



MCDONALD INSTITUTE MONOGRAPHS

# The Isola Sacra Survey

## Ostia, Portus and the port system of Imperial Rome

Edited by Simon Keay, Martin Millett,  
Kristian Strutt and Paola Germoni



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*With contributions by*

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# Preface

Carlo Pavolini

The survey that is published in this volume forms part of the Portus Project which is directed by Simon Keay. This initiative followed on from the overall 1998–2004 survey of Portus (Keay *et al.* 2005) and, since 2007, has produced several benchmark publications (eg. Keay and Paroli 2011).<sup>1</sup> It is an initiative conducted in close collaboration with the *Soprintendenza Archeologica di Ostia*, now the *Parco Archeologico di Ostia Antica*. The contribution of the latter to the publication is recognized by the presence of its archaeologist Paola Germoni, who is one of the four editors of the book, and who also co-signed the introduction, oversaw the preparation of other parts of the book, and took part in the drafting of its text (see below), along with Simon Keay, Martin Millett and Kristian Strutt.

In the first years of its activity, the Italian-British research programme was focused upon the imperial harbour basins to the north of the Tiber delta at the site of Portus and in its hinterland. They produced extraordinary results, for an idea of which one only needs to refer to the essential works mentioned in the previous paragraph. But in turning specifically to the Isola Sacra – where the results of the research are no less exceptional, as we shall see – the greater part of the work was undertaken between 2008 and 2012, with the collaboration (apart from the *Soprintendenza*, now the *Parco Archeologico di Ostia Antica* by virtue of its responsibilities to protect its cultural heritage) of such scientific institutions as the British School at Rome, the Universities of Southampton and Cambridge, and many other institutions and scholars of diverse origins and specialisms.

The difference between the survey of 1998–2004 (Keay *et al.* 2005) and that published here is fairly clear. The objective of the former was to study an area that had been built-up in antiquity, in some areas densely, while the latter is a landscape survey that has as its setting an area of c. 98 ha that we could define as ‘free’ of structures. However, this was only ‘free’ in a certain

sense: the authors of the introduction make it clear that while the lands of the Isola Sacra are largely used for agricultural purposes today, there is also a large presence of houses, warehouses and other structures, as well as drainage channels relating to the *Bonifica* (drainage programme) of the early twentieth century and trenches for electric cables etc, all of which have inevitably conditioned a survey based upon geo-detection methodologies. While undertaking the survey, the archaeologists also had to take into account periods of time when fields were fallow or used for pasture.

A separate debate concerns the serious problem of illegal building. Nowadays, this is less prevalent and more controlled across the land area of the ancient Isola Sacra on account of various land protection measures; unfortunately, however, it is still widespread across the land which extends as far as the present-day coast of Fiumicino, and which corresponded to the sea in antiquity. It is also responsible for the current state of the banks of the watercourses which define the Isola to the north-east and to the north-west (in other words the Fiumicino Canal, or ‘*Fossa Traiana*’, and the Tiber itself), which are cluttered with workshops for boat repairs and other often illegal installations. It is a situation that is lamented by the authors and which only leaves free the area of the Capo Due Rami, which corresponds to the north-eastern angle of the Isola.<sup>2</sup>

I will not detain myself on the numerous details provided in the text. This is the case of the ‘traditional’ sources discussed in Chapter 2, in which are included, for example, maps before and after the flood of 1557,<sup>3</sup> and aerial photographs from 1911 (Shepherd 2006) down to the Second World War (R.A.F. and *Aeronautica Militare Italiana*) and subsequently (S.A.R.A.-*Nis-tri*). Amongst these sources, those that derived from archaeological research undertaken before the start of the Portus Project stand out, and the description of them by the authors of this book forms a cohesive whole in the context of a review of the topography of

the Isola as traditionally understood. Some of these are very well-known sites, such as the *Ponte di Matidia*, the *Basilica di S. Ippolito*, and the building identified as the *Isaeum* of Portus, a hypothesis which the authors support, to my mind correctly. Above all, the famous *Necropoli di Porto*, otherwise known as the Isola Sacra necropolis, which has been the object of excavations since the time of Guido Calza,<sup>4</sup> and which was given this name at a time before other burial areas, often of a similar size, had been uncovered in the vicinity. At this point, it is useful to mention the important Gazetteer of Sites, an appendix to the volume prepared by Paola Germoni, which lists discoveries of every kind from the Isola Sacra, collated not only from earlier publications, but also from official archives, including the old *Giornali di Scavo*, accounts sent to the *Ministero*, unpublished notes produced by members of the *Soprintendenza* etc. It consists of 52 sites that are distinguished with the symbol G (G1, G2, etc) that are located on the map Fig. 2.11.

I do not wish to reflect upon the methodologies used in the survey (Chapter 3, which like Chapters 6 and 7, was written by Keay, Millett and Strutt), not least because I do not feel sufficiently competent to do so. Correctly, this is a very technical account which will surely be of great value to experts who specialize in the application of non-destructive techniques to the study of ancient landscapes, an area of expertise which is going through a period of continual development. In the case of the Isola Sacra, therefore, the use of aerial photographs was accompanied by the study of satellite images and LiDAR data, the latter being a form of aerial laser scanning. I have already referred to the topographic survey undertaken between 2008 and 2012, and in Chapter 3 it is mentioned again, providing numerous technical details; the same is the case for the approach taken by the main form of geophysical survey undertaken in the Isola Sacra, namely magnetometry.

Up until this point, I have reflected upon the methods used in the survey. The following chapter, however, examines the results, which are presented on a method-by method basis: the results obtained from the gradiometry - effectively the interpretation of the geophysical anomalies, those from Ground-Penetrating Radar (G.P.R.), aerial photographic evidence and LiDAR coverage. The outcome of all of this fieldwork is provided by the splendid set of images, all of a high quality and definition, that are amongst the greatest merits of the book. It is logical that within its broader iconographic repertoire, and over and above the many photographs provided, the drawings should be of overall importance, particularly the plans. To give just one example to illustrate my point, the plan in Fig. 4.2

reproduces the general 'mosaic' of the 33 rectangular areas in which the area covered by the Roman Isola Sacra was divided in order to present the results of the survey. Area by area, the successive figures present the results obtained by means of the different (and integrated) techniques that I briefly describe above. Thus, for instance, Fig. 4.4 (which corresponds to Area 1, which represents the northern sector of the Isola Sacra between the *Basilica di S. Ippolito*, the '*Fossa Traiana*', and the *Ponte* and *Terme di Matidia*) synthesizes the results from the gradiometry and the discoveries made before the survey, which are superimposed upon the layout of the modern landscape, which is represented in a lighter colour.

In any event, the author of the preface to a book does not need to describe the results point by point, as this would be both repetitive and boring. For a book as rich and complex as this one, it was necessary to try and understand its overall structure and to focus upon specific issues. Now that I have done this, I would like to concentrate upon several specific points about which it seems to me possible to put forward some personal reflections, in some cases. There are also the issues relating to the most 'revolutionary' discoveries provided by the Portus Project in relation to the historical and archaeological study of the Isola Sacra in recent years.

