Managing the Underwater Cultural Heritage

Papers Presented at the Fourth International Congress on Underwater Archaeology (IKUWA 4)

Zadar (Croatia), September 29th – October 2nd, 2011

On behalf of the German Society for the Promotion of Underwater Archaeology
edited by Christoph Börker

Beiträge des 4. Internationalen Kongresses für Unterwasserarchäologie (IKUWA 4)

Zadar (Kroatien), 29. September – 2. Oktober 2011

im Auftrag der Deutschen Gesellschaft zur Förderung der Unterwasserarchäologie e.V. (DEGUWA)
herausgegeben von Christoph Börker

Internationale Tagung zur Unterwasserarchäologie

In Poseidons Reich XXI

Unter der Schirmherrschaft des Oberbürgermeisters der Landeshauptstadt Dresden Dirk Hilbert

Unterwasserarchäologie – Interdisziplinäre Fragestellungen und technische Innovationen

21. - 24. April 2016 in Dresden

Die Tagung wird präsentiert in Kooperation mit:

DEGUWA

TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG
Die Ressourcenuniversität. Seit 1765.

LANDESAMT FÜR ARCHÄOLOGIE

Dresden.

Freistaat SACHSEN

Mit Unterstützung von:

Offset-druckerei Gunter Dünnbier

Brauerei Meister Untersaunsbach

Verlag Bernhard Albert Greiner
Silcherstr. 14
71384 Weinstadt

Tel 07151-276645
Fax 07151-276647
eMail: bag@bag-verlag.de
http://www.bag-verlag.de

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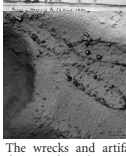

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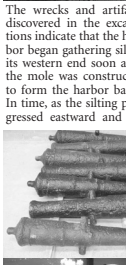

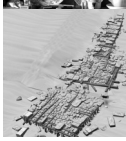

Vorwort

Wenn in diesem Band nur ein kleiner Teil der Referate, die bei dem 4. Internationalen Kongress für Unterwasserarchäologie in Zadar im Herbst 2011 gehalten worden sind, vorgelegt werden kann, so hat dies in erster Linie seinen Grund in finanziellen Problemen der Drucklegung. Eine möglichst vollständige Publikation war selbstverständlich von Anfang an beabsichtigt, aber ein schon als sicher betrachtetes Angebot der Finanzierung zerschlug sich schließlich. Weitere Bemühungen, den für Redaktionsarbeiten und Druck veranschlagten Betrag von 50.000 € aufzutreiben, blieben erfolglos, woran auch die allgemeine Wirtschaftskrise der Zeit eine Mitschuld tragen dürfte.

Im Juni 2014 musste das endgültige Scheitern aller damaligen Bemühungen um eine Drucklegung festgestellt werden. Nachdem der Vorstand der Deutschen Gesellschaft zur Förderung der Unterwasserarchäologie e.V. (DEGUWA) hiervon Kenntnis erhalten hatte, begannen in diesem Kreise Überlegungen, wie man die Publikation aus eigenen Kräften zustande bringen könnte. Da die Serie der Kongresse ursprünglich auf eine Anregung der DEGUWA zur ersten Veranstaltung dieser Art im Jahre 1999 zurückging und diese auch an allen späteren Veranstaltungen mitgearbeitet hat, fühlte sich der Vorstand in besonderer Weise verantwortlich. Eine von einem Fachverlag erbetene Schätzung der zu erwartenden reinen Druckkosten ergab einen weitaus geringeren als den oben genannten Betrag; wenn also die gesamten Redaktionsarbeiten von Mitgliedern der DEGUWA ehrenamtlich und somit kostenlos ausgeführt würden, wäre die Publikation gesichert. Ein entsprechender Vorschlag wurde dem Leiter des Organisationskomitees, Herrn Luka Bekić , mitgeteilt und von diesem begrüßt.

Ende Juli und Anfang August wurden alle potentiellen Autorinnen und Autoren per E-Mail über den Plan einer Drucklegung informiert und um Mitteilung gebeten, ob sie an der Publikation ihrer Referate interessiert seien. Antworten gingen zunächst – vielleicht wegen der Sommerpause – sehr spärlich ein und mehrten sich erst gegen Jahresende, nachdem sich einige Mitglieder der *steering* und *organization committees* der Kongresse von Zadar und Cartagena (IKUWA 5) werbend an ihre Landsleute gewendet hatten und die ursprüngliche Abgabefrist auf Wunsch einzelner Referenten erst auf Ende März und dann auf Ende Juli 2015 verlängert worden war. Während in Zadar rund 90 Referate gehalten worden waren, lagen schließlich Zusagen für etwa ein Sechstel davon vor. Mehr als die Hälfte der Vortragenden haben von Anfang an nicht geantwortet, sechs E-Mail-Adressen erwiesen sich als fehlerhaft oder veraltet, etwa ein Dutzend Empfänger haben abgesagt und andere zwar zunächst Interesse bekundet, aber auf spätere Rundschreiben nicht mehr reagiert und auch ihren in Aussicht gestellten Beitrag nie eingesandt. Vereinzelt wurden Hinderungsgründe angeführt: man habe den Beitrag bereits anderswo publiziert; es fehle die Zeit für eine gründliche Überarbeitung; der Stoff werde für eine größere Arbeit, z.B. eine Dissertation, benötigt. Ähnliches mag für andere Fälle gelten, doch sind weitere Spekulationen müßig.

