to Third Century AD): Correlation Between Stable Carbon and Nitrogen Isotope Values and Auricular Exostosis Prevalence', *American Journal of Physcical Anthropology* 142: 355-366.

Cucchi, F. and Finocchiaro, F. (2017). 'Karst Landforms in Friuli Venezia Giulia: From Alpine to Coastal Karst', in M. Soldati and M. Marchetti (eds.), *Landscapes and Landforms of Italy* (World geomorphological landscapes). New York, 147-156.

Čuka, A. (2002). 'Geographical Basis for Development of Organic Olive Grow in Croatia', *Geoadria* 7.1: 97-107.

Curtis, R.I. (2001). *Ancient Food Technology*. Leiden.

D'agostino, M. and Medas, S. (2010). 'Roman Navigation in Venice Lagoon: the Results of Underwater Research', *International Journal of Nautical Archaeology* 39.2: 286-294.

D'Alessandro, L., Miccadei, E., and Piacentini, T. (2008). 'Morphotectonic study of the lower Sangro River valley (Abruzzi, Central Italy)', *Geomorphology* 102.1: 145-158.

De Caro, S. (1994). *La villa rustica in località Villa Regina a Boscoreale*. Naples.

De Franceschini, M. (1998). *Le ville Romane della X regio (Venetia et Histria)*. Rome.

de Graauw, A. (2019). 'Ancient Ports and Harbours, The Catalogue', *'Ancient Ports--Ports antiques,' website* http://www.ancientportsantiques.com/docs-pdf/ (accessed 20/10/21).

de Ligt, L. (2012). *Peasants, citizens and soldiers: studies in the demographic history of Roman Italy 225 BC-AD 100*. Cambridge and New York.

De Soto, P. (2010). *Anàlisi de la xarxa de comunicacions i del transport a la Catalunya romana: estudis de distribució i mobilitat*, Doctoral, Universitat Autònoma de Barcelona.

— (2019). 'Network Analysis to Model and Analyse Roman Transport and Mobility', in P. Verhagen, J. Joyce, and M.R. Groenhuijzen (eds.), *Finding the Limits of the Limes: Modelling Demography, Economy and Transport on the Edge of the Roman Empire*. New York. 271-290.

de Vivo, F. (2003). 'Historical Justifications of Venetian Power in the Adriatic', *Journal of the History of Ideas* 64.2: 159-176.

Degrassi, A. (1953). 'Aquileia e l'Istria in età romana', in G. Brusin (ed.), *Studi Aquileiesi offerti*. Aquileia.

— (1956). ‘L’esportazione di olio e olive istriane nell’età romana’, *Atti e memorie della Società istriana di archeologia* 4: 104-112.

— (1962). ‘L’esportazione di olio e olive istriane nell’età romana’, in A. Degrassi (ed.), *Scritti Vari di Antichità II*. Rome, 965-972.

Delli Santi, M. and Corrado, A. (2013). *Il canale reale nel territorio di oria (Brindisi): Un percorso turistico tra geologia, ambienti, centro storico e siti arhcaeologici*. Bologna.

Demiraj, E., Malltezi, J., and Sulejman, S. (2015). *Environmental assessment of consequences from point and non-point pollution sources in the Shkodra/Skadar Lake*. Tirana.

Dermody, B.J., Boer, H.J. de, Bierkens, M.F.P., Weber, S.L., Wassen, M.J., and Dekker, S.C. (2012). ‘A seesaw in Mediterranean precipitation during the Roman Period linked to millennial-scale changes in the North Atlantic’, *Climate of the Past* 8.2: 637-651.

Desbat, A. (1991). ‘Un bouchon de bois du Ier s. aprés J.-C. recueilli dans la Saône á Lyon et la question du tonneau á l’époque romaine’, *Gallia* 48: 319-336.

— (1997). ‘Le tonneau antique: questions techniques et problème d’origine’, in *Techniques et économie antiques et médiévales: le temps de l’innovation, colloque international (C.N.R.S.), Aix-en-Provence 21-23 mai 1996*. Paris, 113-120.

Deutsche, K.W., Burrell, S.A., Kaan, R.A., Lee, M., and Lichterman, M. (1957). *Political Community and the North Atlantic Area: International Organization in the Light of Historical Experience*. Princeton.

Devlahović, A. (2012). ‘Starogradsko polje - Kupinovik’, *Hrvatski arheološki godišnjak* 9: 798-800.

— (2013). ‘Starogradsko polje - Kupinovik’, *Hrvatski arheološki godišnjak* 10: 617-618.

Ditzler, C. (2017). ‘Soil Properties and Classification (Soil Taxonomy)’, in L.T. West, M.J. Singer, and A.E. Hartemink (eds.), *The Soils of the USA*. New York.

Donev, D. and Willet, R. (2017). ‘J. W. Hanson, An Urban Geography of the Roman World, 100 BC to AD 300’, *American Journal of Archaeology* 121.4.

Doyle, J. and Garrison, T.G. (2012). ‘Watchful realms: integrating GIS analysis and political history in the southern Maya lowlands’, *Antiquity* 86: 792-807.

Drachman, A.G. (1932). *Ancient oil mills and presses*. Copenhagen.

Drohan, P.J., Ross, C.N., Anderson, J.T., Fortney, R.F., and Rentch, J.S. (2006). 'Soil and Hydrological Drivers of Typha latifolia Encroachment in a Marl Wetland', *Wetlands Ecology and Management* 14.2: 107-122.

Dungworth, D. (2016). 'Metals and Metalworking', 1 September 2016 The Oxford Handbook of Roman Britain, https://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199697731.001.0001/oxfordhb-9780199697731-e-030 (accessed 07/12/20).

EEA (2012). *EEA Catchments and Rivers Network System ECRINS v1.1: rationales, building and improving for widening uses to Water Accounts and WISE applications.* Luxembourg.

Engels, D.W. (1990). *Roman Corinth: an alternative model for the classical city*. Chicago and London.

Epstein, J. (2008). 'Why Model?', *Journal of Artificial Societies and Social Simulation* 11: 4-12.

Ercolino, R. and Mazzochin, S. (2000). 'La coltura dell'olivo nell'area pedemontana trevigiana e bassanese tra età antica e basso medioevo: un'ipotesi dalle fonti scritte e materiali,' *QuadAVen* 16: 172-183.

Erdkamp, P. (2005). *The Grain Market in the Roman Empire*. Cambridge.

Erdkamp, P. (2012). 'Urbanism', in W. Scheidel (ed.), *The Cambridge Companion to the Roman Economy*. Cambridge, 241-265.

Esquilini, E. (2011). 'Studio archeometrico preliminare di anfore greco-italiche medio adriatiche (Cattolica, Rimini)', *Ocnus* 19: 223-230.

Faivre, S., Fouache, E., Ghilardi, M., Antonioli, F., Furlani, S., and Kovačić, V. (2011). 'Relative sea level change in western Istria (Croatia) during the last millennium', *Quaternary International* 232.1-2: 132-143.

Feinman, Gary.M. (2017). 'Roman Economic Practice across Time and Space: An Outside Perspective', in T. de Haas and G. Tol (eds.), *The Economic Integration of Roman Italy: Rural Communities in a Globalizing World*. Leiden, 417–425.

Fernández-López, J. and Schliep, K. (2019). 'rWind: download, edit and include wind data in ecological and evolutionary analysis', *Ecography* 42: 804-810.

Filipovski, Gj. and Ćirić, M. (1969). *Soils of Yugoslavia*. Belgrade.

Finley, M.I. (1974). *The Ancient Economy*. Berkeley.

Finley, M.I. (1977). 'The Ancient City: From Fustel de Coulanges to Max Weber and Beyond', *Comparative Studies in Society and History* 19.3: 305-327.

Fontana, A., Frassine, M., and Ronchi, L. (2020). 'Geomorphological and Geoarchaeological Evidence of the Medieval Deluge in the Tagliamento River (NE Italy)', in J. Herget and A. Fontana (eds.), *Palaeohydrology*. New York, 97–116.

Forbes, H. (1992). 'The ethnoarchaeological approach to ancient Greek agriculture: olive cultivation as a case study', in B. Wells (ed.), *Agriculture in ancient Greece. Proceedings of the Seventh International Symposium at the Swedish Institute at Athens, 16-17 May 1990*. Stockholm, 87-101.

Forenbaher, S. (ed.) (2009). *A connecting sea: maritime interaction in Adriatic history* (BAR International series 2037). Oxford.

Formenti, F., Hesnard, A., and Tchernia, A. (1978). 'Note sur le contenu d'une amphore Lamboglia 2 de l'épave de la Madrague de Giens', *Archaeonautica* 2.1: 95-100.

Fortini, P. (1993). 'Cupra Maritima: Aspetti di vitaeconomica attraverso la documentazione storica ed archeologica', in G. Paci (ed.), *Cupra Marittima e il suo territorio in età antica, Atti del Convegno di Studi, Cupra Marittima 3 maggio 1992* (Picus Supplementi 2). Macerata, 83-181.

Fouache, E., Gruda, G., Mucaj, S., and Nikolli, P. (2001). 'Recent geomorphological evolution of the deltas of the Rivers Sema and Vjosa, Albania', *Earth Surface Processes and Landforms* 26: 793-802.

Foxhall, L. (2007). *Olive Cultivation in Ancient Greece: Seeking the Ancient Economy*. Oxford.

Franconi, T. and Green, C. (2019). 'Broad and Coarse: Modelling Demography, Subsistence and Transportation in Roman England', in P. Verhagen, J. Joyce, and Groenhuijzen (eds.), *Finding the Limits of the Limes: Modelling Demography, Economy and Transport on the Edge of the Roman Empire.* New York. *61*-76.

Frangeš, G. (2010). 'Park prirode Učka: Zaštićeno područje kao mjesto namijenjeno društvenom sjećanju', *Etnološka istraživanja* 15: 7-20.