Pride of place amongst these goes to the discovery of the canal which crossed the whole of the island from north-west to south-east: this had already been reported in previous years,<sup>5</sup> but is only described in detail and with the benefit of full documentation in this volume. Thus, the Portus to Ostia Canal not only occupies the whole of Chapter 5 in this book, but also acts as one of the key factors underlying the new interpretation of the topography of the ancient island. In the conclusions, the authors define it as the most ambitious work of infrastructure and engineering documented on the Isola Sacra, with evident implications for the history of the entire port and urban system that had the mouth of the Tiber as its fulcrum. And it is right that the editors refer to it as the Portus to Ostia Canal, and not *vice versa*; this might seem to be purely a question of terminology but for them, however, it confirms the absolute centrality of the creation of the Claudian and Trajanic basins (and the settlement which developed around them) within the context of the transformations of the entire coastline which they brought about during the first and second centuries AD.

The mouth of the northern end of the canal was cut into the southern quay of the '*Fossa Traiana*'. Significantly, this point lay opposite the mouth of the *Canale Romano* on the northern side, a canal which

ran eastwards in an arc in the direction of the Tiber (see the topography of this in Fig. 1.2). The Portus to Ostia Canal was the widest<sup>6</sup> of all those that have been located so far at Portus and in its vicinity since the publication of the 1998–2004 geophysical survey. It is not worth going into detail here about the geological and geoarchaeological research that has defined its characteristics, and which has been the result of work of experts on the prehistoric and protohistoric phases of the fluvial and coastal phases of the Tiber delta, such as F. Salomon, J.-Ph. Goiran, A. Arnoldus-Huyzendveld† amongst others. The boreholes, already published in part and now interpreted as part of a stratigraphic sequence in their broader context, were drilled in part between 2011 and 2013, and completed in 2017.

Turning attention to the historical aspects, and in particular hypotheses about ship draught and navigability, it is very interesting to learn that the canal could have been used at least in part by commercial ships of considerable tonnage equivalent to, for example, the 150-ton vessel on display in the splendid museum of the *Bourse* at Marseille. While it is true that this water route seems to have been crossed by a road and thus a bridge at a certain point, it is possible that this may have been a mobile installation. Moreover, the question as to whether the Portus to Ostia Canal was used for navigation alone or whether it also served to relieve Tiber flood waters, remains open.<sup>7</sup> Another major problem to confront us concerns the southern end of the canal. One cannot state with certainty that it flowed into the Tiber opposite Ostia, or directly into the sea; the various possibilities can be seen in Figs 5.1, 5.2 and 5.7. The writers would seem to favour the first possibility, not unreasonably. This issue is so important that it recurs several times, as well as in Chapters 6 and 7, where it is noted that in all the hypotheses noted above, the interplay of currents and the silt transported by the canal would have created difficulties for manoeuvring ships and made it difficult to establish a river port in this sector.

Nevertheless, a first conclusion concerning such a new and unexpected feature of the topography of the Isola is its chronology. In the volume it is argued that the watercourse was created between the end of the first and the beginning of the second century AD, an obvious coincidence with the grandiose Trajanic engineering enterprise at Portus; in the conclusions of the book, the dating is further refined to a date of somewhere between AD 110–120, with a final completion during the reign of Hadrian. Its disuse, however, would have begun between the late second and the beginning of the third century AD: this is an interesting suggestion which could be taken to support those

arguments which have suggested that the first signs of the decline of the port system at the mouth of the Tiber – referring to Ostia, however, and not Portus – were already becoming manifest in the Severan period (see below). This therefore means that the canal would have been in full use for a relatively short period of time, perhaps a century or so; in the conclusions, it is argued that after this, the authorities were clearly not able to manage dredging operations, and the canal silted up, perhaps in the course of the fourth century AD, as the 1998–2004 survey has shown to have been the case with other watercourses around Portus.

There are several indicators that help us to better define this chronology, such as the function of the watercourse as interpreted from another sensational discovery. This concerns two shipwrecks from the Isola Sacra (Figs 5.9–13), whose relationship to the canal is stated as probable rather than certain.<sup>8</sup> The section of text that discusses these benefitted from an expert in the archaeology of ships, Giulia Boetto, as well as Alexandra Ghelli and Paola Germoni. Wreck no. 1 was discovered in 2011, c. 300m to the north of the north bank of the Tiber, in the course of works for the new *Ponte della Scafa*; Wreck no. 2 (arranged perpendicularly to Wreck 1) was found a little later, but while the remains of the former were completely recovered,<sup>9</sup> the latter has not yet been completely excavated (the known section is 14m long). Apart from presenting very interesting details about process of excavation, restoration and conservation, and the types of wood used in Wreck no. 1, there is a discussion of its chronology, with a *terminus ante quem* of the third century AD proposed on the basis of stratigraphic evidence.<sup>10</sup> On the other hand, the relatively small size of the boats supports the idea – proposed by the writers in the preceding pages – that this watercourse may have also been used by boats of small and medium capacity, with a draught of 2.5m: in other words, *naves caudicariae* or boats of a similar typology used for local commercial cabotage and, above all else, in connecting Portus with Ostia.

Overall, therefore, the Isola Sacra canal would not have constituted port infrastructure in the strict sense, as was indeed the case of the *Canale Romano* or the '*Fossa Traiana*' itself; nor were warehouses or analogous installations documented along its banks. It must, therefore, have served more for transit (and occasionally for mooring<sup>11</sup>) than for the unloading and storage of merchandise.

In the final part of the book (Chapters 6 and 7), Keay, Millett and Strutt present a holistic synthesis of everything presented up to this point. For ease of reference, I have alluded to many of their conclusions in my preceding pages. For what remains, I will omit

much information that was known prior to the survey. However, it is important to note that the writers take a stand on the respective roles of Claudius and Trajan in the complex process of the port system as we understand it today. The impact of the interventions undertaken under the first of the two emperors is reinforced: while the Fiumicino Canal was thought to have been excavated in the Trajanic period until recently, the 1998–2005 survey has confirmed that it must have already existed under Claudius.<sup>12</sup> A not unimportant consequence of this was that the Isola Sacra could be considered to have been an island by the middle of the first century AD,<sup>13</sup> even though it did not have the epithet ‘Sacra’; the chapter also discusses the Late Antique name for this strip of land and its possible explanation, an issue upon which I will not dwell.

The frequent floods which would have affected the Isola, also explain the rarity of ancient rural settlements, a fact confirmed by the survey. The excavation of canals clearly improved the situation, as we have seen, but the impression that the Isola had a limited population is also true of subsequent periods, with one exception. It is at this point that a highly relevant issue, that of the so-called *Trastevere Ostiense*, makes its first appearance in the book. It has only been in the last decades that it has begun to receive the attention that it deserves, owing to discoveries on the ground and numerous publications. One should not forget that the Isola Sacra in the Roman period was very different to what it is today, not only because it was ‘narrower’ on the coastal side, but also because to the east, the ancient course of the Tiber incorporated the extensive meander that was subsequently cut and isolated by the sixteenth century flood mentioned earlier. They are very well-known issues, but not everyone realizes that the part of the Isola which corresponded to the spur of land within the meander was relatively heavily urbanized down to at least the first century AD.<sup>14</sup>

In terms of terrestrial communications, the principal ancient road on the Isola was the via Flavia, as is well known; but also of importance here, was its connection with Portus (and thus its crossing of the ‘*Fossa Traiana*’). The authors argue in favour of a Flavian date for the origin of the *Ponte di Matidia*, which would have then been repaired – by Matidia – in the Trajanic period. In short, the Flavian interventions in the Isola would have been considerable, and are also attested (as is discussed in another part of the text) by both the building of the first *mausolea* at the *Necropoli di Porto* at the end of the first century AD, and the fact – noted by P. Pensabene – that 15 percent of the documented marble blocks from the *statio marmorum* on the south side of the ‘*Fossa Traiana*’ are also attributable to the Flavian period.