Angesichts der doch etwas enttäuschenden Entwicklung hatte der Vorstand der DEGUWA zu überlegen, ob eine Publikation überhaupt noch als sinnvoll erschien. Entscheidend war schließlich der Wunsch, diejenigen, die sich Mühe gegeben hatten, nicht zu enttäuschen. So können hier nun wenigstens 16 Beiträge vorgelegt werden, von denen die meisten auf neuesten Stand gebracht oder in anderer Hinsicht überarbeitet worden sind. Sollten sich weitere Referentinnen oder Referenten von Zadar zu einer Publikation entschließen, so steht ihnen die Zeitschrift SKYLLIS mit ihren zweimal jährlich erscheinenden Heften jederzeit zur Verfügung.

Die Beiträge sind in derselben Reihenfolge wie in der Kongressbroschüre angeordnet, um die thematische Unterteilung der Vortragsgruppen widerzuspiegeln. Das Oberthema hatte „Managing the Underwater Cultural Heritage“ gelautet. Am ersten Arbeitstag ist hierzu vor der Vollversammlung gesprochen worden. Unsere ersten vier Beiträge von Robert Yorke, Andrew Viduka, Beat Eberschweiler und Miran Erič /Sašo Poglajen gehören dazu. Am zweiten Tag wurden drei, am letzten Tag zwei Sektionen gleichzeitig veranstaltet. Für das Thema „Public Access“ stehen hier die vier Referate von Vicente Benitez-Cabrera/Antonio Becerra-Bolaños/ Michel Jorge-Millares, José Manuel Mates Luque, Hanz Günter Martin/ PeterWinterstein und Jennifer Rodrigues/Vicki Richards. Von der Sektion „Research Strategies“ ist leider kein Beitrag eingetroffen, während aus der Sektion „Site Report“ zwei Berichte von Vladimir Kuznetsov/Sergey Olkhovskiy und Jørgen Johannessen vorgelegt werden können. Der letzte Sachbereich des zweiten Tages, „Post Excavation“ betitelt, ist mit den beiden Beiträgen von David Blackman/ Maria Costanza Lentini und Karla Gusar/Mate Parica vertreten. Aus den zwei Sektionen des letzten Tages „Good Practice“ und „In situ Preservation“ ist je ein Beitrag eingereicht worden, nämlich der von Massimo Capulli/Alessandro Pellegrini/Arianna Traviglia/Riccardo Rizzotto bzw. von Hanna Steyne Chamberlin. An den Abdruck von Poster-Beiträgen war ursprünglich nicht gedacht, da sich aber zwei Autorinnen, Anita Jelić und Antonija Jozić , von selbst meldeten, erschien es unbillig, ihre Berichte über Konservierung und Restaurierung archäologischer Unterwasserfunde nicht aufzunehmen.

Den genannten Autorinnen und Autoren und darüber hinaus allen

denen, die sich um die Einwerbung von Beiträgen bemüht haben – soweit mir namentlich bekannt, waren es Arianna Traviglia, Jennifer Rodrigues, Beat Eberschweiler, Mark Beattie-Edwards, Luka Bekić und Sergey Olkhovskiy – sei zum Schluss ausdrücklich Dank gesagt dafür, dass zumindest eine „kleine Lösung“ in Gestalt eines Supplementbandes der Zeitschrift für Unterwasserarchäologie SKYLLIS zustande gekommen ist. Für die Übersetzung des Vorworts ins Englische ist Angela Middleton zu danken.

Christoph Börker

Foreword

Only a small number of the papers given at the 4th International Congress for Underwater Archaeology in Zadar in 2011 are presented here, mainly due to financial constraints. A complete publication was of course anticipated but an assumed financial promise fell eventually through. Further efforts, to source 50.000 € for editorial works and printing remained fruitless; something the general economic crisis is also to blame for.

The failure to bring the proceedings to print was finally acknowledged in June 2014. After informing the managing committee of the German Society for the Promotion of Underwater Archaeology (DEGUWA), the initiative was taken to print the publication ourselves. The committee felt a sense of responsibility for this as the series of conferences was suggested by DEGUWA, the first one dating back to 1999 and also because the committee has been involved in the organisation of subsequent events ever since. An estimate by a professional publisher of the expected printing costs was much lower than the above mentioned amount. If the editing could be carried out by employees of DEGUWA on a voluntary basis, the publication would be saved. This proposal was submitted to the head of the organising committee, Mr. Luka Bekić , and accepted by him.

By the end of July, early August 2014, potential authors were informed of the new plan by e-mail and asked whether they would be interested in having their papers published. Replies were sparse initially, possibly due to the summer break, but this improved towards the end of the year. The situation was further improved when members of the steering and organising committees of the Zadar and Cartagena (IKUWA 5) conferences got in touch with fellow countrymen and the submission deadline, based on requests by some speakers, was extended first till March, and then to the end of July 2015. Approximately of a sixth of all 90 papers given at the Zadar conference finally the authors agreed to submit their papers for publication. More than half of the speakers never replied from the start, six e-mail addresses were either incorrect or outdated, roughly a dozen declined, others did initially express an interest, but then did not reply to further circulars and also did not send their contribution despite an intial promise. Occasionally reasons were given: the paper has been published elsewhere already; no time to work on the contribution; the material is needed for a bigger piece, e.g. a dissertation. Similar may be true for other cases, but further speculations are tedious.