Frank, T. (1933). *An Economic Survey of Ancient Rome. Volume 1: Rome and Italy of the Republic*. Baltimore.

Fredi, P. and Palmieri, E.L. (2017). 'Morphological Regions of Italy', in M. Soldati and M. Marchetti (eds.), *Landscapes and Landforms of Italy* (World geomorphological landscapes). New York, 39-76.

Frier, B. (2000). 'Demography', in A. Bowman, P. Garnsey, and D. Rathbone (eds.), *The Cambridge Ancient History*. Cambridge, 787-816.

Fulford, M. (1987). 'Economic interdependence among urban communities of the Roman Mediterranean', *World Archaeology: Urbanization* 19.1: 58-75.

Gaffney, V.L. and Kirigin, B. (eds.) (2006). *The Adriatic Islands Project: The archaeological heritage of Vis, Biševo, Svetac, Palagruža and Šolta* (BAR international series 1492). Oxford.

Gaffney, V.L., Kirigin, B., Petric, M., and Vujnovic, N. (eds.) (1997). *The Adriatic Islands Project: contact, commerce and colonialism, 6000 BC-AD 600* (BAR international series 660). Oxford.

Gallant, T.W. (1991). *Risk and Survival in Ancient Greece : Reconstructing the Rural Domestic Economy.* Cambridge.

Gamberini, A. (2014). 'Anfore', in L. Mazzeo Saracino (ed.), *Scavi di Suasa I. I reperti ceramic e vitrei dalla Domus dei Coiedii* (Studi e Scavi, nuova serie 39). Bologna, 553-585.

Gamble, A. and Payne, A. (eds.) (1996). *Regionalism and world order*. Basingstoke, Hampshire.

Garnsey, P. (1998). *Cities, Peasants and Food in Classical Antiquity: Essays in Social and Economic History*. Cambridge.

Garnsey, P., Hopkins, K., and Whittaker, C.R. (1983). *Trade in the Ancient Economy*. London.

Gassner, V. (2011). '*Amphorae* Production of the Ionic-Adriatic Region', *FACEM* 7.

Gates, C. (2003). *Ancient cities: the archaeology of urban life in the ancient Near East and Egypt, Greece and Rome*. London.

Gentilucci, M., Barbieri, M., and Burt, P. (2018). 'Climatic Variations in Macerata Province (Central Italy)', *Water* 10.8: 1104.

Gioia, P. and Volpe, R. (2009). 'Archeologia nel Parco di Centocelle', *Dialoghi di Archeologia e Architettura* 102-115.

Gioia, E., Carone, T., and Marincioni, F. (2015). 'Rainfall and land use empirically coupled to forecast landslides in the Esino river basin, central Italy', *Natural Hazards and Earth System Sciences* 15.6: 1289–1295.

Giuliodori, M., Di Cintio, C., Capponi, C., and Forti, C. (2007). 'Produzione e circolazione della ceramica ad Urbs Salvia tra il III sec. a.C. e la prima età imperiale.', *Studi Maceratesi* 41: 389-449.

Glicksman, K. (2005). 'Internal and External Trade in the Roman Province of Dalmatia', *Opvscula Archaeologica* 29: 189-230.

— (2007). 'Olive and Vine Cultivation in the Roman Province of Dalmatia', *Histria Antiqua* 15: 43-50.

— (2009). *The Economy of the Roman Province of Dalmatia*, D.Phil, University of Oxford.

Gliozzo, E., Leone, D., Origlia, F., Memmi, I.T., and Volpe, G. (2010). 'Archaeometric characterisation of coarse and painted fine ware from Posta Crusta (Foggia, Italy): technology and provenance', *Archaeological and Anthropological Sciences* 2.3: 175-189.

Goffredo, R. (2010). 'Persistence and change in settlement patterns in the Ofanto valley near Canusium and Cannae (Apulia) (late 4th c. B.C.-1st c. A.D.)', *Journal of Roman Archaeology* 23: 7-33.

Goffredo, R., Ficco, V., and Costantino, C. (2013). 'Ville e vici della valle del Carapelle (Puglia settentrionale). Approcci integrati allo studio dei paesaggi di età romana', *Mélanges de l'École française de Rome - Antiquité*. 125-1: DOI: 10.1007/978-3-030-04576-0_10 .

Goodchild, H. (2009). 'Modelling the Productive Landscape of the Middle Tiber Valley', in F. Coarelli and H. Patterson (eds.), *Mercator placidissimus: the Tiber Valley in antiquity: new research in the upper and middle river valley: Rome, 27-28 February 2004*. Roma, 769-796.

Greene, K. (2000). 'Technological Innovation and economic progress in the ancient world: M.I. Finley re-considered', *Economic History Review* 53: 29–59.

Grisonic, M. and Stepan, N. (2017). 'Italska terra sigillata iz rimske vile rustike u uvali Caska na otoku Pagu', *Archaeologia Adriatica* 11.1: 69-143.

Güimil-Fariña, A. and Parcero-Oubiña, C. (2015). '"Dotting the joins": a non-reconstructive use of Least Cost Paths to approach ancient roads. The case of the Roman roads in the NW Iberian Peninsula', *Journal of Archaeological Science* 54: 31-44.

Gustas, R. and Supernant, K. (2017). ‘Least cost path analysis of early maritime movement on the Pacific Northwest Coast’, *Journal of Archaeological Science* 78: 40-56.

Haas, T.C.A. de and Tol, G.W. (eds.) (2017). *The economic integration of Roman Italy: rural communities in a globalizing world* (Mnemosyne supplements volume 404). Leiden and Boston.

Haggard, S. (1993). ‘Comment’, in J.A. Frankel and M. Kahler (eds.), *Regionalism and Rivalry: Japan and the United States in Pacific Asia*. Chicago, 48-52.

Hägglund (1995). *La Villa Rustica di Monte Torto: Gli Impianti Produttivi*. Ancona.

Hammond, N.G.L. (2012). ‘The Western Part of the Via Egnatia’, *The Journal of Roman Studies* 64: 185-194.

Hanson, J.W. (2016). *An urban geography of the Roman world, 100 BC to AD 300* (Archaeopress Roman archaeology 18). Oxford.

Harris, W.V. (ed.) (2013). *The ancient Mediterranean environment between science and history* (Columbia studies in the classical tradition volume 39). Leiden and Boston.

Has-Schön, E., Bogut, I., and Strelec, I. (2006). ‘Heavy Metal Profile in Five Fish Species Included in Human Diet, Domiciled in the End Flow of River Neretva (Croatia)’, *Archives of environmental contamination and toxicology* 50: 545-551.

Hazell, L.C. and Brodie, G. (2012). ‘Applying GIS tools to define prehistoric megalith transport route corridors: Olmec megalith transport routes: a case study’, *Journal of Archaeological Science* 39.11: 3475-3479.

Hersbach, H., Bell, B., Berrisford, P., Hirahara, S., Horányi, A., Muñoz-Sabater, J., Nicolas, J.,Peubey, C., Radu, R., Schepers, D., Simmons, A., Soci, C., Abdalla, S., Abellan, X., Balsamo, G., Bechtold, P., Biavati, G., Bidlot, J., Bonavita, M., De Chiara, G., Dahlgren, P., Dee, D., Diamantakis, M., Dragani, R., Flemming, J., Forbes, R., Fuentes, M., Geer, A., Haimberger, L., Healy, S., Hogan, R. J., H´olm, E., Janiskov´a, M., Keeley, S., Laloyaux, P., Lopez, P., Lupu, C., Radnoti, G., de Rosnay, P., Rozum, I., Vamborg, F., Villaume, S., and Thépaut, J.-N. (2020). ‘The ERA5 global reanalysis’. *Quarterly Journal of the Royal Meteorological Society*, 146(730):1999–2049.

Herzog, I. (2014). ‘Least-cost Paths - Some Methodological Issues’, *Internet Archaeology* 36: DOI:10.11141/ia.36.5.

Hodges, R. (2010). 'Adriatic Sea trade in a European perspective', *Scottish Archaeological Journal* 32.2: 95-119.

Hopkins, K. (1980). 'Taxes and Trade in the Roman Empire (200 B.C.-A.D. 400)', *The Journal of Roman Studies* 70: 101-125.

— (2017). 'Economic Growth and Towns in Classical Antiquity', in C. Kelly (ed.), *Sociological Studies in Roman History* (Cambridge Classical Studies). Cambridge,

Horden, P. and Purcell, N. (2000). *The Corrupting Sea: A Study of Mediterranean History*. Oxford.

Howey, M.C.L. (2011). 'Multiple pathways across past landscapes: circuit theory as a complementary geospatial method to least cost path for modeling past movement', *Journal of Archaeological Science* 38.10: 2523-2535.

Hunter, L.C., Hendrix, E.C., and Dean, J.C. (2010). 'The cost of walking downhill: Is the preferred gait energetically optimal?', *Journal of Biomechanics* 43: 1910-1915.

Huntley, B. and Birks, H.J.B. (1986). 'An atlas of past and present pollen maps for Europe: 0-13 000 years ago', *Biol Plant* 28.4: 302-302.

Hurst Thomas, D. (1978). 'The Awful Truth about Statistics in Archaeology', *American Antiquity* 43: 231.

Hyatt, A.P. (2011). *From Taras to Tarentum: The Evolution of a Greek City in Roman Italy*, Doctorate, University at Buffalo.

Ilakovac, B. (1992). 'Hidroarheološko rekognosciranje Zadarskog i Pašmanskog kanala,' *Diadora* 14: 279-290.

— (1998). 'Rekonstrukcija rimskog tijeska za masline u Mulinama na otoku Ugljanu', *Radovi Zavoda povijest i znanosti HAZU u Zadru* 40: 1-26.