The line of the via Flavia in the southern part of our territory is uncertain, and its relationship to that of the Portus to Ostia Canal cannot be defined with certainty; neither are we in a position to document in detail and with certainty the route by which, in the opposite sense, it entered Ostia from the south and left it again by the north in order to reach the river, and in the end to cross the Isola itself and arrive at Portus.<sup>15</sup> As for the means by which the road crossed the Tiber, the location and configuration of the bridge whose piers were seen in 1879, are not precisely known (Site G50 of the Gazetteer). Several suggestions, however, are possible. The text provides reasons for thinking that in origin, the via Flavia would have followed a straight line, from its origin in the north-west down to the right bank of the river. This would support an argument in favour of a bridge at the position of site G50 (Fig. 2.10), and thus a road access into Ostia at a point at or near Tor Boacciana. The creation of the canal on the Isola under Trajan would have thus led to a change in the line of the via Flavia and the creation of a bridge on the canal itself (see above), which should not be confused with the archaeologically attested structure crossing the Tiber to the south. All of these topographic details are illustrated on Figs 5.1, 5.7 and various others.

The survey has also documented – and this is another significant novelty – the division of the land on the Isola into lots (Fig. 6.4), by ditches of substantial width that could also have been navigated by small boats, as well as being used for drainage. Leaving details of them aside, there are several important aspects worth noting. In some parts of the Isola one glimpses the existence of rectangular allotments oriented east–west, following a modular length equivalent to 50m or multiples of 50m (100m, 150m) that are difficult to relate to the customary system of Roman land divisions; nor are the productive uses of the allotments easy to identify. As regards their chronology, there are reasons for thinking that the sub-divisions of the land into allotments occurred after the establishment of the via Flavia, which then came to constitute the western, or rather the north-western, margin of the land scheme, and was subsequently cut by the Portus to Ostia Canal. Did this belong to a formal *limitatio*? The authors leave this question open, while recalling that in one passage (222.6) the *Liber Coloniarum* speaks of lands around Portus being assigned to *coloni* by Vespasian, Trajan and Hadrian, and to single individuals by Lucius Verus, Marcus Aurelius and Commodus. Certainly, none of these sources explicitly mention the Isola Sacra, although in theory, the term *strigae* could correspond to these lots.

In terms of the areas of burial, the survey confirms the existence of a burial area along the via

Redipuglia (G17–G19) that largely represented a continuation of the *Necropoli di Porto* par excellence, which is situated along the via Flavia, and its offshoots (viz. the burials of the *Opera Nazionale Combattenti*, site G20). There were also other groups of tombs, and for an overall evaluation of this phenomenon and the observations that follow, the general plans on Figs 6.4–6.5 prove useful.

It is interesting to note that, amongst other things, the tombs located to the north-east of the via Flavia, which are difficult to identify from geophysical evidence alone, do not seem to have included standing *mausolea*, with a few exceptions. Moreover, the strange structures identified along the west bank of the Tiber on the eastern side of the Isola, could also be evidence of *mausolea*, although this would need to be confirmed with excavation.

With good reason, the authors pose the question: since fairly large cemeteries have been documented on the Isola, where did the people reside when they were alive? There was a settlement near the southern bridgehead of the *Ponte di Matidia*, to be sure, but this was not very dense and was for the most part occupied by public buildings.<sup>16</sup> There is a lack of evidence for *domus*, *insulae* and similar buildings on the Isola, and this is also in large measure the situation at Portus. This is at least what is understood from the current state of research.

This is a major issue that is not easily interpreted. As the geophysical survey proceeded and subsequent open area excavations of certain areas were undertaken, it has intrigued members of the Portus Project and caused them to pose questions about the ‘urban’ character of Portus. In his publications and in conference presentations, Simon Keay has put forward the suggestive hypothesis that there existed a substantial degree of commuting between Ostia and Portus: that is that many individuals involved in the loading and unloading of merchandise at the imperial harbour basins, and in storing it in the warehouses etc, would have lived in the old *colonia* and travelled to their ‘place of work’ daily, either by road (along the via Flavia), or by boat – in which case they would have used the Isola Sacra canal, or directly by sea. Boats for local cabotage, such as the *caudicariae* or the *lyntres*, would have also been used for this. This is what is left to be guessed at in another passage of the text, where it is argued that thanks to the transport infrastructure that we now understand better, Portus could be reached from Ostia (and *vice versa*) in as little as an hour on foot or by boat. Another hypothesis that is suggested in addition, or as an alternative, is that some of the port workers could have resided in lodgings situated on the now lost upper storeys of the *horrea* at Portus.

Returning to the funerary landscape of the Isola Sacra, the authors suggest, if I understand them correctly, that the *mausolea* on the north side of the Isola were destined for the inhabitants along the southern bank of the ‘*Fossa Traiana*’ and the *Portuenses*, and that the tombs along the via Flavia (including the so-called *Necropoli di Porto*), as well as those situated along the banks of the Tiber, would have served the needs of the *Ostienses*. This is an interpretation about which I would be cautious, and indeed the conclusions warn against overly simplistic hypotheses about ‘spatial segregation’ and instead suggest the existence of ‘mixed’ funerary situations; in relation to this, they cite inscriptions from the *Necropoli di Porto* recording individuals who were active in both port cities,<sup>17</sup> both of which were characterised by having societies that were both complex and mobile. All of this is true, although in my opinion, the main argument is a topographic one: in fact, if one examines plans like Figs 6.4–5 (and others), one cannot not help but notice the fact that the tombs along the via Flavia only become dense along the northern stretch of the route, suggesting or confirming the idea that this cemetery had mainly comprised just one of the ‘*necropolis di Porto*’.<sup>18</sup> When (and if) the funerary panorama of the north-east bank of the Isola along the Tiber are better known, it will perhaps be possible to know whether this sector really was a burial space shared by the residents of Ostia and Portus.

The settlement which, thanks to the survey, has been identified along the southern bank of the Isola Sacra, and thus the right bank of the Tiber, constitutes a reality that is so new and important, as well as having so many implications, that it is justly assigned ample space in the concluding chapters of the book, and inevitably I will do the same here. The discovery, even if only by means of geophysical survey and without verification by means of excavation, had already caused a major sensation (and not just in the scientific community) at the time when Simon Keay made it the object of a press conference held in Rome in April of 2014, that was broadly taken up by the mass media. Following that public presentation, the coordinators of the survey published a report on the discovery that was synthetic, but also exhaustive (Germoni *et al.* 2019). I also attempted to formulate some personal reflections on the matter that were published in the same collection of papers (Pavolini 2019).

The settlement of which we are speaking covers c. 4 ha, and is comprised – overall or in large part – by a group of warehouses that were aligned along the southern bank of the Isola. This excluded the area lying between the presumed course of the canal and the route of the via Flavia to the west, which is

understandable because between both of these only a narrow tongue of land would have remained available, and it would have been unsuitable for these kinds of construction. On the eastern side, the complex of buildings that have been identified could be seen to represent a continuation of the collection of buildings that had already been identified in the spur of land within the ancient meander of the Tiber (see in particular, Fig. 6.2). However, it is unclear whether or not there was a gap between both groups of buildings at its narrowest point.