In the light of this rather dissapointing development, the DEGUWA committee had to decide whether a publication was still worthwhile. Crucial was the desire not to dissapoint those who had put in a lot of effort. So finally 16 papers can be presented here; most of which have been updated or were revised in some other form. Should other speakers of the Zadar conference decide to publish, then the journal SKYLLIS which is published twice a year, would be available for this.

The contributions are presented in the same order as in the conference brochure, to reflect the thematic groupings of the speakers. The overarching theme was „Managing the Underwater Cultural Heritage". This was covered on day one, in advance of the plenary meeting. Our first four contributions by Robert Yorke, Andrew Viduka, Beat Eberschweiler and Miran Erič / Sašo Poglajen are part of this. There were three parallel sessions on the second day and two on the last. The theme „Public Access" is represented with four papers by Vicente Benitez-Cabrera/Antonio Becerra-Bolaños/ Michel Jorge-Millares, José Manuel Mates Luque, Hanz Günter Martin/ PeterWinterstein and Jennifer Rodrigues/Vicki Richards. Unfortunatley there was no contribution for the theme „Research Strategies". However, there are two contributions on „Site Report" by Vladimir Kuznetsov/Sergey Olkhovskiy and Jørgen Johannessen. The last theme of the second day „Post Excavation" is represented with two papers by David Blackman/Maria Costanza Lentini und Karla Gusar/Mate Parica. From the two sessions of the last day „Good Practice" and „In situ Preservation", we received one contribution each, namely by Massimo Capulli/Alessandro Pellegrini/Arianna Traviglia/Riccardo Rizzotto and by Hanna Steyne Chamberlin. Printing of posters was not considered initially. But since two authors, Anita Jelić and Antonija Jozić , expressed an interest, it would have been undue not to include their contributions on conservation of archaeological underwater finds.

Finally thanks are due to all the authors and furthermore those, who worked hard to secure contributions; as far as I know, those were Arianna Traviglia, Jennifer Rodrigues, Beat Eberschweiler, Mark Beattie-Edwards, Luka Bekić and Sergey Olkhovskiy. Their efforts resulted in a „small solution" in the form of a supplement to the journal of underwater archaeology SKYLLIS. For the translation of the forword into English, thanks are due to Angela Middleton.

Christoph Börker

Archaeological Impact Assessments (AIA) in underwater environments

A case study from the Lagoon of Venice

Massimo Capulli – Alessandro Pellegrini – Arianna Traviglia – Riccardo Rizzotto

Abstract *– 'City of waters', Venice represents a unique example of the challenges to be met in order to reconcile the conflicting demands of heritage preservation, infrastructural development and environmental management.*
This paper expands on the strategic value of Archaeological Impact Assessments (AIA) – studies initiated in response to development proposals that will potentially disturb or alter archaeological sites – by presenting a case study related to an AIA undertaken in Venice prior to the construction of a pipeline stretching across the central and south parts of its lagoon (Fusina Integrated Project). The morphology of this area is very complex and diverse, and it is characterised by the presence of numerous canals, shallows and shoals, a landscape (or, rather, a waterscape) shaped by countless natural and anthropogenic modifications that occurred over the past centuries. The AIA involved the analysis of a variety of datasets acquired through historical, archaeological, geomorphologic and palaeo-environmental investigations coupled with information retrieved by remote sensing imagery analysis and interpretation, and direct survey. The analysis of these datasets led to the identification of a new, large archaeological site located along the planned pipeline track. The elevated 'archaeological sensitivity' of this area caused a change in the project plan, resulting in the relocation of the original pipeline track at an early stage of the work.

Inhalt *– Venedig als "Gewässerstadt" bildet ein einzigartiges Beispiel für die Probleme, denen man begegnet, wenn es gilt, einander entgegesetzte Anforderungen des Schutzes des Kulturerbes, der Infrastrukturentwicklung und des Umweltschutzes in Einklang zu bringen.*
Dieser Artikel handelt vom strategischen Wert der Archaeological Impact Assessments (AIA) – d.h. Untersuchungen anlässlich von Entwicklungsplänen, die archäologische Stätten stören oder verändern könnten – wobei eine entsprechende, in Venedig vor dem Bau einer Pipeline durch seine mittlere und südliche Lagune (Fusina Integrated Project) unternommene Fallstudie vorgestellt wird. Die Morphologie dieses Gebietes ist sehr kompliziert und vielfältig und charakterisiert durch die Existenz zahlreicher Kanäle, Untiefen und Sandbänke – eine Landschaft (oder eher "Wasserschaft"), geformt durch ungezählte natürliche Veränderungen und menschliche Eingriffe in den vergangenen Jahrhunderten. Die AIA umfasste die Analyse einer Vielfalt an durch historische, archäologische, geomorphologische und Altumwelt-Forschungen gewonnenen Datensätzen in Verbindung mit Erkenntnissen aus der Analyse und Deutung von Bildmaterial des Remote Sensing sowie aus Untersuchungen am Ort selbst. Die Auswertung dieses Datenmaterials führte zur Feststellung einer neuen, großen archäologischen Fundstelle längs der geplanten Pipeline. Die hohe archäologische Empfindlichkeit dieses Gebietes bewirkte eine Planänderung, die im frühen Stadium der Arbeiten eine Verlegung der Pipeline zur Folge hatte.