Indruszewski, G. and Barton, C.M. (2008). 'Cost surface DEM modelling of Viking Age seafaring in the Baltic Sea', in B. Frischer and A. Dakouri-Hild (eds.), *Beyond Illustration: 2D and 3D Digital Tools for Discovery in Archaeology* (BAR International Series 1805). Oxford,

IUSS Working Group WRB (2015). *World reference base for soil resources 2014: international soil classification system for naming soils and creating legends for soil maps.* Rome.

Jarriel, K. (2018). ‘Across the Surface of the Sea: Maritime Interaction in the Cycladic Early Bronze Age’, *Journal of Mediterranean Archaeology* 31: 52-76.

Jelinčić Vučković, K. (2011). ‘Luke kod Škripa na otoku Braču - novi arheološki nalazi’, *Archaeologia Adriatica* 5.1: 127-149.

Jones, A.H.M. (1964). *The Later Roman Empire, 284-602 : A Social Economic and Administrative Survey*. Oxford.

Jones, A.H.M. (Arnold H.M. (1940). *The Greek city from Alexander to Justinian*. Oxford.

Jongman, W. (1988). *The Economy and Society of Pompeii*. Amsterdam.

Jongman, W.M. (2001). ‘II. Bevolkerung und Wirtschaft der Stadt Rom’, in H. Cançik and H. Schneider (eds.), *Der Neue Pauly*. Stuttgart, 1077-1079.

Jurišić, M. (2000). *Ancient shipwrecks of the Adriatic: maritime transport during the first and second centuries AD* (BAR international series 828). Oxford.

Jurkić-Girardi, V. (1979). ‘Scavi in una parte della villa rustica romana a Cervera Porto presso Parenzo, I, Campagne 1976-1978’, *Atti* 9: 263-298.

Kapusta, A. and Wiluś, R. (2017). ‘Geography of Tourism in Croatia’, in K. Widawski and J. Wyrzykowski (eds.), *The Geography of Tourism of Central and Eastern European Countries*. New York, 109-147.

Karaman, Lj. (1930). *Iz kolijevke hrvatske prošlosti*. Zagreb.

Karambinis, M. (2019). ‘Urban Networks in Early Roman Macedonia and Aegean Thrace’, in L. de Ligt and J. Bintliff (eds.), *Regional Urban Systems in the Roman World, 150 BCE - 250 CE*. Leiden, 440-481.

Karivieri, A. (2008). ‘Creating Contacts: Trade and Exchange along the Via Egnatia from the Roman to the Early Byzantine Period’, *Bollettino di Archeologia online* Speciale: 15-22.

Katić, M. (1994). ‘Utvrda Drid’, *Prilozi povijesti umjetnosti u Dalmaciji* 34.1: 5-18.

Kehoe, D. (2012). ‘Contract Labor’, in W. Scheidel (ed.), *The Cambridge Companion to the Roman Economy*. New York, 114-130.

Killgrove, K. and Tykot, R.H. (2013). ‘Food for Rome: A stable isotope investigation of diet in the Imperial period (1st-3rd centuries AD)’, *Journal of Anthropological Archaeology* 32.1: 28-38.

Kingsley, S. (2008). 'Decline & Fall in Late Antique Croatia: Analytical Models for Marine Archaeology', in I. Radić, A. Gaspari, and A. Pydyn (eds.), *Underwater Archaeology: Past, Present, Future. Proceedings of the EAA conference Session,*. Zadar,

Kintigh, K. (2006). 'The Promise and Challenge of Archaeological Data Integration', *American Antiquity* 71.3: 567–578.

Kirigin, B., Johnston, A., Vučetić, M., and Lušić, Z. (2009). 'Palagruza- The Island of Diomedes- And Notes on Ancient Greek Navigation in the Adriatic', in *A Connecting Sea: Maritime Interaction in Adriatic Prehistory*. Oxford, 137-155.

Kolb, A. (2009). *Transport und Nachrichtentransfer im Römischen Reich*. Berlin.

Kopackova, J. (2014). 'Production of Wine and Olive Oil in Roman Histria and Dalmatia in Late Antiquity', *Studia Hercynia* 18: 75-88.

Köppen, W. (1918). 'Klassification der Klimate nach Temperatur, Niederschlag and Jahreslauf', *Petermanns Geographische Mitteilungen*. 64: 193-248.

Kron, G. (2012). 'Agriculture, Roman Empire', in *The Encyclopedia of Ancient History* eds R.S. Bagnall, K. Brodersen, C.B. Champion, A. Erskine and S.R. Huebner. https://doi.org/10.1002/9781444338386.wbeah18004 (accessed 03/03/22).

Krugman, P.R. (1987). 'Is Free Trade Passé?', *The Journal of Economic Perspectives* 1: 131–144.

Lamboglia, N. (1955). 'Sulla cronologia delle anfore romane di età repubblicana', *Rivista di Studi Liguri* 31: 241-270.

Laurence, R. (1999). *The Roads of Roman Italy: Mobility and Cultural Change*. London.

Lastoria, B., Miserocchi, F., Lanciani, A., and Monacelli, G. (2008). 'An Estimated Erosion Map for the Aterno-Pescara River Basin', *European Water* 21:

Lazović, B., Adakalić, M., Pucci, C., Perović, T., Bandelj, D., Belaj, A., Mariotti, R., and Baldoni, L. (2016). 'Characterizing ancient and local olive germplasm from Montenegro', *Scientia Horticulturae* 209: 117-123.

Leidwanger, J. (2013). 'Modeling distance with time in ancient Mediterranean seafaring: a GIS application for the interpretation of maritime connectivity', *Journal of Archaeological Science* 40: 3302-3308.

— (2020). *Roman Seas: A Maritime Archaeology of Eastern Mediterranean Economies*. Oxford.

Leidwanger, J. and Knappett, C. (2018). 'Maritime Networks, Connectivity, and Mobility in the Ancient Mediterranean', in J. Leidwanger and C. Knappett (eds.), *Maritime Networks in the Ancient Mediterranean World*. Cambridge, 1-21.

Lenzi, F. (2003). *L'archeologia dell'Adriatico dalla preistoria al Medioevo : Atti del convegno Internazionale*. Florence.

Leone, D. (2000). 'D. Leone, Le ceramiche tardoantiche della fattoria di Posta Crusta', in G. Volpe (ed), *Ordona X. Ricerche archeologiche a Herdonia (1993-1998), (Scavi e ricerche 12), Edipuglia.* Bari. 387-431.

Leveau, P. and Goudineau, C. (1983). 'La ville antique, ville de consommation? Parasitisme social et économie antique', *Études rurales* 89.1: 275-289.

Li, X.J., Bevan, A., Martinón-Torres, M., Rehren, T., Cao, W., Xia, Y., and Zhao, K. (2014). 'Crossbows and imperial craft organisation: the bronze triggers of China's Terracotta Army', *Antiquity* 88.339: 126–140.

Liebeschuetz, J.H.W.G. (1972). *Antioch : City and Imperial Administration in the Later Roman Empire*. Oxford.

Lindhagen, A. (2009). 'The transport amphoras Lamboglia 2 and Dressel 6A: A central Dalmatian origin?', *Journal of Roman Archaeology* 22: 83-108.

— (2013). 'The freedmen milieus at Delos and Narona. New perspectives on the Lamboglia 2 wine trade', in A.-L. Schallin (ed.), *Perspectives on ancient Greece. Papers in celebration of the 60th anniversary of the Swedish Institute at Athens (ActInstAthRegSuec, ser. in 8°, 22, 2013)*. Athens, 231–250.

Lionello, P. (ed.) (2012). *The climate of the Mediterranean region: from the past to the future.* London and Waltham.

Liverani, P. (1987). 'Resti di torchi di tradizione romana in Valpolicella', *Annuario storico della Valpolicella* 53-62.

Llobera, M. (2000). 'Understanding Movement: A Pilot Model Towards the Sociology of Movement', in *Beyond the Map: Archaeology and Spatial Technologies*. Oxford, 65–84.

Llobera, M., Fábrega-Álvarez, P., and Parcero-Oubiña, C. (2011). 'Order in movement: a GIS approach to accessibility', *Journal of Archaeological Science* 38.4: 843-851.

Lo Cascio, E. (2009). 'Urbanization as a Proxy of Demographic and Economic Growth', in A. Bowman and A. Wilson (eds.), *Quantifying the Roman Economy: Methods and Problems*. Oxford, 88-106.

Lock, G.R. and Stančič, Z. (eds.) (1995). *Archaeology and geographical information systems: a European perspective*. London ; Bristol, PA.

Lombardo, M. and Marangio, C. (eds.) (1998). *Il territorio brundisino: dall'età messapica all'età romana, atti* (Historiē 1). Galatina.

Lukić, I. and Horvat, I. (2017). 'Differentiation of Commercial PDO Wines Produced in Istria (Croatia) According to Variety and Harvest Year Based on HS-SPME-GC/MS Volatile Aroma Compound Profiling', *Food Technol. Biotechnol.* 55.1: 95-108.

Malmberg, S. (2015). 'Ships are seen gliding swiftly along the sacred tiber': The river as an artery of urban movement and development.', in I. Östenberg, S. Malmberg, and J. Bjørnebye (eds.), *The moving city: processions, passages and promenades in ancient Rome*. London, 187-201.

Manning, S.W. (2013). 'The Roman World and Climate: Context, Relevance of Climate Change, and Some Issues', in W.V. Harris (ed.), *The Ancient Mediterranean Environment between Science and History.* Leiden, 103-170.

Mansfield, E.D. and Solingen, E. (2010). 'Regionalism', *Annual Review of Political Science* 13.1: 145-163.

Manzelli, V. (2000). *Ravenna Citta' Romane 2*. Rome.

Mardešić, J. and Šalov, T. (2000). 'Keramički nalazi s istraživanja bazilike u Erešovim Barama - Vid kod Metkovića', *Vjesnik za arheologiju i historiju dalmatinsku* 94: 105-163.

Marion, Y. and Tassaux, F. (2020). *Les amphores d'Istrie septentrionale et centrale : ateliers et typochronologie*. Paris.