In summary, therefore, five buildings have been revealed to date by the geophysics (the essential details are summarized in Table 6.1 of the book), of which four were definitely warehouses,<sup>19</sup> while the interpretation of the fifth remains more uncertain. In terms of the typology, three of the *horrea* belong to the courtyard type,<sup>20</sup> for which the authors cite Ostian parallels. The fourth is also a probable warehouse although it may perhaps have had a different function and is without any strict parallels on the other side of the river. The fifth building is decisively different, as it seems to consist of a large enclosed quadrangular area and subdivided by lines of internal pilasters<sup>21</sup> (a space for unloading cargoes prior to their storage in warehouses?). In terms of the chronology of this quarter, settlement evidence prior to the late first century AD is rare, perhaps on account of the frequent Tiber floods, while the excavations of the last century indicate that the earliest structures were built from *opus reticulatum* (see Note 21), which can be generically dated to the first–second century AD.

An equally relevant structure that has been revealed by the non-destructive survey in this southern sector of the Isola, is the probable defensive wall that shuts off the ‘warehouse quarter’ to the north (Fig. 6.6), whose chronology is far from clear. It is significant that, as its discoverers note, it respects the orientation of the system of landscape division that has been discovered to the north: but does that mean that we ought to necessarily attribute it to the same period, that is the late first century AD, or ought we think instead of a more recent date which is not in itself identifiable? To answer this is challenging: as we will see, the authors incline towards the second hypothesis, but in the meantime discount the idea that this defensive circuit could be considered to have been some kind of continuation, on the other side of the river, of the walls of Ostia that are dated by Fausto Zevi on the basis of epigraphic evidence to 63–58 BC. They do this because it is logical to do so (the Isola defensive circuit was clearly destined to protect a complex of vital importance such as the series of *horrea*, and these are much later than the Ciceronian period,

as we know), as well as for a whole series of issues. In effect, the defensive wall has a width of 3–5m and has square external towers (not on the angles) of c. 6–8m: these are characteristics that – without going into too much detail – differ significantly from those of the late Republican wall circuit of Ostia.

In terms of its circuit, once the Isola Sacra wall reached its western limit, it turned sharply south in the direction of the northern wall of Building 1. The relative chronology of both structures will only be resolved by excavation; however, there are indications from the magnetometry to make one think that the defences were later than the outer wall of the warehouse and that this was incorporated into them in order to consolidate the defensive system. Towards the east, albeit without proof, the authors argue that the wall continued in a straight line as far as the inner (west) bank of the meander (as the above cited plans might be taken to suggest). If this is the case, it would have ensured that the southern and eastern arms of the Tiber would have been provided with an adequate degree of protection against any assailants.

Turning now to the crucial question of its chronology, one point of great importance is the fact that if on the one hand the Isola Sacra wall circuit is significantly different from that of Ostia, on the other it has characteristics that are remarkably similar to those of late antique date that were built at Portus,<sup>22</sup> as the authors argue. Fundamental to understanding the chronology of these are the results of the sondage, albeit of limited scope, undertaken at the so-called ‘*Antemurale*’ of Portus. The stratigraphic sequence here has made it possible to push the date of the fortifications of Portus back from both the traditional Constantinian period, and the late fourth to early fifth century AD date that had been attributed to them at one stage. It is now argued that the fortification could have been completed around AD 470–80, and that it could have been undertaken by a *praefectus Urbi* of Odovacar (Keay and Paroli 2011, 7, notes 22, 82 and 141).

It is clear, then, that if the fortification running along the northern side of the *horrea* on the southern side of the Isola Sacra should also be attributed to a late date on the grounds of similarity, and that if a future stratigraphic excavation should confirm this, then it would raise interesting questions about the last stages of the history of Ostia. These are issues that I have raised in the article mentioned above (Pavolini 2019), which is also cited by the authors of this volume who tend to agree with the hypotheses formulated there. They thus espouse the vision of an Ostia in which the underlying rationale for its earlier floruit had already begun to fade from the third century AD onwards, and which in the middle of the fifth century AD was

heading towards its definitive crisis as an urban institution. There is far too much to say about this issue, but it has already been done on numerous occasions and not only by me.

And still, given the context of our discussion, we can do no less than remember a key fact which is that after the end of the Republic, let alone during Late Antiquity by which time they had largely fallen into disuse, the fortifications of Ostia were never reconstructed. At Portus, as we have just seen, matters played out differently, something which makes one think that in the last period of its use, the warehouse quarter of the *Trastevere Ostiense*<sup>23</sup> with its protective wall, and I would say the Isola Sacra as a whole, was by now under the administrative jurisdiction of Portus<sup>24</sup> rather than Ostia, and therefore under its economic and political control as well. The historical implications would have been evidently highly significant, and need to be further explored.

The final paragraphs of Chapter 7 are dense with final observations and important questions. For the large scale building projects undertaken at both Ostia and at Portus at different times in their histories, particularly those completed for the *annona*, should one think of them in terms of public or private initiatives, or perhaps as combined operations, and in what proportions? As regards Ostia, Janet Delaine (2002) has suggested that in many cases, the investment would have come from private sources (from members of the urban *ordo* or from *collegia*, freedmen of the *colonia* etc), but it is then worth posing the same question about land ownership, as the authors of the book do, where there are similar problems. In the case of Portus, one can probably attribute it to imperial property, which would have been acquired through inheritance: but what about the lands of the Isola Sacra? Here the question seems to be more complex: the directors of the survey tend to distinguish between the lots, which in the central and northern sectors of the Isola came to be divided up and distributed to *coloni* or those to whom it had been assigned – perhaps as a result of imperial intervention, and those along the southern strip, which at least from the second half of the first century AD when the *horrea* began to appear, could have been in private hands.

The definitive conclusions to the volume do no more than expand upon the contents of Chapters 6 and 7 (which are in themselves conclusive as we have seen), but do so in terms of a broader context. One aspect perhaps prevails above all others: for any future study of Ostia, the change in our perception of its history as a result of the survey results is, and will remain, fundamental. This is because from now on, we need to envisage Ostia as no longer being just

the settlement on the left bank of the river as we have traditionally known it, with the *Trastevere* as a poorly studied appendage, but as a great commercial river port (a ‘commercial corridor’ is the textual definition), or a port cut in two by a river (‘a port bisected by a river’ as described in the book). And here, a comparison with the Urbs itself becomes inevitable, since studies in recent decades (it is not necessary to provide references, but sufficient to think of the contributions by C. Mocchegiani Carpano, E. Rodríguez Almeida and F. De Caprariis, amongst others) have given the impression of a Rome served commercially by quays and landing stages – with their ensemble of storage buildings – not just concentrated around the *Emporium* and the northern river port of *Tor di Nona*, but spread out along the whole length of the urban stretch of the Tiber.