Introduction

M. Capulli

The city of Venice is not just a heritage site or an open-air museum, but a unique living context characterised by residential, commercial and production activities, and set in a very fragile environment exposed to pollution, high water ('*acqua alta*') and coastal erosion. The city and its surrounding lagoon are therefore constantly the object of maintenance work – namely, canal excavation and dredging, refurbishment of the island banks, creation of artificial '*barene*' (shoals) and infrastructure laying – aimed to re-establish and ensure the balance of the lagoon ecosystem. The most remarkable (and certainly well-known) of these maintenance activities is the MOSE, an integrated system built to protect Venice from high waters by means of mobile barriers placed at the inlets of the lagoon. The implementation of this project, still underway, sparked, since the first years of 2000, a series of studies and research that can undoubtedly be considered as the most important and macroscopic example of underwater preventive archaeology realised in Italy to this day (Fozzati 2009).

It is evident that the scale and complexity of the many works yearly undertaken in Venice and its lagoon as well as their routine implementation may impact on the local archaeological heritage and result in its severe and permanent damage. The '*Soprintendenza per Beni Archeologici del Veneto*' (Superintendency for Archaeological Herit-

Fig. 1: PIF pipeline laying operations.

age of Veneto Region), a local office of the Italian Ministry of Cultural Heritage and Activities in charge of the safeguard and management of Venetian archaeological sites and findings, is called to the rigorous application of laws and regulations set to minimise the negative effects of daily life activities in Venice on cultural heritage. Within it, a special unit named NAUSICAA (*Nucleo Archeologia Umida Subacquea Italia Centro Alto Adriatico*, Italian for 'Italian North and Central Adriatic Wet and Underwater Archaeology Team') is dedicated to underwater and wet archaeology (Fozzati – Asta 2014). In recent years, the Superintendency has consistently put the Italian government directives into full effect by requiring to developers the delivery of Archaeological Impact Assessments (AIA) – assessment studies initiated in response to development proposals that will potentially disturb or alter archaeological sites – prior the beginning of any public work (Nava 2009). The main rationale for conducting an AIA is to identify possible archaeological sites that may be affected or disturbed during a project development and implementation, using a variety of methodologies ranging from archive data and literature analysis to direct fieldwork. The role of the AIA is to assist the local authorities (primarily the Superintendency) and private sector in making decisions that will ensure effective management of archaeological resources as well as optimal land and lagoon use.

The case study discussed in this paper[1] refers to an AIA performed prior to an extensive infrastructural work started in 2007, the 'Integrated Fusina Project' (*Progetto Integrato Fusina* in Italian – henceforth PIF)[2], which envisaged the laying of an 20+ km lagoon bottom pipeline (Fig. 1) across the Venetian Lagoon and beyond – up to the open Adriatic sea – aimed to eject in the open sea waste water coming from mainland domestic and industrial sources, with the goal of reducing the water pollution in the lagoon (Direzione Progetto Venezia 2012)[3].

2. The case study area

M. Capulli

The AIA focused on the initial section of the pipeline track, an area stretching from the mainland locality of Fusina to the Malamocco inlet in the Lido Island across the central and south Lagoon of Venice, for a total length of 10 km (Fig. 2). The pipeline, beginning in the proximity of the industrial area of Fusina, cuts through the *Canale di Malamocco-Marghera* (Malamocco-Marghera Canal) at about 300 m south of the turning basin of

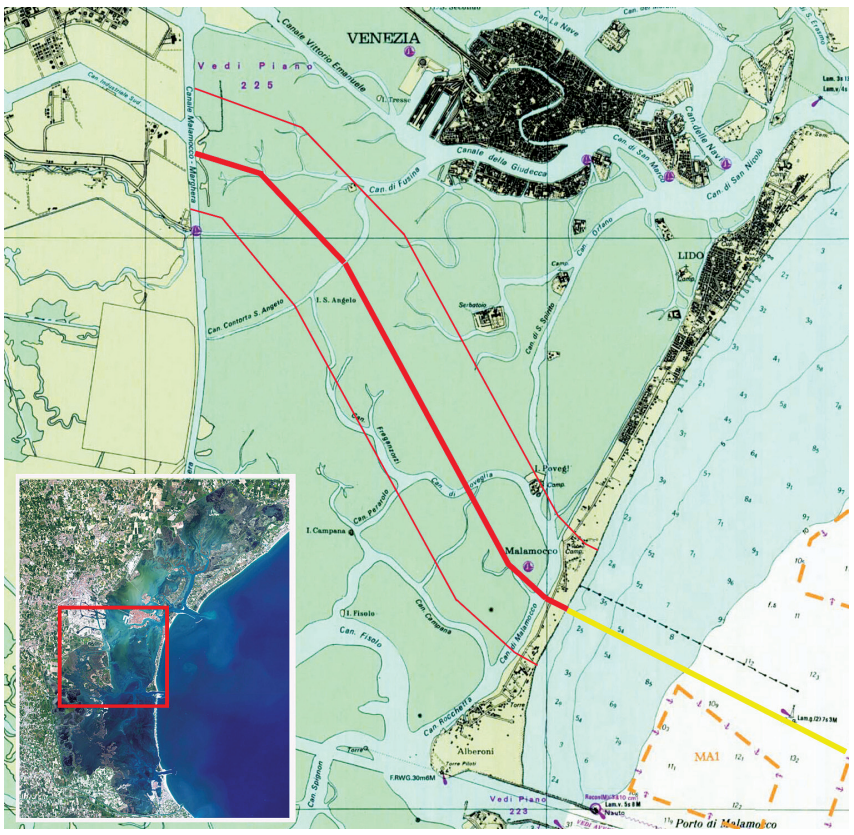

Fig. 2: Lower-left: a satellite image of the overall Lagoon of Venice (Landsat); main: case study area overlaid on the Italian Navy Hydrographical Institute Lagoon Chart (scale 1:50.000); the thicker red mark indicates the pipeline track across the Lagoon; the thinner red mark denotes the limits of the case study area.