Markusen, J.R., Melvin, J.R., Maskus, K.E., and Kaempfer, W. (1995). *International trade: theory and evidence*. Boulder.

Marliére, E. (2002). *L'o tre et le tonnea dans l'Occident romain*. Montagnac.

Martínez Tuñón, A., Robles García, N.M., Clark, D.J., Warinner, C., and Tuross, N. (2018). 'Clandestine pulque production during the sixteenth century in the Tlacolula Valley, Oaxaca, Mexico', *Mexicon* 40: 52-59.

Martino, A., Fatiguso, F., Tommasi, G., and Casal, J. (2016). 'Accidental Impacts on Historical and Architectural Heritage in Port Areas: The Case of Brindisi', *International Journal of Architectural Heritage* 11.2: 219-228.

Martino, A., Fino, M., and Tommasi, G. (2015). 'Historic ports of Apulia: Brindisi from investigation to enhancement Historic ports of Apulia: Brindisi from investigation to enhancement', *Portus - Port-City Relationship and Urban Waterfront Redevelopment (RETE)*.

Marx, K. (1867). *Capital: A Critique of Political Economy*. New York.

Marzano, A. (2007). *Roman villas in central Italy: a social and economic history* (Columbia studies in the classical tradition v. 30). Leiden and Boston.

Maselli Scotti, F. (1987). 'La Produzione del Vasellame Fittile nel Territorio di Aquileia', *Antichità Altoadriatiche* 29: 427-444.

Matijašić, R. (1993). 'Oil and Wine Production in Istria and Dalmatia in Classical Antiquity and the Early Middle Ages', *Bulletin de Correspondance Hellénique* Supplement 26: La Production du Vin et de l'Huile en Mediterranee: 247-261.

— (1994). 'Gli agri delle colonie di Pola e di Parentium', *Atti e memorie della Società istriana di archeologia e storia patria* 94: 7-104.

— (1998). *Gospodarstvo antičke Istre*. Pula.

— (2007a). 'O Nalazu Kasniantićkih Tijesaka u Poreću', *Opuscvla Archaeologica* 31: 265-281.

— (2007b). 'Impianti antichi per olio e vino in contesto urbano in Istria', *Histria antiqua* 15: 13-26.

— (2012). 'Le Città Romane Dell'Istria: Nuovi Particolari', in *I processi formativi ed evolutivi della città in area adriatica* (BAR International Series 2419)

— (2013). 'L'Istria: dai castellieri al sistema delle ville romane, dalle ville ai villaggi altomedievali ed oltre', *Antichità Altoadriatiche* 76: 181-198.

Mattingly, D. (1988a). Oil for export? A comparison of Libyan, Spanish and Tunisian olive oil production in the Roman empire. *Journal of Roman Archaeology, 1*, 33-56.

— (1988b). 'Megalithic Madness and Measurement. Or how many olives could and olive press press?', *Oxford Journal of Archaeology* 7: 159-195.

— (1993). 'Maximum Figures and Maximizing Strategies of Oil Production? Further Thoughts on the Processing Capacity of Roman Olive Presses', in M.C. Amouretti and J.P. Brun (eds.), *La production du vin et de l'huile en Méditerranée*. Paris,

— (1994). 'Regional variation in Roman oleoculture: some problems of comparability', in J. Carlsen, P. Orsted, and J.E. Skydsgaard (eds.), *Landuse in the Roman Empire, Atti del convegno tenutosi presso ii Danish Institute di Roma nel gennaio ,993*. Rome, 91-106.

Mazzeo Saracino, L. (1991). 'Aspetti della produzione e della commercializzazione dell'instrumentum domesticum di età romana nelle Marche alla luce dei rinvenimenti di Suasa', in Istituto Internazionale di Studi Piceni (ed), *Le Marche. Archeologia Storia Territorio*. Sassoferrato, 53-94.

Mazzochin, S. (2013). *Vicenza: Traffici commerciali in epoca romana. I dati della anfore*. Trieste.

Mazzochin, S. and Pastore, P. (1996). 'Nuove testimonianze epigrafiche sul commercio dell'olio istriano a Padova', *AVen* 19: 151-176.

Mazzoli, C., Maritan, L., and Pesavento Mattioli, S. (2009). 'Anfore da Olio e Anfore da Pesce: Le Analisi Archaeometriche', in S. Pesavento Mattioli and M.-B. Carre (eds.), *Olio e Pesce in Epoca Romana: Produzione e Commercio nelle Regioni dell'Alto Adriatico: Atti del Convegno (Padova 16 febbraio 2007)*. Rome, 239–255.

McLean, A. (2016). *Approaching Ancient Economic Specialisation: The economy of central Italy, 250 BC-AD 250*, MScR, University of Edinburgh.

— (forthcoming). 'Modelling viticultural suitability in the Adriatic region', in E. Dodd and D. Van Limbergen (eds.), *The Handbook of Roman Wine Archaeology: New data, methods, and scientific approaches*, (1-16), London.

McLean, A. and Rubio-Campillo, X. (2022). 'Beyond Least Cost Paths: Circuit theory, maritime mobility and patterns of urbanism in the Roman Adriatic', *Journal of Archaeological Science* 138: 1-14.

McRae, B., Shah, V., and Edelman, A. (2016). *Circuitscape: modeling landscape connectivity to promote conservation and human health*. The Nature Conservancy, Fort Collins, CO. 14 pp. https://circuitscape.org/pubs/circuitscape_whitepaper.pdf (accessed 03/03.22).

McRae, B.H., Shah, V.B., and Mohapatra, T.K. (2013). *Circuitscape 4 User Guide,* The Nature Conservancy, Fort Collins, CO. 14 pp. *https://docs.circuitscape.org/Circuitscape.jl/latest/* (accessed 03/03.22).

Meadwell, H. (1991). 'A Rational Choice Approach to Political Regionalism', *Comparative Politics* 23: 401-421.

Meeder, M., Aebi, T., and Weidmann, U. (2017). 'The influence of slope on walking activity and the pedestrian modal share', *Transportation Research Procedia* 27: 141-147.

Menchelli, S. (2011). 'Anfore vinarie adriatiche: Il Piceno e gli altri contesti produttivi regionali', *Ocnus* 19: 239-244.

Menchelli, S. and Picchi, G. (2014). 'Distorsioni interpretative e concretezza epistemologica nello studio delle anfore romane; l'esempio dell'ager Firmanus (Marche meridionali, Italia)', *The Journal of Fasti Online*.

Mercando, L. (1979). 'Marche-Rinvenimenti di insediamenti rurali: Cesano di Senigallia (Ancona)', *Notizie degli Scavi di Antichità* 110-131.

Middell, M. (2012). 'Regionalism', in *Encyclopedia of Global Studies*. Thousand Oaks, CA.

Milošević, A. (1998). *Arheološka topografija Cetine*. Split.

Miše, M. (2012). 'Trgovački kontakti dvaju jadranskih obala krajem 4. i u 3. st. pr. Kr. na primjeru slikane keramike/Trade route between two Adriatic coasts in 4th and 3rd c. BC', *Histria antiqua, 21, 231-240.*

Mlakar, Š. (1966). *Die Römer in Istrien*. Pula.

Moeller, W. (1976). *The Wool Trade of Ancient Pompeii*. Leiden.

Monfort, C.C. (2018). 'Olive-oil *amphorae* imports in Roman Britain: 20 years later', *Heródoto - Revista do Grupo de Estudos e Pesquisas sobre a Antiguidade Clássica e suas Conexões Afro-asiáticas* 3.1: 313-335.

Monke, E. and Petzel, T. (1984). ‘Market Integration: An Application to International Trade in Cotton’, *American Journal of Agricultural Economics* 66.4: 481.

Monsieur, P. and Carboni, F. (2017). ‘*Amphorae*’, in F. Vermeulen, D. Van Limbergen, P. Monsieur, and D. Taelman (eds.), *The Potenza Valley Survey (Marche, Italy), Settlement Dynamics and Changing Material Culture in an Adriatic Valley between Iron Age and Late Antiquity* (Academia Belgica. Studia Archaeologica 1). Rome, 186-194.

Montanari, A. (2012). ‘Hydrology of the Po River: looking for changing patterns in river discharge’, *Hydrology and Earth System Sciences* 16.10: 3739-3747.

Moret, I., Scarponi, G., and Cescon, P. (1994). ‘Chemometric Characterization and Classification of Five Venetian White Wines’, *Journal of Agricultural and Food Chemistry* 42.5: 1143-1153.

Morgan, L.H. (1877). *Ancient Society*. New York.

Moriondo, M., Trombi, G., Ferrise, R., Brandani, G., Dibari, C., Ammann, C.M., Lippi, M.M., and Bindi, M. (2013). ‘Olive trees as bio-indicators of climate evolution in the Mediterranean Basin’, *Global Ecology and Biogeography* 22.7: 818-833.

Morley, N. (1996). *Metropolis and Hinterland*. Cambridge.

Moss, R.W. (1975). ‘The Ancient Economy (Review)’, *Science and Society* 39: 226–229.

Mozzi, P., Piovan, S., and Corrò, E. (2020). ‘Long-term drivers and impacts of abrupt river changes in managed lowlands of the Adige River and northern Po delta (Northern Italy)’, *Quaternary International* 538: 80-93.

Mužinić, J. (2007). ‘The Neretva Delta: Green Pearl of Coastal Croatia’, *Croatian Medical Journal* 48: 127-129.

Niavis, S., Papatheochari, T., Kyratsoulis, T., and Coccossis, H. (2017). ‘Revealing the potential of maritime transport for “Blue Economy” in the Adriatic-Ionian Region’, *Case Studies on Transport Policy* 5.2: 380–388.

Nieto, X. (1997). ‘Le commerce de cabotaje et de redistribution’, in P. Gianfrotta, X. Nieto, P. Pomey, and A. Techernia (eds.), *Navigation dans l’Antiquité, Aix-en-Provence*. Paris, 146-159.