Consequently, our image of Ostia should also change in respect of its demographic profile. Even though calculations concerning this have always been somewhat random, for obvious reasons, and it seems appropriate to retain the same note of caution from now onwards, it is clear that we cannot still think – for this Ostia as broadly understood – of a population equivalent to the figure of 30,000–40,000 that is usually cited; there would have been many more. The text states this, as well as alluding to another element that, in the context of needing to re-examine the size of the population, is particularly relevant: I am alluding to the large urban expansion of Ostia to the south-east of the Republican walls that would have been documented by another programme of non-destructive survey, namely the geophysical survey directed years ago by Michael Heinzelmänn, which remains almost completely unpublished, as our authors lament. In any event, if there is a confirmation of this and add this possible ‘Ostia outside the walls’ to a *Trastevere* that is otherwise somewhat more densely occupied than previously thought, in schematic terms Ostia would pass from the status of a small to medium sized centre to one of a middle to large size. So many aspects of its history (its relations with Rome and Portus itself), will have to be radically reviewed, while in terms of didactic communication to the non-specialist public, someone would need to re-write the popular guides as well.

The conclusions to the volume speak of the beginnings of the first century AD as the possible initial establishment phase of the commercial infrastructure to the north of the Tiber, with everything that this implies. Without prejudice to excavation controls, this dating could be considered to be too high, since in some parts of the text, the second half of the first century AD had been suggested as the period that

marked the first appearance of the *horrea*, which would have developed above all in the course of the second century AD. In any case, even if it is admitted that a true flourishing of the 'Trastevere' had begun between AD 50 and 100, in the analysis of the authors this would suggest that the commercial and urban revitalization of the old colony of Ostia was essentially determined by the establishment of the Claudian basin at Portus, rather than as a result of the Trajanic basin, and we have already seen some possible reasons for this.

This picture is completed by the reflections that appear in the final paragraphs of the chapter, and which encompass the broader geographical context of the port system created by the Romans along the central stretch of the Tyrrhenian coast (with Trajan as the protagonist in some of the decisive interventions), and which ranged from Centumcellae in the north to Terracina to the south, if not beyond, since further south lie Pozzuoli and Naples. At the 'heart' of this system lay the Ostia/Portus conurbation, and the 'heart of the heart' was the Isola Sacra, for the understanding of which this book accomplishes a gigantic breakthrough. Notwithstanding its length and completeness and the fact that the present contribution stands out as an essential point of departure, it is not necessarily one of arrival (and I believe that the authors can agree with this). So, the wish – that can perhaps seem to be customary but which has rarely been so justified – is that the Portus Project and the Italian-British surveys of the Isola Sacra around the imperial harbour basins and in its hinterland continue, using both non-destructive and traditional archaeological methodologies, so that they can provide us with further new and unexpected discoveries for historical reflection.

## Notes

- 1 In relation to this Pavolini 2013.
- 2 Many programmes of urban and landscape replanning along the modern Roman coastline have been drawn up in recent years, with few practical outcomes up until now. Nevertheless, interesting ideas relating to these – with projects in which the archaeological context based upon Ostia and Portus (with the Isola Sacra at their heart) assumes crucial importance – are to be found, for example, in two recent volumes produced by the *Dipartimento di Architettura e Progetto dell'Università di Roma La Sapienza*, with a contribution by this writer. (Pavolini 2015); see also Pavolini 2019.
- 3 This is the date which is usually attributed to the moment when the meander formed by the Tiber close to Ostia is cut, remains isolated and silts up, creating the so-called Fiume Morto, although it has been argued that this was a gradual process lasting several years and was not complete until 1562: see amongst others Pannuzi and Rosa 2017.
- 4 The book cites works down to and including the most recent contribution by Olivanti and Spanu 2019, although it omits the matching article in the same *Atti del Terzo Seminario ostiense* (Baldassarre *et al.* 2019) which integrates and replaces earlier publications by Baldassarre and her collaborators.
- 5 It was first presented publicly by Germoni *et al.* 2011: figs 1.3–4, although at this stage it was only possible to provide an illustration of the first stretch of the canal.
- 6 The writers estimate its width at c. 35m.
- 7 In effect, given the general topography, a double function would seem the most probable, and this would not only be the case with the Portus to Ostia Canal, but also those that have been identified, or better interpreted, as a result of recent fieldwork (the *Canale Romano*) mentioned above, the northern canal and the '*Fossa Traiana*' itself: see Keay and Paroli 2011: Figs 1.3–4.
- 8 Further on, the editors of the volume put forward the hypothesis that the vessels were found in what was the final stretch of the canal which, in nearing the bank of the Tiber, would have turned gently to the west, as seems to be suggested by aerial photographs, coinciding with the route taken by the via Flavia.
- 9 Length of c. 12m x width of 4.88m.
- 10 This is the rationale for suggesting that the canal was not abandoned later than the Severan period.
- 11 This may have been the context of the Isola Sacra wrecks.
- 12 This is probably one of the canals referred to in the well-known inscription (CIL XIV, 85) that records the decision of the central power to create canals that aimed to resolve at least in part the problems of the Tiber floods. It dates to AD 46, and such a chronology confirms (something implicit in the analysis of the authors) that the excavation of the first harbour basin and its canal lying to the south of it must have been planned together. However, the fact that the *statio marmorum* along the line of the '*Fossa Traiana*' was active during the final decades of the first century AD (see below), is a fact that speaks for itself.
- 13 Which implies that it is only from this point that we can speak of a Tiber delta.
- 14 All of the relevant bibliography for this, with studies by A. Arnoldus-Huyzendveld, L. Paroli, A. Pellegrino and others, is cited in the volume.
- 15 In respect to the solution adopted in this book, the question is perhaps rather more complex. I simply refer the reader to Pavolini 2018 which discusses hypotheses relating to the final stretch of the coastal *via Severiana*, which ran from southern Lazio, and after entering Ostia from the south probably, at least to my mind, coincided with the southern stretch of the Decumanus Maximus and the *Via della Foce* as far as the Tiber. There must have been, therefore, stretches of coastal roads that existed prior to the Severan re-organization of the road, and hypothetically the via Flavia could thus be considered to represent their continuation on the Isola Sacra.
- 16 I note in passing some hypotheses that appear later in the text (in other words, the conclusions), that suggest

the possibility that both here and in the *statio marmorum* further to the east were situated offices – used by imperial officials – charged with collecting customs on merchandise that being transported from the ports to Rome (and in lesser quantity to Ostia).

- 17 Also, in another passage which refers to epigraphic and juridical documentation, it is noted how many *navicularii* and other members of associations connected with commerce supply and port activities, would have carried out their work both in the old *colonia* and the imperial harbours.
- 18 And to my mind it is significant that the ‘decline’ of the cemetery dateable only by its *mausolea* can only be detected from *c.* the first half of the third century AD, as has always been understood. This is perhaps a confirmation of the fact that the importance of Ostia was gradually decreasing and that, as a consequence, the intensity of fluvial and terrestrial connections between Ostia and Portus was also diminishing. While all of this was occurring, Portus obviously continued to be inhabited and flourished, although its inhabitants came to be buried elsewhere. This is, therefore, a complex issue that clearly cannot be developed here.
- 19 A small part of Building 1 was discovered during an excavation in 1968 (Zevi 1972 and G41).
- 20 I would like to draw attention in this note to many issues relating to such warehouses and related problems that are all very well documented in Chapters 6 and 7 of the book. For example, the probability that the principal product stored in them was grain; the possibility that there were auctions or similar activities in their courtyards, as Janet DeLaine (2005) has suggested in relation to some Ostian buildings; finally, calculation

of storage capacity, not only that of the ‘warehouse quarter’ but also of the urban area of both Portus and Ostia as a whole, a subject about the authors themselves stress prudence.