the *Canale Industriale Sud* (South Industrial Canal), and – after crossing the shoals located amid *Canale Nuovo di Fusina* (New Canal of Fusina), the *Canale Contorta Sant'Angelo* (Contorta Sant'Angelo Canal) and the *Canale di Poveglia* (Poveglia Canal) – cuts the Malamocco-Marghera Canal south of the residential area bearing the same name; it then runs through Lido Island and ends up in the Adriatic Sea.
This area boasts a complex morphology characterised by a network of canals cutting through wet land and submerged areas consisting of shoals, natural salt marshes, mudflats and shallows. Such fragile ecosystem is exposed to constant erosion, greatly increased in the early 1970s by the dredging of the *Canale dei Petroli* ('Petrol Canal') and the large tanker passages that began following its excavation.

The area subject to the AIA spanned a buffer zone of 1 km in width on each side of the planned pipeline path (**Fig. 2**). This was due to the fact that extensive excavations would have been required even at a considerable distance from the pipeline track; in addition, severe environmental and archaeological impact would have been likely determined by the movement and mooring of working and support boats, the operating range of which would have been clearly quite wide and not necessarily limited to the immediate vicinities of the pipeline track.

3. The AIA methodology

M. Capulli - A. Pellegrini

By now, in Italy it is a well-established practise that all the projects and works that are implemented in areas of historical and archaeological interest must be carried out with technical assistance provided by archaeologists. This is to limit as much as possible the disturbance, destruction or damage of archaeological monuments and sites identified or uncovered during the building stage of a construction project. With the Italian Decree Law n. 63, April 26 2005, archaeologists took on a new, fundamental role in the process of safeguard of the national heritage (Galasso 2010). The Decree Law bound all the construction companies and proponents to take responsibility over the safeguard of cultural heritage by introducing the legal obligation to deliver an *'Archaeological Impact Assessment'* prior the commencement of all public works that could potentially impact significantly on the cultural environment of the development sites, regardless of their size.

The AIA procedure is composed of two principal parts: the first consists of identifying, inventorying and evaluating the archaeological resources before the beginning of the works, during the preliminary stages of the project planning; the second consists of assessing the potential impacts of the project on such resources, instigating alterations in project design where required, and suggesting work methodologies changes when mitigation measures are needed. The potential negative impact on the archaeological resources associated with a project is determined by the evaluation of the net change of the site archaeological integrity that may be incurred as a consequence of a proposed development.

There are several methodological approaches that can be employed in conducting an impact assessment, but generally speaking it always involves a multidisciplinary research where archaeological resource identification may be achieved in two distinct manners: desk based research and site survey. Thus, activities to be undertaken in order to determine the archaeological sensitivity of an area include a thorough review of literature (mainstream literature, grey literature, pre-existing archaeological maps etc.), archival documents (such as historic maps), as well as the performing of specialist assessments (e.g. geomorphologic and remote sensing analyses) coupled with site survey, core sampling, geophysical survey, and pit tests (Malnati 2005).

Noticeably, AIA principles and requirements have been formulated essentially for application on land and their implementation in aquatic environment requires adjustments and modifications to adapt them to an entirely different ecologic situation (Fozzati 2009; Stefanile 2010). However, much of the desk base study approach remains the same and even specialist (both field or desk) analyses to be undertaken do not differ much in principle – rather in methods – from the ones applied on land.

Based on this, the first stage of the PIF AIA was to assess the sensitivity of the case study area by acquiring pertinent information and datasets. Desk based research thus consisted of review of ancient sources, retrieval of archive datasets – including the analysis of historic maps and medieval and post-medieval documents – and gathering of relevant literature (mainly academic publications, grey literature and archaeological fieldwork reports). Specialist desktop studies concentrated on geomorphologic and palaeo-environmental analyses as well as remote sensing survey.

3.1 Desk based research: ancient and historical sources

A. Pellegrini

Ancient literary sources provided very little elements useful to understand the evolution of this territory in the past. It is worth mentioning that before the medieval period a real lagoon did not exist here; indeed, the use of the term '*laguna*' (lagoon) is not used in any document source prior to the 11th-12th centuries (Dorigo 1995). Strabo [*Geographica* 5, 212], at the beginning of the 1st century AD, describes this area as cultivated land (*agros campestres*); in reality, it was probably a wet land (*stagna inrigua aestibus marinis*) periodically flooded by high tides and crossed by the river *Meduacus*, as described in Livius [*Ab urbe condita* X, 2] about the same time.