Nissen, H. (1912). *Italische landeskunde*. Berlin.

Oreb, F. (1999). ‘Rimska vila u Strožancu nedaleko od Splita’, *Opvscvla archaeologica* 23-24.1: 441-450.

Orlić, M., Dadić, V., Grbec, B., Leder, N., Marki, A., Matić, F., Mihanović, H., Beg Paklar, G., Pasarić, M., Pasarić, Z., and Vilibić, I. (2007). ‘Wintertime buoyancy forcing, changing seawater properties, and two different circulation systems produced in the Adriatic’, *Journal of Geophysical Research* 112.C3: 1-21

Osborne, R. (1987). *Classical Landscape with Figures. The Ancient Greek City and its Countryside*. London.

Osipova, L., Okello, M.M., Njumbi, S.J., Ngene, S., Western, D., Hayward, M.W., and Balkenhol, N. (2019). ‘Validating movement corridors for African elephants predicted from resistance-based landscape connectivity models’, *Landscape Ecol* 34.4: 865-878.

Oteros, J., Orlandi, F., García-Mozo, H., Aguilera, F., Dhiab, A.B., Bonofiglio, T., Abichou, M., Ruiz-Valenzuela, L., del Trigo, M.M., Díaz de la Guardia, C., Domínguez-Vilches, E., Msallem, M., Fornaciari, M., and Galán, C. (2014). ‘Better prediction of Mediterranean olive production using pollen-based models’, *Agronomy for Sustainable Development* 34.3: 685–694.

Paci, G. (2009). ‘Una Nuova Testimonianza sul Consumo di Olive Picene in Ambio Renano’, *Picus* 29: 179-186.

Pandžić, K. and Likso, T. (2005). ‘Eastern Adriatic Typical Wind Field Patterns and Large-Scale Atmospheric Conditions’, *International Journal of Climatology* 25: 81-98.

Panella, C. (1989). ‘Le anfore italiche del II sec. d.C.’, in *Amphores et économie romaine. Actes du Colloque de Sienne 1986*. Rome, 139-178.

— (2010). ‘Roma, il suburbio e l’Italia in età medio- e tardo-repubblicana: cultura materiale, territorie, economie’, *Facta* 4: 11-124.

Paraman, L., Ugarković, M., and Steskal, M. (2020). ‘Field survey and documentation of hillfort sites in the greater Trogir area in 2019 as a starting point of the systematic study of the Hyllean peninsula’, *Annales Instituti Archaeologici* 16.1: 260-261.

Parker, A.J. (1992). *Ancient Shipwrecks of the Mediterranean and the Roman Provinces*. Oxford.

— (2008). ‘Artifact Distributions and Wreck Locations: The Archaeology of Roman Commerce’, *Memoirs of the American Academy in Rome. Supplementary Volumes* 6: 177-196.

Pasquinucci, M. and Menchelli, S. (2017). 'Rural, Urban and Suburban Communities and Their Economic Interconnectivity in Coastal North Etruria (2nd Century BC-2nd Century AD)', in T. de Haas and G. Tol (eds.), *The Economic Integration of Roman Italy.* Leiden, 322-341.

Patsch, K. (1990). *Lika u rimsko doba*. Gospić.

Peacock, D.P.S. (1977). 'Roman *Amphorae* : Typology, Fabric and Origins', *Publications de l'Ecole Francaise de Rome* 32: 261-278.

Peacock, D.P.S. and Williams, D.F. (1991). *Amphorae and the Roman economy: an introductory guide.* London and New York.

Pelletier, D., Clark, M., Anderson, M.G., Rayfield, B., and Wulder, M.A. (2014). 'Applying Circuit Theory for Corridor Expansion and Management at Regional Scales: Tiling, Pinch Points, and Omnidirectional Connectivity', *PLOS ONE* 9.1: 1-11.

Pempel, T.J. (2005). 'Introduction: Emerging Webs of Regional Conectedness', in T.J. Pempel (ed.), *Remapping East Asia: The Construction of a Region*. Ithaca, 1-30.

Pesavento Mattioli, S. (1996). 'Gli apporti dell'archeologia alla ricostruzione della viti-vinicoltura cisalpina in età romana', in G. Forni and A. Scienza (eds.), *2500 anni di cultura della vite nell'ambito alpino e cisalpino*. Trento, 396-397.

Pesavento Mattioli, S. and Carre, M.-B. (eds.) (2009). *Olio e Pesce in Epoca Romana: Produzione e Commercio nelle Regioni dell'Alto Adriatico: Atti del Convegno (Padova 16 febbraio 2007)* (Antenor quaderni / Università degli studi di Padova, Dipartimento di archeologia 15). Rome.

Pesavento Mattiolo, S. (2007). 'Aquileia e le anfore: lo stato della ricerca', *Antichità Altoadriatiche* 65: 459-477.

Pfuntner, L. (2017). 'An Urban Geography of the Roman World, 100 BC to AD 300. Archaeopress Roman archaeology, 18 -', *Bryn Mawr Classical Review* 2017.05.12.

Phelps, N.M. (2013). 'Nationalists Who Feared the Nation: Adriatic Multi-Nationalism in Habsburg Dalmatia, Trieste, and Venice by Dominique Kirchner Reill (review)', *Journal of World History* 24.3: 712-715.

Pignocchi, G. (2001). *Monte Torto di Osimo: L'impianto Produtivo*. Falconara.

Poljanšek, S., Vilhar, U., and Levanic, T. (2018). ‘Green water reconstructed for Rižana watershed, SW Slovenia’, *Environmental Earth Sciences* 77.3: 92–102.

Potter, T.W. (1979). *The changing landscape of South Etruria*. London.

Previato, C. and Zara, A. (2014). ‘Il trasporto della pietra di Vicenza in età romana. Il relitto del fiume Bacchiglione’, *Marmora. An International Journal for Archaeology, History and Archaeometry of Marbles and Stones* 10: 59-78.

Pritchard, R.T. (1972). ‘Some aspects of First Century Sicilian Agriculture’, *Historia* 21: 646-660.

Pupilli, L. (1994). *Il Territorio del Piceno Centrale in eta Romane: Impianti do produzione, villae risticae, villae di otium*. Ripatransone.

Purcell, N. (1985). ‘Wine and Wealth in Ancient Italy’, *The Journal of Roman Studies* 75: 1-19.

Radić, D. (2009a). ‘The Beginnings of Trans-Adriatic Navigation: A View from Vela Spila Cave (Korcula Island)’, in S. Forenbaher (ed.), *A Connecting Sea: Maritime Interaction in Adriatic Prehistory* (BAR International series 2037). Oxford, 13-24.

Radić, T. (2009b). ‘Preliminary Flow Cytometric Analyses of Phototrophic Pico- and Nanoplankton Communities in the Northern Adriatic’, *Fresenius Environmental Bulletin* 18.5: 11.

Raper, R.A. (1977). ‘The Analysis of the Urban Structure of Pompeii: A Sociological Examination of Land Use’, in D.L. Clarke (ed.), *Spatial Archaeology*. London, 65-82.

Rathbone, D.W. (1983). ‘Matijašić’, *Opus* 2.1: 81-98.

Ravenhill, J. (2008). ‘East Asian regionalism: Much ado about nothing?’, *Australian National University, Department of International Relations, Research School of Pacific and Asian Studies* 3: 1-28.

Raviola, F. (2002). ‘L’Italia adriatica in Strabone’, *Hesperìa* 15: 199-210.

Reale, O. (2000). ‘Modeling the effects of vegetation on Mediterranean climate during the Roman Classical Period Part I: Climate history and model sensitivity’, *Global and Planetary Change* 25.3-4: 163-184.

Reger, G. (1994). *Regionalism and change in the economy of independent Delos, 314-167 B.C* (Hellenistic culture and society 14). Berkeley.

— (2007). ‘Region Revisited : Identifying Regions in a Greco-Roman Mediterranean Context’, *FACTA* 1: 1000-1010.

— (2011). ‘Inter-Regional Economies in the Aegean Basin’, in Z. Archibald, J.K. Davies, and V. Gabrielsen (eds.), *The Economies of Hellenistic Societies, Third to First Centuries BC*. Oxford, 368–389.

Reill, D.K. (2012). *Nationalists Who Feared the Nation: Adriatic Multi-Nationalism in Habsburg Dalmatia, Trieste, and Venice*. Standford.

Rendina, S. (2018). *Villa harbours and the economy of Roman Istria*, MPhil, University of Oxford.

Reynolds, P. (2004). ‘The Roman pottery from the Triconch Palace, the Medieval *Amphorae* and Appendix 1. Catologue of Roman Cermics and Selected Medival Pottery from Butrint 1994-99’, in *Byzantine Butrint: Exavations and Surveys 1994-99*. Oxford, 224-277, 327-395.

— (2010). ‘Trade Networks of the East, 3rd to 7th Centuries: The View from Beirut (Lebanon) and Butrint (Albania) (Fine Wares, *Amphorae* and Kitchen Wares)’, in *LRCW3: late Roman coarse wares, cooking wares and amphorae in the Mediterranean: archaeology and archaeometry: comparisn between western and eastern Mediterranean* (BAR International series 2185). Oxford, 89-114.

Reynolds, P., Hernandez, D.R., and Qondi, D. (2008). ‘Excavations in the Roman Forum of Buthrotum (Butrint): First to Third Century Pottery Assemblages and Trade’, *REI Cretariae Romanae* 40: 71-88.

Ricardo, D. (1817). *On the Principles of Political Economy and Taxation*. London.

Rice, C.M. (2016). ‘Shipwreck Cargoes in the Western Mediterranean and the Organization of Roman Maritime Trade’, *Journal of Roman Archaeology* 29: 165-192.

— (2020). ‘The ports of Roman Lycia: urbanism, networks, and hierarchies’, in M. Flohr (ed.), *Urban Space and Urban History in the Roman World*. New York, 241-264.