- 21 This Building 5 had been observed in the sondages dug in the 1960s (the circumstances of the find and the publication by Zevi and others appears in the entry G44 in the Gazetteer), and to it perhaps belonged the mosaics located immediately to the east of the limits of the survey, G45-G46. This was a built-up area, the characteristics of which are for the moment less clear, which extended to the south-west of the sites listed and included structures built from *opus reticulatum* (of the first century AD) that were observed in the same sondages.
- 22 In making all of these observations, I take as read the fact they all derive from magnetometry results. I have pointed this out on various occasions, and the authors themselves also have this in mind; however, this does not prevent us from reasoning and formulating hypotheses from this kind of evidence.
- 23 The date of whose abandonment is unknown; in the conclusion, reference is made only to the existence of an undated tomb ‘a cappuccina’ which was discovered in the old excavations at G43.
- 24 As is well known, the first source that defines Portus as a *civitas* dates to AD 313. The change in its administrative status could have thus occurred earlier, we do not know when, and it could have involved the ‘annexation’ of the Isola Sacra to the new territory administered by the new *civitas*. Rather broader considerations related to the continued flourishing of Portus in Late Antiquity are discussed in Pavolini 2019.



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### Note regarding the Gazetteer

Information about previously explored sites on Isola Sacra is summarized in the Gazetteer (see pp. 173–85). Throughout the text and on the illustrations, references to these sites in text uses the abbreviated form (G1), meaning Gazetteer site 1.

### Note

- 1 It was directed by Simon Keay; Grant numbers AH/1004483/1 and AHE509517/1.



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## Chapter 3

# The Survey Methodology

Simon Keay, Martin Millett and Kristian Strutt

### Abstract

*This chapter explains the methods used in the survey of the Isola Sacra and in the processing of the data produced. The sources of remotely sensed data from aerial photography, satellite imagery and LiDAR are outlined. The equipment and techniques used for the ground-based topographic survey are explained and the limits of the scope of this work noted. The methods of geophysical survey deployed are introduced, with an account of the equipment used in the extensive fluxgate gradiometer and more limited ground-penetrating radar (G.P.R.) surveys. The methods used for the processing of the geophysical survey data are then outlined. Finally, an account is provided of the use of cartographic data and the integration of the different datasets within a geographical information system (G.I.S.).*

### Introduction

The survey strategy for the Isola Sacra provided a framework for the integrated analysis of different datasets across the landscape. This approach involved the use of air photographic images, satellite data, Light Detection and Ranging data (LiDAR) and cartographic sources, in addition to the results of the geophysical survey. This ensured that as much information as possible could be gained about different zones of the landscape, thereby offsetting the constraints caused by lack of access to different fields or hindrances to survey from the presence of modern infrastructure.

As with the geophysical surveys of Portus completed between 1998 and 2004 (Keay *et al.* 2005: Chapter 4), the variable nature of the deposits across the Isola Sacra affected the results of the survey. In the areas close to the 'Fossa Traiana' at the northern end of the island, modern disturbances restricted survey coverage and adversely affected the quality of the results. Across much of the Isola Sacra the varying levels of magnetic susceptibility of the deposits meant that the

results were dominated by banding in the data, marking successive alluvial deposits during the growth of the Tiber delta (Keay *et al.* 2014a; 2014b), similar to those recorded around Portus to the north (Keay *et al.* 2005: 121). However, in many areas, the results of the geophysical survey are very clear, making it possible to generate excellent maps of buried archaeological remains. This is the case with the survey results in the southern part of the Isola Sacra and in the north along the via Redipuglia. The results of the research revealed key differences in both fluvial geology and archaeology across the Isola Sacra in relation to both the development of Portus to the north and the urban features along its southern side that relate to Ostia Antica. Ditches associated with drainage and irrigation cover much of the area, while structural remains are focused at a limited number of locations (Keay *et al.* 2014a).

Where the geophysical survey was constrained, we were more reliant on remotely sensed data in the form of air photographs and satellite imagery. Twentieth-century air photographic evidence in particular provided coverage of areas where modern building now obscures the landscape (Keay *et al.* 2014b). These photographs, when compared with satellite imagery, provided background information that could be integrated with the other survey data to provide a complementary dataset. Finally, information from the cartographic sources discussed above (pp. 13–17) was utilized, with older maps providing historical context from the sixteenth century onwards, and more recent maps and archaeological plans providing complementary information.

### Air photographic evidence

For the Isola Sacra, the individual air photos from the Royal Air Force (R.A.F.) and Aeronautica Militare (A.M.) were scanned and saved as high resolution TIFs

at 600dpi and were then imported into Esri ArcGIS (see Data Integration, below). The photos could then be analysed with overlays of the geophysical survey data, with the anomalies visible in the air photos being mapped and digitized for comparison with the other datasets. The previous rectification of air photographs at Portus had been undertaken using AirPhoto (Keay *et al.* 2005: 67). The system of rectification in ArcGIS, however, was deemed more appropriate for the Isola Sacra, given the varied nature of the photos, including the high-altitude vertical photos and oblique low altitude shots.

While many of the archaeological features identified in the geophysical survey were not visible in the air photographs for the Isola Sacra, these images do provide crucial data relating to areas of the landscape that are now covered by buildings, or which were otherwise inaccessible for ground-based survey. Consequently, the mapping of features provided important information on the continuing alignment of some of the major linear features of the Isola Sacra, such as the via Flavia and the Portus to Ostia Canal, as well as the fluvial deposits distributed across the area as a whole.

### Satellite imagery

Panchromatic and multispectral satellite imagery was also integrated into our analyses to complement our aerial photographic coverage. The use of satellite imagery in archaeology has expanded significantly recently (Beck *et al.* 2007; Calleja *et al.* 2018), with the availability of high resolution Quickbird and Ikonos 2 satellite imagery (Campana 2007) providing high resolution data for mapping and interpreting archaeological features. Satellite imagery has been used widely across different landscapes in Italy (Lasaponara and Masini 2007; Masini and Lasaponara 2007; Mozzi *et al.* 2016). Use of such images to map the Tiber floodplain presents some technical challenges, particularly in relation to the depth of deposits. However, both panchromatic and multispectral data have facilitated the mapping of both archaeological and geomorphological deposits in the area, in particular those relating to the via Flavia, the tombs around the *Necropoli di Porto (G35)*, and the deposits associated with the Fiume Morto to the south-east of the island.

For this project, Worldview 2 panchromatic and 8 band multispectral data were purchased, providing 0.46m resolution greyscale imagery and 1.85m multispectral data (Keay *et al.* 2014b). The imagery covered an area of forty-one 1 x 1km grid tiles, centred on the Isola Sacra, and incorporating Portus to the north and Ostia Antica to the south. The imagery was imported

into ArcGIS for analysis and integrated with the results of the geophysical survey and other remotely sensed datasets. The band settings for the multispectral dataset were adjusted to accentuate the buried archaeological deposits, and the visible anomalies in the data were digitized in ArcMAP. The digitized features were then compared with the results of the geophysical survey and rectified air photographs in order to contribute to the final overall interpretation of archaeological and geomorphological features.