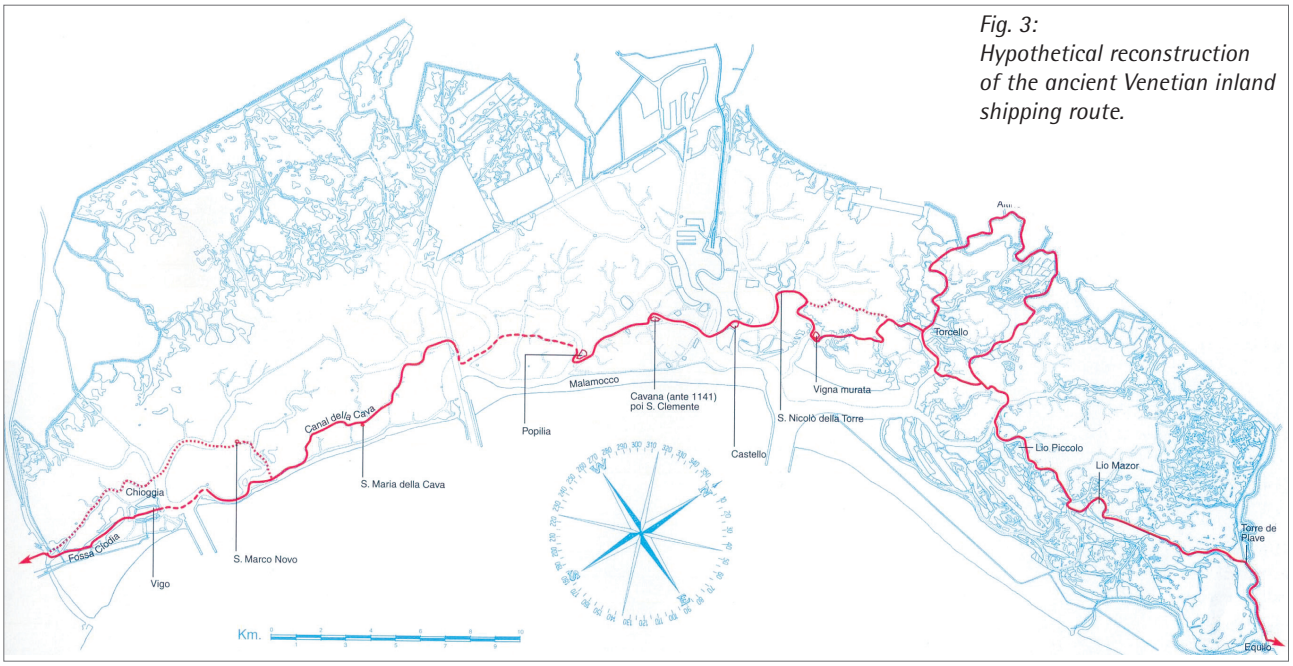

Fig. 3: Hypothetical reconstruction of the ancient Venetian inland shipping route.

Some literary evidences of an inland shipping route running across this area exist (Fig. 3): between the Roman Imperial Age and Late Antiquity such route was probably used by small boats navigating through natural and artificial waterways. A port was located at *Popilia* (modern Poveglia), an island near Malamocco (*Metamaucus* in the ancient sources) (Dorigo 1994). Livius mentions flat-bottomed boats used in the shallows bodies of water (*fluviatiles naves, ad superanda vada stagnorum apte planis alveis fabricatas*) (Dorigo 1995, 139).

Both unpublished and published medieval documents, held at the State Archive of Venice, were analysed as part of the historic and archival research. Only a few documents dating before the 14th century AD were available; moreover, most of the documents consisted in brief and generic descriptions of the overall area, thus making virtually impossible to identify information on historical buildings or roads located in the target area.

A considerable amount of data about the Lagoon were extracted by the documents produced by the Ministers that were in charge of Venetian waters management starting from the 13th century: the *Magistratura dei Savi alle Acque* (Magistracy of the Ministers of the Waterways), established in 1501, represents a main source of information thanks to the literary descriptions and the maps of the lagoon environment it produced. Together with these, other reports were available, such as the technical reports – and the attached drawings – produced by the waterways experts (*periti*) and the documentation related to the *incanti*, i.e. construction or refurbishment works over lagoon structures and infrastructures, the execution of which was assigned through public tender, or *incanto* in Venetian.

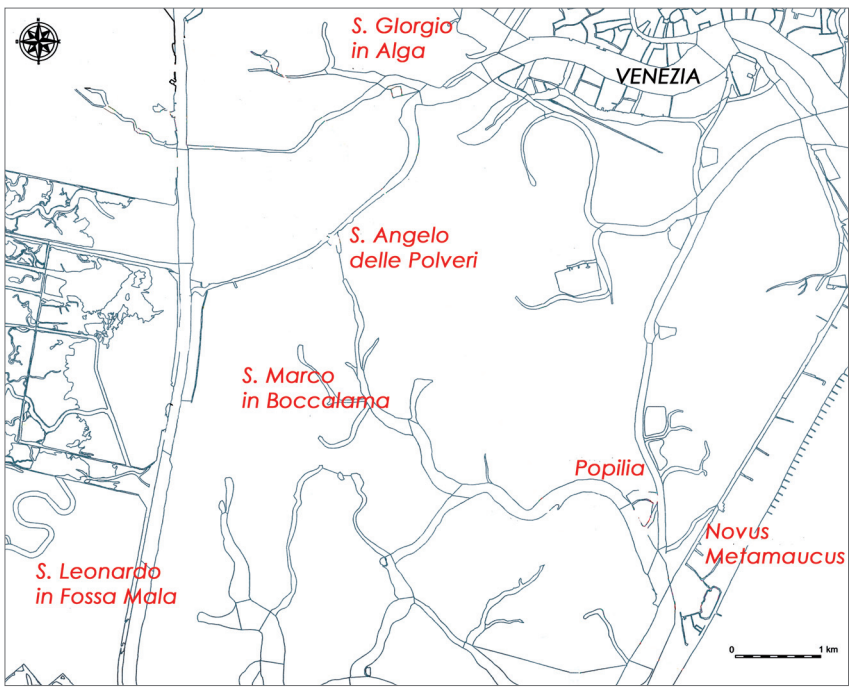

Fig. 4: Approximate location of some of the ancient religious centres mentioned in the historical sources.