Richardson, J. (2008). ‘The Administration of the Empire.pdf’, in J. Crook, A. Lintott, and E. Rawson (eds.), *The Cambridge Ancient History*. Cambridge, 564-598.

Rickman, G. (1991). ‘Problems of Transport and Development of Ports’, in A. Giovannini and D. van Berchem (eds.), *Nourishing the plebs: Proceedings of the conference in tribute to Denis van Berchem (Geneva, 28-29 September 1989)*. Basel, 103-118.

Robinson, D., Rice, C.M., and Schörle, K. (2020). 'Ship Losses and the Growth of Roman Harbour Infrastructure', *Journal of Mediterranean Archaeology* 33.1: 102-125.

Roe, B.C. (1992). *Aspects of the Social and Economic History of Canusium in the Roman Period*, MA, Edmonton.

Romić, D., Zovko, M., Romić, M., Ondrašek, G., and Salopek, Z. (2008). 'Quality aspects of the surface water used for irrigation in the Neretva Delta (Croatia)', *Journal of Water and Land Development* 12.1:

Rosenswig, R.M. and Martínez Tuñón, A. (2020). 'Changing Olmec trade routes understood through Least Cost Path analysis', *Journal of Archaeological Science* 118: 105-146.

Rossi, I.R. and Boetto, G. (2020). 'The Roman Scuttled Ships and Harbour Structures of Caska, Pag Island, Croatia in their Cultural and Historical Context', *International Journal of Nautical Archaeology* 49.2: 263-290.

Rossiter, J.J. (1981). 'Wine and oil processing at Roman farms in Italy', *Phoenix* .35: 345-361.

— (1998). 'Pressing issues: wine and oil production', *Journal of Roman Archaeology* 11: 597-602.

Rousse, C., Munda, D., Benčić, G., Sotončić, K.G., Leonardis, V.D., Dumas, V., Maggi, P., Tillier, M., and Vaschalde, C. (2013). 'Loron / Santa Marina - Busuja (Tar-Vabriga, Poreč, Croatie)', *Chronique des activités archéologiques de l'École française de Rome* https://doi.org/10.4000/cefr.1009 (accessed 05/10/20).

Royal, J. (2015). 'Maritime Evidence for Overseas Trade along the Illyrian Coast: The Eastern Mediterranean Connections', in S. Demesticha (ed.), *Per terram, per mare: seaborne trade and the distribution of Roman amphorae in the Mediterranean*. Uppsala, 199–218.

— (2018). *The Illyrian Coastal Exploration Program (2010-14): The Roman and Late-Roman Finds*. DOI:10.13140/RG.2.2.19048.11525.

Rubio-Campillo, X. (2016). 'Model Selection in Historical Research Using Approximate Bayesian Computation', *PLOS ONE* 11.1: e0146491.

Rubio-Campillo, X., Coto-Sarmiento, M., Pérez-Gonzalez, J., and Remesal Rodríguez, J. (2017). 'Bayesian Analysis and Free Market Trade Within the Roman Empire', *Antiquity* 91.359: 1241–1252.

Ruggini, L. (1961). 'Economia e società', in *"Italia annonaria". Rapporti fra agricoltura e commercio dal iv al vi sec. d.C*. Milan, 530-533.

Rubio-Campillo, X., Ble, E., Pujol, À., Sala, R., and Tamba, R. (2022). 'A Spatial Connectivity Approach to Landscapes of Conflict: Julius Caesar and the Assault to Puig Ciutat (NE Iberian Peninsula)', *Journal of Archaeological Method and Theory* https://doi.org/10.1007/s10816-022-09549-7

Russell, B. (2011). 'Lapis transmarinus: stone-carrying ships and the maritime distribution of stone in the Roman empire',Robinson, D.J. and Wilson, A. (eds.) *Maritime Archaeology and Ancient Trade in the Mediterranean. Proceedings of the 2008 OCMA Conference, Madrid. Oxford Centre for Maritime Archaeology 7* 137-52.

— (2013). *The Economics of the Roman Stone Trade* (Oxford Studies on the Roman Economy). Oxford and New York.

Russett, B. (1967). *International Regions and International Systems*. Chicago.

Safadi, C. and Sturt, F. (2019). 'The warped sea of sailing: Maritime topographies of space and time for the Bronze Age eastern Mediterranean', *Journal of Archaeological Science* 103: 1-15.

Salković, E., Djurović, I., Knežević, M., Popović-Bugarin, V., and Topalović, A. (2018). 'Digitization and mapping of national legacy soil data of Montenegro', *Soil and Water Research* 13.2: 83-89.

Sallares, R. (1991). *The Ecology of the Ancient Greek World*. Ithaca.

Salvini, M. (2003). *Area archeologica e Museo La Fenice*. Senigallia.

Santolini, R., Morri, E., Pasini, G., Giovagnoli, G., Morolli, C., and Salmoiraghi, G. (2015). 'Assessing the quality of riparian areas: the case of River Ecosystem Quality Index applied to the Marecchia river (Italy)', *International Journal of River Basin Management* 13.1: 1–16.

Šašel Kos, M. (2017). 'The Statii of Risinium', in D. Demicheli (ed.), *Illyrica Antiqua.* Zagreb, 171-185.

Scagliarini Còrlaita, D. (1997). 'La villa di Desenzano sul Garda', in E. Roffia (ed.), *Ville romane sul Lago di Garda*. Brescia, 191-210.

Scheidel, W. (2007). 'Demography', in W. Scheidel, I. Morris, and R.P. Saller (eds.), *The Cambridge Economic History of the Greco-Roman World*. Cambridge, 38-86.

— (2009). 'In Search of Roman Economic Growth', *Journal of Roman Archaeology* 22: 46–70.

— (2012). *The Cambridge Companion to the Roman Economy*. Cambridge.

— (2014). 'The Shape of the Roman World: Modelling Imperial Connectivity', *Journal of Roman Archaeology* 27: 7–32.

— (2015). 'Orbis: the Stanford geospatial network model of the Roman world', *Princeton/Stanford Working Papers in Classics*.

Scheidel, W. and Friesen, S.J. (2009). 'The Size of the Economy and the Distribution of Income in the Roman Empire', *Journal of Roman Studies* 99: 61–91.

Scheidel, W., Morris, I., and Saller, R.P. (2008). *The Cambridge Economic History of the Greco-Roman World*. Cambridge.

Schiemer, F., Beqiraj, S., Drescher, A., Graf, W., Egger, G., Essl, F., Frank, T., Hauer, C., Hohensinner, S., Miho, A., Meulenbroek, P., Paill, W., Schwarz, U., and Vitecek, S. (2020). 'The Vjosa River corridor: a model of natural hydro-morphodynamics and a hotspot of highly threatened ecosystems of European significance', *Landscape Ecol* 35.4: 953–968.

Schörle, K. (2011). 'Constructing port hierarchies: harbours of the central Tyrrhenian coast', in D. Robinson and A. Wilson (eds.), *Maritime Archaeology and Ancient Trade in the Mediterranean* (Oxford Centre for Maritime Archaeology Monographs 6). Oxford, 93-106.

Schrunk, I. and Begović, V. (2000). 'Roman estates on the island of Brioni, Istria', *Journal of Roman Archaeology* 13: 252-276.

Seifried, R. and Gardner, C. (2019). 'Reconstructing historical journeys with least-cost analysis: Colonel William Leake in the Mani Peninsula, Greece', *Journal of Archaeological Science: Reports* 24: 391-411.

Sembroni, A., Molin, P., Soligo, M., Tuccimei, P., Anzalone, E., Billi, A., Franchini, S., Ranaldi, M., and Tarchini, L. (2019). 'The uplift of the Adriatic flank of the Apennines since Middle Pleistocene: New insights from the Tronto River basin and the Acquasanta Terme Travertine (central Italy)', *Geomorphology* 352: 106990.

Sheehan-Finn, K. (2012). *Vindolanda's Amphora Stamps (2007-2012)*. The Vindolanda Trust https://www.vindolanda.com/Handlers/Download.ashx?IDMF=395c9504-045c-43b8-8538-241e7aece5d6 (accessed 03/03/22).

Shennan, S. (1990). *Quantifying archaeology*. London.

Sherratt, S. and Sherratt, A. (1993). 'The growth of the Mediterranean economy in the early first millennium BC', *World Archaeology* 24.3: 361-378.

Šiljeg, B. (2003). 'Neki antički lokaliteti naronitanskog agera, 22, Zagreb 2003, 267-276.', *Arheološka istraživanja u Naroni i dolini Neretve, Izdanja HADA* 22: 267-276.

Silver, M. (n.d.). 'Historical Otherness, the Roman Bazaar, and Primitivism: P. F. Bang on the Roman Economy', *Journal of Roman Archaeology* 22.2: 421–440.

Škegro, A. (1999). *Gospodarstvo Rimske Provincije Dalmacije*. Zagreb.

Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations*. London.

Scheidel, W. (2009). 'In Search of Roman Economic Growth', *Journal of Roman Archaeology* 22: 46–70.

Smith, M.E. (2015). 'How can archaeologists make better arguments?', *SAA Archaeological Record* 18–23.

Smith, W. (1894). *Dictionary of Greek and Roman geography*. London.

Snoj, M. (2009). *Etimoloski slovar slovenskih zemljepisnih imen*. Ljubljana.

Soczka Mandac, R., BogunoviĆ, B., Žagar, D., and Faganeli, J. (2014). 'Riverine impact on the thermohaline properties, turbidity and suspended solids in a shallow bay (Bay of Koper, northern Adriatic Sea)', *Acta Adriatica* 55: 195-212.

Sondi, I. and Slovenec, D. (2003). 'The mineralogical characteristics of the Lamboglia 2 Roman-age *amphorae* from the central Adriatic (Croatia)', *Archaeometry* 45.2: 251-262.