### LiDAR data

Airborne laser scanning (LiDAR) data are collected in Italy by the *Ministero dell'Ambiente*, and there is good coverage available for the Isola Sacra. The data comprise measurements taken by infrared laser pulses, usually from a laser mounted beneath an aircraft (Davis 2012: 4), allowing collection of thousands of points over a defined area. The first return from the laser will normally be reflected from the surface vegetation or the tree canopy. However, later responses will come from deeper in the canopy, while the final return will be received from the ground surface. Thus, LiDAR data can be used to record topography from beneath the tree canopy of wooded areas. Use of LiDAR has increased considerably in Italy over the last decade, particularly with work undertaken in southern Italy in Puglia, Basilicata and Calabria (Lasaponara *et al.* 2010). For the Isola Sacra, the Digital Surface Model (D.S.M.) dataset provided unimpeded coverage of the open arable and pasture areas of the delta, and the beaches and dune cordons. However, areas under tree canopy and covered by modern development were of limited use in the overall dataset. By contrast, the Digital Terrain Model (D.T.M.) dataset provided some bare earth topographic data for wooded areas.

LiDAR data for the Isola Sacra were imported as a series of ASCII files. They were supplied as Digital Terrain Model (D.T.M.) and first and last return Digital Surface Model (D.S.M.) data. In addition, a series of intensity Tiff files were also supplied. These data were imported into ArcCatalogue and a mosaic was created using a standard procedure (Davis 2012: 6), with the other grid tiles then loaded into the first imported tile.

### Topographic survey

The topographic survey of the Isola Sacra was undertaken over the period 2008–12 when the Portus Project was moving from total station and theodolite survey to the use of a Real Time Kinetic (R.T.K.) Global Positioning System (G.P.S.). While surveying was not undertaken to produce a close interval contour model

like that which had been created for Portus (Keay *et al.* 2005: 62, 71), there was a requirement for topographic point data to enable mapping and geophysical survey, and the geo-referencing of cartographic data and air photographs.

Initially the survey was reliant upon a total station (Fig. 3.1) based at the survey stations established at Portus. The original baseline for that survey was established using two survey stations established by the *Soprintendenza per i Beni Archeologici di Ostia* located close to the *Grandi Magazzini di Settimio Severo* at the centre of Portus (Keay *et al.* 2005: 63). An open traverse of backsights and foresights was then extended south across the '*Fossa Traiana*' to establish survey stations with Gauss Boaga co-ordinates around the area of the *Basilica di S. Ippolito* (G14) and the *Terme di Matidia* (G12) on the Isola Sacra. The total station was also used to establish the 30m by 30m survey grid across the northern part of the Isola Sacra. This grid followed the alignment of the roads and canals of the *bonificazione* in order to optimize survey coverage and to ensure that the traverses of the geophysical survey ran at a tangent across the alignment of buried archaeological

features. These grids were then georeferenced to the Gauss Boaga co-ordinate system.

The use of the total station for establishing topographic control on the Isola Sacra was ultimately inadequate for the purposes of the survey, due to compound error in the survey traverse as it was extended further from the original baseline. While topographic survey using a G.P.S. at Portus was limited by the dense tree canopy in the *Parco Archeologico*, the open landscape of the Isola Sacra made it possible to use this survey technology. Thus, it was decided to use an R.T.K. G.P.S. for survey from 2009 to 2012. A Leica 500 series instrument was used, incorporating a base station with antenna, terminal and radio, and a rover with antenna and radio (Fig. 3.2). Survey stations that were created using the total station survey had their correct co-ordinates recorded using the G.P.S., whilst new survey stations were established across the southern half of the Isola Sacra. Existing survey grid markers were then used to establish a local co-ordinate system and baseline, and the 30m by 30m survey grid was extended across the Isola Sacra in order to enable the geophysical survey to take place.



**Figure 3.1.** Total station survey in progress by the Terme di Matidia (G12). (Photograph: Martin Millett.)



**Figure 3.2.** GPS survey in progress. (Photograph: Kristian Strutt.)

All survey data were downloaded as ASCII file format data for importing into Esri ArcGIS. This facilitated the integration of the topographic survey and grid data with satellite and LiDAR data, and the results of the geophysical survey. It also aided in the geo-rectification of the oblique air photographs in the G.I.S. We did not attempt to provide a comprehensive topographic survey using spot heights to generate contours, as the landscape was mainly level or slightly undulating, but also because of the availability of LiDAR data (see above).

### Geophysical survey

Previous work at Portus showed the potential for large-scale geophysical survey in the Tiber Delta, particularly on the alluvium and other deposits of the floodplain. Survey between 1998–2004 had shown that use of a fluxgate gradiometer (colloquially referred to as a magnetometer) successfully facilitated the recognition of sub-surface archaeological structures relatively quickly (Keay *et al.* 2005; Strutt 2006, 7; Strutt *et al.* 2008). Fluxgate gradiometry was thus chosen as the most effective technique for use across the Isola Sacra.

Fluxgate gradiometers function by measuring minor variations in the earth's magnetic field, allowing the detection of different types of archaeological features including kilns, hearths, ovens, ditches and walls, particularly where ceramic material or tufa have been used in their construction (Gaffney *et al.* 2002: 6). This technique is therefore very well suited for the detection of Roman remains which have many of these characteristics, although it should be noted that the results of a magnetometer survey can be adversely affected by areas of modern disturbance, the presence

of ferrous material or spreads of surface rubble (Scollar *et al.* 1990: 362). Other advantages offered by this technique are its relative speed and efficiency in surveying large open areas, allowing the more extensive sites to be assessed over a relatively short period of time. Variations in the earth's magnetic field that are associated with archaeological features are weak, especially considering the overall strength of the magnetic field of around 48 Teslas (= 48,000 nanoTesla, or nT). Fluxgate gradiometers are based around a highly permeable nickel iron alloy core, which is magnetized by the earth's magnetic field, together with an alternating field applied via a primary winding. Due to the fluxgate's directional method of functioning, a single fluxgate cannot be utilized on its own, as it cannot be held at a constant angle to the earth's magnetic field. Fluxgate gradiometers therefore have two fluxgates positioned vertically in relation to one another on a rigid staff. This reduces the effects of instrument orientation on readings. They are sensitive to 0.5nT or below depending on the instrument, although they can rarely detect features which are located deeper than *c.* 1m below the surface of the ground. Archaeological features such as brick walls, hearths, kilns and disturbed building material will be represented in the results, as well as more ephemeral changes in soil composition, allowing foundation trenches, pits and ditches to be located. Results are however extremely dependent on the geology of the particular area and can be compromised on those occasions when the archaeological remains are derived from the same materials.

The magnetometer survey on the Isola Sacra was conducted principally using Bartington Instruments Grad 601-2 dual sensor fluxgate gradiometers (Fig. 3.3). Measurements were taken at 0.25m intervals on



**Figure 3.3.** Gradiometry survey in progress using a Bartington Instruments Grad 601-2 dual sensor instrument. (Photograph: Kristian Strutt.)



**Figure 3.4.** The LEA MAX fluxgate gradiometer array being prepared for use by Eastern Atlas. (Photograph: Gregory Tucker.)

0.5m traverses, with data collected in a zig-zag fashion. An initial small-scale survey had been conducted around the *Terme di Matidia* in 2002 and 2005, where Geoscan Research FM36 fluxgate gradiometers were used. Here, these single sensor instruments were used along 1m traverses with a reading interval of 0.5m. All data were recorded using parallel collection, with the operator collecting data in each traverse running from west to east. During the 2011 season, part of the south sector of the Isola Sacra was surveyed by a team from Eastern Atlas GmbH, using a multi-sensor array of Foerster fluxgate gradiometers (Fig. 3.4). A LEA MAX with 10 Fluxgate gradiometer Foerster FEREX CON400 sensors was used and the survey conducted by means of traverses at 0.5m spacing. A 10-channel digitizer LEA D2 was used to collect the data, and the location of the survey was recorded using a GNSS receiver NovAtel Smart G.P.S.