These documents bring forth the evidence of an important settlement centre located around Fusina, characterised by the presence of several religious centres (Fig. 4), namely the three monasteries of *San Leone in Bucca Fluminis, of Santi Ilario e Benedetto* and *Sant' Onofrio* (Fersuoch 1995). Fusina, seat of production activities such

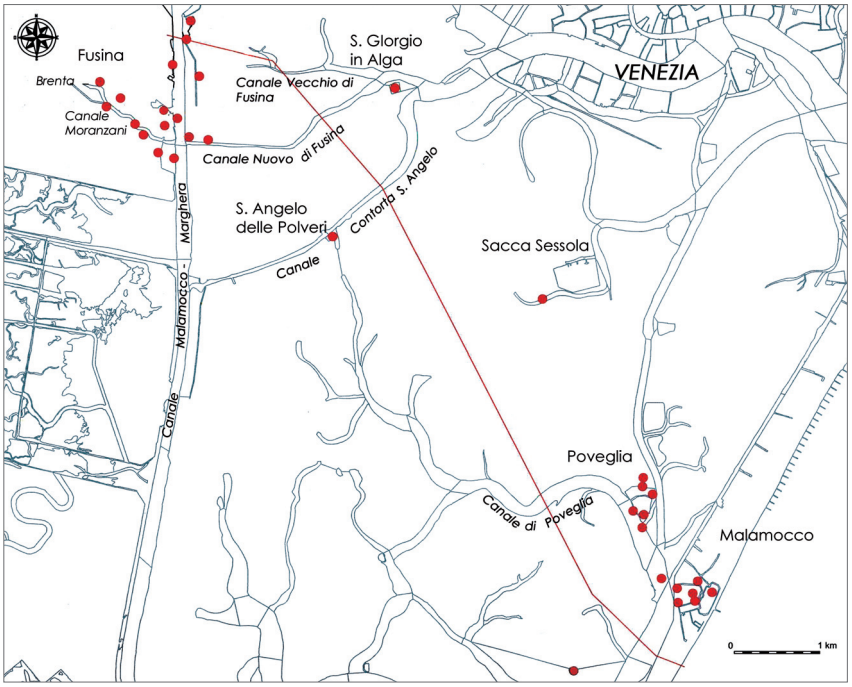

Fig. 5: Distribution map of the archaeological sites identified within the case study area overlaid on the Regional Technical Chart (Region Veneto, scale 1:10.000).

as wool scouring and drinking water storage, was set along the main route between Venice and the mainland territories of Padua and Vicenza. Traces of some canals that in different chronological periods served the transport between Fusina and Venice can be identified in historical maps and documents.

Other important residential centres were located on the islands set along the route of the pipeline. The islands of *San Leonardo in Fossa Mala*, attested from 1156 (Fersuoch 1995), and *San Marco in Bocca Lama*, attested from 1213 (Fozzati 2003; D'Agostino – Medas 2006), were located near the current mainland, along the course of the ancient *Meduacus* river (modern Brenta): both were already abandoned in the late Middle Ages and completely submerged by waters soon after (Fig. 4). The island of *San Giorgio in Alga,* where in the 11th century the Benedictine monks founded a monastery, is the first island encountered along the New Canal of Fusina when starting from the current shore north of Fusina. The island of *Sant'Angelo della Polvere* is located along the canal with the same name, which can be encountered on the right side when travelling along the pipeline route towards Malamocco. The island was the site of a Benedictine monastery, founded in Byzantine period (1060), as military outpost and later (1555) converted to a factory for gun powder.

Closer to Malamocco, Poveglia Island is set at the crossing of the Poveglia Canal and the *Canale di Santo Spirito* (Holy Spirit Canal): it was almost certainly a station (*statio*) along the internal route connecting the coastal town of Chioggia to Equino lying behind the shores existing in the Roman Imperial period, set on an ancient branch of the *Meduacus* River.

Archival documents show how the Malamocco coastline on Lido Island (where the other end of the pipeline route is located) developed through continuous manmade transformations of the area previously occupied by marshes, shoals and waters over dry land: current Malamocco (in the past called *Novus Metamaucus*, i.e. New Metamaucus) was the main settlement in the area starting from the 12th century. There is no archaeological evidence, instead, of the precise location of the ancient Malamocco, or Metamaucus vetus (Old Metamaucus), cited by ancient sources as the seat of the Venetian Duchy from 742 to 811 AD and disappeared apparently due to erosion caused by currents or a seastorm, or a combination of the two.

3.2 Desk based research: archaeological sources

A. Pellegrini

Desk based research incorporated the gathering and analysis of published archaeological literature focused on the central and south Lagoon of Venice, including conference proceedings and scientific journal articles, as well as data from unpublished resources, such as the archaeological excavation reports and site identification reports held at the Superintendency archive. Helpful information was also acquired from a dataset completed by a local historian, E. Canal, in 1995 (Canal 2013)[4] in the form of paper pro-forma; these data are now partially included in the comprehensive 'Chart of Venetian Lagoon Archaeological Sites', the publication of which is still in progress (Fozzati 2009).