Spataro, M. (2009). 'The First Specialised Potters of the Adriatic Region: The Makers of Neolithic Figulina Ware', in S. Forenbaher (ed.), *A connecting sea: maritime interaction in Adriatic prehistory* (BAR international series 2037). Oxford, 59–72.

Spurr, M.S. (1986). *Arable Cultivation in Roman Italy c.200 B.C.- c.A.D. 100*. London.

Staffa, A.R. (2001). *Strutture portuali e rotte marittime nell'Adriatico di età romana* (Antichità AltoAdriatiche 46). Trieste/Rome.

— (2002). *L'Abruzzo costiero. Viabilità, insediamenti, strutture portuali ed assetto del territorio fra Antichità ed Alto Medioevo*. Lanciano.

— (2003). 'Impianti produttivi d'età romana nel territorio della provincia di Pescara. Le fornaci', *Rivista di topografia antica* 13: 117-154.

Staffa, A.R., Siena, E., Troiano, D., and Verrocchio, V. (1995). 'Progetto Valle del Pescara: terzo rapporto preliminare di attività', *Archeologia Medievale* 22: 291-342.

Stančič, Z. (1999). *The Adriatic Islands Project: The archaeological heritage of the island of Brač, Croatia* (BAR international series S803). Oxford.

Stanić, P. (1891). 'Rimski spomenici Vrličke okolice u Dalmaciji (II)', *Vjesnik Arheološkog muzeja u Zagrebu* 13.1: 99-108.

Starac, A. (2010). 'The Workshop of Laecanius at Fažana. Some recent testimonies', *Rei Cretariae Romanae Fautores* 41: 61-65.

— (2012). 'Dragonera South, The Planimetry of the Villa Maritima', in B. Migotti, P. Mason, B. Nadbath, and T. Mulh (eds.), *Scripta in Honorem Bojan Djurić*. Ljubljana, 271–284.

Stefani, M. (2017). 'The Po Delta Region: Depositional Evolution, Climate Change and Human Intervention Through the Last 5000 Years', in M. Soldati and M. Marchetti (eds.), *Landscapes and Landforms of Italy* (World geomorphological landscapes). New York, 193-202.

Stein, G.J. (1994). 'Introduction Part II, The Organizational Dynamics of Complexity in Greater Mesopotamia', in *G.Stein and M.Rothman (eds.), Chiefdoms and Early States in the Near East*. Madison, Wisconsin, 11–22.

Stillwell, R. and Mcallister, M.H. (1979). *Princeton encyclopedia of classical sites*. Princeton.

Stoppinoi, M.L. (2009). 'Cattolica (Rimini): discarica di anfore greco-italiche', in S. Pesavento Mattioli and M.-B. Carre (eds.), *Olio e pesce in epoca romana. Produzione e commercio nelle regioni dell'alto Adriatico, Atti del Convegno (Padova, 16 febbraio 2007)*. Rome, 301-307.

Stoppioni, M.L. (2008). 'Anfore greco-italiche', in L. Malnati and M.L. Stoppioni (eds.), *Vetus Litus. Archeologia della foce. Una discarica di materiali ceramici del III sec. a.C. alla darsena di Cattolica lungo il Tavollo* (Quaderni di Archeologia dell'Emilia Romagna 23). Firenze, 131-150.

Stratton, G., O. (2015). *The Joni Wreck: An Archaeological Study of Late Roman Trade Patterns in the Adriatic Sea*, MA, East Carolina University.

Strauss, J. (2013). *Shipwrecks Database. Version 1.0* (Oxford Roman Economy Project).

Strazzulla Rusconi, M.J. (1979). 'Scavo di una villa rustica a Joannis (Udine)', *Aquileia Nostra* 50: 1-124.

Suić, M. (1960). 'Arheološka istraživanja u Mulinama na otoku Ugljanu, Ljetopis', *Jugoslavenska Akademija Znanosti i Umjetnosti* 64: 230-249.

Susini G. (1989). 'Herennii: una traccia cispadana', *Acta Archaeologica* 41: 141-143.

Tammuz, O. (2005). 'Mare clausum? Sailing Seasons in the Mediterranean in Early Antiquity', *Mediterranean Historical Review* 20: 145-162.

Tassaux, F. (2001). 'Production et Diffusion des Amphores a Huile Istriennes', *Antichità Altoadriatiche* 46: 501-543.

Tchalenko, G. (1953). *Villages Antiques de la Syrie du Nord; le massif du Belus a l'eopoque romaine*. Paris.

Tchernia, A. (1986). *Le vin de l'Italie romain. Essai d' histoire economique d'apres les amphores*. Rome.

— (1993). 'Le vignoble italien du Ier siecle avant notre ere au IIIe siecle de notre ere: repartition et evolution', in M.C.Amouretti and J.P.Brun, (eds), *Oil and Wine Production in the Mediterranean Area, BCH Suppl*. Athens, 283-296.

Tchernia, A., Grieve, J., and Minchin, E. (2016). *The Romans and trade*English edition (Oxford studies on the Roman economy). Oxford, United Kingdom.

Tchernia, A. and Zevi, F. (1972). 'Amphores vinaires de Campanie et de Tarraconaise à Ostie', *Publications de l'Ecole Francaise de Rome* 10: 35-67.

Temin, P. (2001). 'A Market Economy in the Early Roman Empire', *The Journal of Roman Studies* 91: 169-181.

Temin, P. (2013). *The Roman Market Economy*. Princeton.

Thayn, J.B., Sampeck, K., and Spaccapaniccia, M. (2016). 'Refining Hernando de Soto's Route Using Electric Circuit Theory and CircuitScape', *The Professional Geographer* 68.4: 595-602.

Thompson, T. and Thompson, D. (2004). *Adriatic pilot: Albania, Montenegro, Croatia, Slovenia and the Italian Adriatic coast,* 4th edition. Cambridgeshire.

Thompson, W.R. (1973). 'The Regional Subsystem: A Conceptual Explication and a Propositional Inventory', *International Studies Quarterly* 17.1: 89-117.

Thurmond, D.L. (2016). *From Vines to Wines in Classical Rome: a Handbook of Viticulture and Oenology in Rome and the Roman West.* Leiden.

Tirelli, M. (1987). 'Oderzo: necropoli in via Spinè', *Quaderni di Archeologia del Veneto* 3: 77-85.

Tockner, K., Ward, J., Arscott, D., Edwards, P., Kollmann, J., Gurnell, A., Petts, G., and Maiolini, B. (2003). 'The Tagliamento River: A model ecosystem of European importance', *Aquatic Sciences - Research Across Boundaries* 65: 239-253.

Tol, G. (2017). 'From Surface Find to Consumption Trend: A Ceramic Perspective on the Economic History of the Pontine Region (Lazio, Central Italy) in the Roman Period', in T. de Haas and G. Tol (eds.), *The Economic Integration of Roman Italy*. Leiden, 367-387.

Trethewey, K. (2018). *Ancient Lighthouses: and other lighted aids to navigation.* Torpoint.

Tyree, E.L. and Stefanoudaki, E. (1996). 'The Olive Pit and Roman Oil Making', *Biblical Archaeologist* 59: 171-178.

Uggeri, G. (1997). 'I canali navigabili dell'antico delta padano', *Atlante tematico di topografia antica : supplementi* 2: 55-60.

Ugolini, F. (2015). 'The Roman Harbour of Ariminum and its connections with the Aegean and Black Seas', in G.R. Tsetskhladze, A. Avram, and J. Hargrave (eds.), *The Danubian Lands Between the Black, Aegean and Adriatic Seas*. Oxford, 243-248.

— (2021). 'Shipping Adriatic Wines in the Roman Mediterranean: A Quantitative Approach', *BABESCH Annual Papers on Mediterranean Archaeology* 96: 83-100.

Ulbrich, U., Lionello, P., Belušić, D., Jacobeit, J., Knippertz, P., Kuglitsch, F.G., Leckebusch, G.C., Luterbacher, J., Maugeri, M., Maheras, P., Nissen, K.M., Pavan, V., Pinto, J.G., Saaroni, H., Seubert, S., Toreti, A., Xoplaki, E., and Ziv, B. (2012). 'Climate of the Mediterranean: Synoptic Patterns, Temperature, Precipitation, Winds, and Their Extremes', in P. Lionello (ed.), *The Climate of the Mediterranean Region From the Past to the Future.* Elsevier, 301-346.

USDA (2018), *Foreign Agricultural Service Commodity Intelligence Report Crop Production in Greece and Italy*, Washington, D.C.

Vairo, M.R., Veal, R.J., and De Simone, G.F. (2013). 'Lo sfruttamento delle risorse boschive nella Campania tardoantica: l'evidenza antracologica da due siti vesuviani', *Rivista di Studi Pompeiani* 24: 71-78.

Valescchi, V., Fisinger, W., Tinner, W., and Ammann, B. (2006). *Holocene population expansions of Fagus in the Southern Alps, evidences from Lago di Fimon and Lago Piccolo di Avigliana (northern Italy)* (International Moor-Excursion 2006 Northern and Central Italy. Excursion Guide.Università di Berna 30). Berna.

Van Limbergen, D. (2011). 'Vinum Picenum and Oliva Picena', *Babesch* 86: 71-94.

— (2016). 'A Note on Olives and Olive Oil from Picenum (Marche, Northern Abruzzo) An Obscured Food Product Within the Eocnomy of Central Adriatic Italy in Roman Times?', *PICUS* 36: 171-182.

— (2018). 'The Central Adriatic Wine Trade of Italy Revisited', *Oxford Journal of Archaeology* 37.2: 201-226.

— (2019). 'Vinum picenum and oliva picena II : further thoughts on wine and oil presses in Central Adriatic Italy', *Babesch* 94: 1-31.

Van Limbergen, D., Monsieur, P., and Vermeulen, F. (2017). 'The Role of Overseas Export and Local Consumption Demand in the Development of Viticulture in Central-Adriatic Italy (200BCAD150). The Case of the Ager Potentinus and the Wider Potenza Valley', in T. de Haas and G. Tol (eds.), *The Economic Integration of Roman Italy: Rural Communities in a Globalizing World*. Leiden, 342-366.