The fluxgate gradiometer survey data were processed using Geoplot 3.0 software. This was necessary to remove any effects produced by broad variations in geology, or small-scale localized changes in magnetism of material close to the present ground surface. The data were then de-spiked to remove any extreme magnetic values caused by metallic objects in the soil. A zero mean traverse function was subsequently applied to remove any drift caused by changes in the magnetic

field. Lastly, a low pass filter was applied to remove any high frequency readings, and results were then interpolated to 0.5m resolution across the traverses.

In addition to the gradiometry, some targeted Ground-Penetrating Radar (G.P.R.) survey was conducted to the south of the *Basilica di S. Ippolito* on the line of the via Flavia. It was hoped that the characteristics of the G.P.R. technique would provide a dataset for comparison with the magnetometer survey at key points. G.P.R. survey involves the passing of an electromagnetic radar wave through the ground and measures the time in nanoseconds (ns) for the signal to be reflected back to the receiver (Conyers and Goodman 1997: 27; Conyers 2013: 24). The velocity of the radar wave and its reflections are dictated by the changing relative dielectric permittivity (R.D.P.) of the buried materials. Thus, changing R.D.P. between buried archaeological structures and the surrounding sub-soil (Conyers 2013: 170) provides the basis for mapping buried archaeological remains. For the surveys on the Isola Sacra, a GSSI G.P.R. was used with a 400MHz antenna and cart, and an SIR 3000 console (Fig. 3.5). Data were collected in profiles in zig-zag mode at 0.5m traverse intervals, with traces at 0.05m intervals.

Data were processed using GPR-Slice software. The different survey profiles were presented in their



**Figure 3.5.** The GSSI Ground-Penetrating Radar array in use. (Photograph: Kristian Strutt.)

relative positions and were then processed to remove background noise. A band-pass filter was applied to each profile to remove all high and low frequency readings. The presence of hyperbola in the data were utilized to produce an estimation of signal velocity through the deposits at each site, facilitating a calculation of the depth of different features across each site. Profiles were then converted into grid data and sliced horizontally to produce a series of time-slices through each survey area.

All geophysical survey data from the survey were exported as a series of bitmaps, and were then imported into, and geo-referenced within, a G.I.S. An interpretation layer representing archaeological and modern features was subsequently digitized. The nature of different anomalies in the survey data was inferred from their form, extent, size and other appropriate information. Although no direct chronological information can be derived from the geophysical survey data, a relative chronology had to be inferred from the morphology of the identified anomalies and their spatial inter-relationships. Thus, for instance, features that cut each other or those that share the same alignment can often be used to hypothesize relative sequences. Similarly, the relationship of features detected in survey to those excavated can help to establish a chronology.

### Cartographic evidence

A number of cartographic sources were consulted in the course of the analysis of the geophysical results, although there were fewer useful maps of the Isola Sacra than there were of Portus. The antiquarian maps,

reviewed in Chapter 2, provide an historical dimension to our research and enhance our understanding of the development of the landscape, but contain little information directly relevant to the interpretation of known monuments or those revealed by our survey.

The base cartography for our survey and the analysis of the remote sensing imagery was provided in the form of a digital map based on the 1:2000 cadastral map of the Isola Sacra (Roma-Alleg. 1042 Capo Due Rami) and 1:1000 map of the *Basilica di S. Ippolito* (Roma-Alleg. 247) provided by the *Soprintendenza per i Beni Archeologici di Ostia*. We geo-referenced this map (as described above), to provide an accurate base map for our survey. It was imported into ArcGIS together with the results of the survey and remotely sensed imagery, in order to provide a backdrop to the images of the results and to facilitate the geo-rectification of oblique air photos and other imagery.

In addition to the large-scale cartography, a number of archaeological plans and maps were incorporated in the research. These included the plans of the excavations of the so-called *Isaeum* (G7), the *Terme di Matidia* (G12) and the *Basilica di S. Ippolito* (G14) from the Soprintendenza archives, as well as plans from the excavations of the *Necropoli di Porto* (G35) published by Calza (1928; 1940) and the work of Veloccia Rinaldi and Testini (1975). The work also incorporated the locations of the sites listed in the Gazetteer (pp. 173–85).

### Data integration

Our overall aim was to present the results of the survey in an integrated format, allowing analysis of all the datasets from across the Isola Sacra to be undertaken alongside the documentary evidence. To that end all data were digitized and georeferenced in ArcGIS. Datasets were either imported or created in a personal geo-database, before being imported into ArcMAP.

In order to achieve this, several diverse datasets with different co-ordinate systems had to be integrated. Many of the archaeological plans and maps published by the Italian state use the Gauss-Boaga co-ordinate system with an origin at Monte Mario in Rome. Air photographic images, in particular those already digitized by the Istituto Centrale per il Catalogo e la Documentazione (I.C.C.D.), utilized UTM 32N and UTM 33N with European Datum (E.D.) 1950. Finally, our own survey results in part utilized a local co-ordinate system, aligned on the roads and field boundaries of the *bonificazione*, thus requiring georeferencing into real-world co-ordinate systems. For the G.I.S., the project used UTM 33N with E.D. 1950. All datasets were transformed in ArcGIS to this

system or, in the case of our local co-ordinate system data, were geo-referenced to this system.

### **Conclusions**

It will be evident from the preceding discussion that our survey of the Isola Sacra drew on a variety of complementary sources. It should be noted that the different datasets each have their own limitations, but used in combination these can be offset, allowing

us to present a view of the Isola Sacra as a complete landscape, to some extent mitigating the problem of fragmented evidence noted in our discussion of past archaeological work in Chapter 2. However, whilst the various techniques of survey outlined above are valuable in providing a new and integrated view of the Roman landscape, none provides the same level of chronological control or detail of structural sequences that is given by excavation. In this sense the survey offers a complementary contextual view of the island.



# The Isola Sacra Survey

The Isola Sacra occupies the land between Ostia and Portus at the mouth of the Tiber, and thus lies at the centre of the massive port complex that served Imperial Rome. This volume focuses on the results of a survey of the island completed as part of the Portus Project, complementing the previously published survey of Portus (2005) and the forthcoming publication of the German Archaeological Institute's survey of Ostia. The survey is framed by an analysis of the geomorphology of the delta, and integrated with information from past excavations. It is complemented by a programme of geoarchaeological coring and a short account of the ships excavated on the Isola Sacra in 2011.

The results make an important contribution to the understanding of the landscape of both Portus and Ostia, offering new information about the development of the delta, and the changing use of the Isola Sacra. They also provide evidence for the buildings along Isola Sacra's northern shore and the cemeteries that flank this settlement and the via Flavia (which runs between Portus and Ostia across the centre of the island). Most significantly, three completely new sets of features were revealed: a major canal that ran north–south across the island; a system of land divisions, which created blocks of fields; and a suburb of Ostia on the island's southern flank. These results are key for understanding the development of the Portus–Ostia complex, and hence the economy of the City of Rome itself.

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