Van Oyen, A. (2017). 'Agents and Commodities: A Response to Brughmans and Poblome (2016) On Modelling the Roman Economy', *Antiquity* 91.359: 1356–1363.

Van Tilburg, C. (2007). *Traffic And Congestion In The Roman Empire*. London.

VanValkenburgh, P. and Dufton, J.A. (2020). 'Big Archaeology: Horizons and Blindspots', *Journal of Field Archaeology* 45.sup1: S1-S7.

Veal, R. (2017). 'Wood and Charcoal for Rome: Towards an Understanding of Ancient Regional Fuel Economics', in T. de Haas and G. Tol (eds.), *The Economic Integration of Roman Italy*. Leiden, 388-406.

Velde, F. (2014). 'A Review of Peter Temin's The Roman Market Economy', *Journal of Economic Literature* 52.4: 1151–1159.

Vermeulen, F. (2020). 'The Urban Landscape of Roman Central Adriatic Italy', in L. de Ligt and J. Bintliff (eds.), *Regional Urban Systems in the Roman World, 150 BCE - 250 CE*. Leiden and Boston, 188-216.

Vermeulen, F., De Dapper, M., Music, B., Monsieur, P., Verreyke, H., Carboni, F., Dralans, S., Verhoeven, G., Verdonck, L., Hay, S., Sterry, M., De Paepe, P., and De Seranni, S. (2009). 'Investigating the impact of Roman urbanisation on the landscape of the Potenza valley. A report on fieldwork in 2007', *Babesch* 84: 85-110.

Volpe, G. (1990). *La Daunia nell'età della romanizzazione: paesaggio agrario, produzione, scambi*.

— (2002). 'Linee di Storia del Paesaggio dell'Apulia Romana: San Giusto e la Valle del Celone', in E. Lo Cascio and A. Storchi Marino (eds.), *Modalità insediative e strutture agrarienell'Italia meridionale in età romana.* Ann Arbor, 315-361.

Volpe, G., Leone, D., and Turchiano, M. (2011). 'Il Progetto Liburna: Ricerche Archaeologiche Subacquee in Albania (Campagne 2007-2010)', *Annuario della Scuola Archaeologica di Atene e delle Missioni Italiene in Oriente* (III), 89: 251-286.

Vrsalović, D. (1974). 'Istraživanja i zaštita podmorskih arheoloških spomenika u SR Hrvatskoj : dosadašnji rezultati i prijedlozi za dalji rad', Belgrade.

Vučić, J. (2012). *Topografija Naronitanske Biskupije*, Doctoral, University of Zagreb.

Ward-Perkins, J.B. (John B. (1974). *Cities of ancient Greece and Italy: planning in classical antiquity.* London.

Wattenmaker, P. (1994). 'Formation and the Organization of Domestic Craft Production at Third Millennium BC Kurban Höyük, South-East Hirkey', in *G.M.Schwartz and S.E.Falconer (eds), Archaeological Views from the Countryside*. Washington and London, 109–120.

Weng, J. and Yang, D. (2015). 'Investigation of shipping accident injury severity and mortality', *Accident Analysis & Prevention* 76: 92-101.

White, D.A. (2015). 'The basics of least cost analysis for archaeological applications', *Advances in Archaeological Practice* 3.4: 407–414.

White, K.D. (1970). *Roman Farming*. Ithaca.

— (2010). *Farm Equipment of the Roman World*. Cambridge.

Wilkes, J.J. (1962). *Studies in the Roman Province of Dalmatia*, PhD, Durham.

— (1969). *Dalmatia*. London.

— (1979). 'Importation and Manufacture of Stamped Bricks and Tiles in the Province of Dalmatia', in A. McWhirr (ed.), *Roman Brick and Tile (British Archaeological Reports, International Series, 68)*. Oxford, 65–72.

Williams, D. and Carreras, C. (1995). 'North African *Amphorae* in Roman Britain: A Re-Appraisal', *Britannia* 26: 231–252.

Wilson, A. (2002). 'Urban Production in the Roman World: The View from North Africa', *Papers of the British School at Rome* 70: 231-273.

— (2009). 'Indicators for Roman Economic Growth: a response to Walter Scheidel', *Journal of Roman Archaeology* 22: 71-82.

— (2011). 'City Sizes and Urbanization in the Roman Empire', in A. Bowman and A. Wilson (eds.), *Settlement, Urbanization, and Population*. Oxford, 161-195.

Wilson, A., Schörle, K., and Rice, C., M. (2013). 'Roman Ports and Mediterranean Connectivity', in *Rome, Portus and the Mediterranean. Archaeological Monographs of the British School at Rome*. London, 367–391.

Witcher, R. (2017). 'The Economic Integration of Roman Italy: Rural Communities in a Globalizing World', in T. Hodos and A. Geurds (eds.), *The Routledge Handbook of Archaeology and Globalization*. Oxford, 634–651.

Yaalon, D.H. (1997). 'Soils in the Mediterranean region: what makes them different?', *CATENA* 28.3-4: 157-169.

Žagar, D., Knap, A., Warwick, J., Rajar, R., Horvat, M., and Četina, M. (2006). 'Modelling of mercury transport and transformation processes in the Idrijca and Soca river system.', *The Science of the total environment* 368.1: 149–163.

Zaninović, M. (1966). 'O naseljenosti otoka Hvara u antićko doba (Sur le peuplement de l'ile de Hvar dans l'antiquite)', *Vjesnik za arheologiju i historiju dalmatinsku* 68: 195-213.

— (1977). 'The economy of Roman Dalmatia', in H. Temporini and W. Haase (eds.), *Aufstieg und Niedergang der Römischen*. Berlin and New York, 761-801.

Zaninović, M. (1987). 'Rimska villa rustica na Kupinoviku kraj Dola', *Prilozi povijesti otoka Hvara* VIII.1: 91-96.

Zaninović, M. (1997). 'Neki primjeri smje$taja antiikih gospodar.skih zgrada u obalno-oloikom podrudju Dalmacije', *Arheološki radoui i rasprave Jugoslavenska Akademija Znanosti i Umjetnosti* 4-5: 357-371.

Zdruli, P. (2005). 'Soil Survey in Albania', in R.J.A. Jones, B. Houškova, P. Bullock, and L. Montanarella (eds.), *Soil Resources of Europe- European Soil Bureau- Research report No.9*. Luxembourg, 39-45.

Zeman, M. (2014). 'Monumentalne eksedre u rimskoj rezidencijalnoj arhitekturi ranocarskog razdoblja: primjeri istočne obale Jadrana', *Radovi Instituta za povijest umjetnosti* .38: 7-24.

Zevi, F. (1967). 'Anfore istriane ad Ostia (nota sul commercio istriano)', *Atti e memorie della Società istriana di archeologia e storia patria* 15: 21-31.

Zhllima, E., Chan-Halbrendt, C., Zhang, Q., Imami, D., Long, R., Leonetti, L., and Canavari, M. (2012). 'Latent Class Analysis of Consumer Preferences for Wine in Tirana, Albania', *Journal of International Food & Agribusiness Marketing* 24.4: 321-338.

Ziolkowski, A. (1986). 'The Plundering of Epirus in 167 B.C: Economic Considerations', *Papers of the British School at Rome* 54: 69-80.

Zotović, R. (2002). *Population and economy of the eastern part of the Roman province of Dalmatia* (BAR international series 1060). Oxford.

Zovko, M., Romić, D., Colombo, C., Di Iorio, E., Romić, M., Buttafuoco, G., and Castrignanò, A. (2018). 'A geostatistical Vis-NIR spectroscopy index to assess the incipient soil salinization in the Neretva River valley, Croatia', *Geoderma* 332: 60-72.

**Websites**


'Ancient Archaeological Sites of Croatia (Baza antičkih arheoloških lokaliteta Republike Hrvatske Instituta za arheologiju (IARH))', http://baza.iarh.hr/public/locality/map (last accessed 04/03/22). The Institute of Archaeology.

'Climate-Data', https://en.climate-data.org (last accessed 04/03/22).

'Copernicus Land Monitoring Service', https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1 (last accessed 06/12/21). Copernicus Project.

'ERA5 Datasets', https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5 (last accessed (18/11/21). European Centre for Medium-Range Weather Forecasts (See Hersbach *et al.* (2020)).

'Food and Agriculture Organization of the United Nations', https://www.fao.org/home/en (last accessed 04/03/22). FAO.

'International Olive Council', https://www.internationaloliveoil.org/ (last accessed 07/06/19).

'MERCURY-MINERVA-SIMREC - Computational Modelling in Roman Studies', https://projectmercury.eu/ (last accessed 25/02/22). Project MERCURY-MINERVA-SIMREC.

'Open DEM', https://opendem.info/arc2meters.html (last accessed 04/03/22).

'OXREP Databases', http://oxrep.classics.ox.ac.uk/databases (last accessed 05/03/22). Oxford Roman Economy Project.

'Project Mercury bridge database', https://projectmercury.eu/datasets/#bridges (last accessed 15/11/22). Project MERCURY.

'Project Mercury Canal database', https://projectmercury.eu/datasets/#canals (last accessed 25/02/22). Ancient World Mapping Centre.

'Register of Cultural Heritage of Croatia', https://min-kulture.gov.hr/register-of-cultural-property/16777 (last accessed 04/03/20). Republic of Croatia Ministry of Culture and Media.

'University of Southampton (2014) Roman *Amphorae*: a digital resource [data-set]', https://archaeologydataservice.ac.uk/archives/view/amphora_ahrb_2005/cat_amph.cfm (last accessed (02/12/21). Archaeology Data Service.

'*Vinopedia.hr*', www.sommelier.hr/ (last accessed 04/03/22).

'*Wine Searcher'*, www.wine-searcher.com/regions-puglia (last accessed 04/03/22).