The outcomes of this research were then digitally plotted to create an overall map of the case study area along the pipeline track that included known and (partially) investigated archaeological sites (Fig. 5).

In observing the distribution on this map of the numerous identified sites, the historical relevance of the northern part of our case study area became evident. The area surrounding Fusina boasts – both on the mainland side and on the lagoon side – a series of extremely significant archaeological evidences identified during the repeated archaeological surveys along the Malamocco-Marghera Canal and other canals of the area, surveys undertaken both as part of regular and extraordinary civil maintenance work (Fozzati et al. 1998) and for the purpose of determining the 'state of health' of sites located in environmentally hazardous areas (Carlon et al. 2003). Overall,

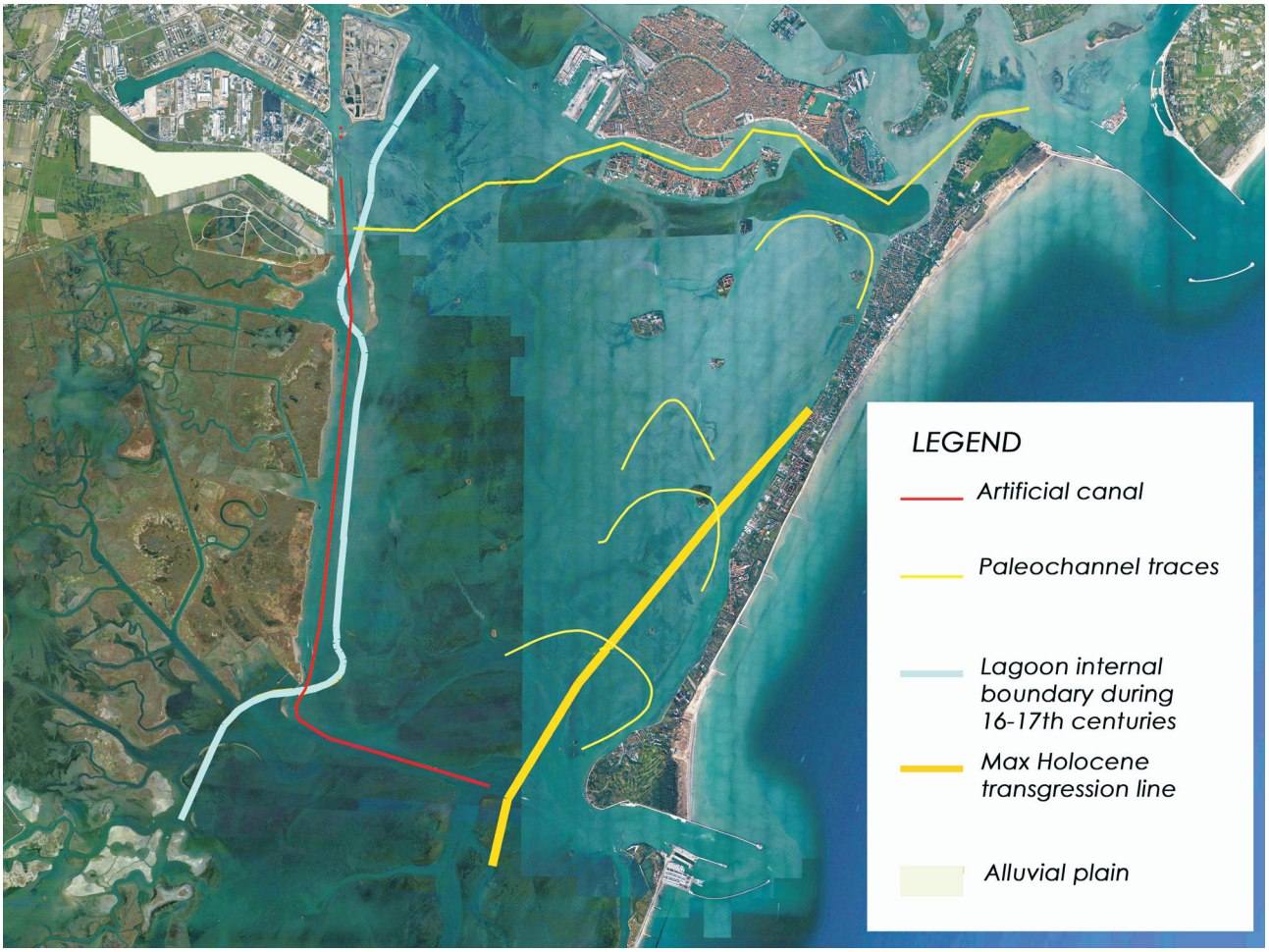

Fig. 6: Schematic reconstruction of the main geomorphologic elements identified in the case study area.

in the area between the Malamocco-Marghera Canal, the Moranzani Canal, the Islands of *San Giorgio in Alga* and *Sant' Angelo della Polvere*, a total 19 sites – for the most part dating from medieval to post-medieval ages – have been discovered since the '70s. Some of them embody the remains of medieval/post-medieval structures or buildings, often associated with Roman findings, testimony to the practise of structural reuse in the Middle Ages.

In the central part of the case study area, between the Contorta Sant' Angelo Canal and Poveglia Canal, little evidence of archaeological sites was found, but many anomalies (not yet verified by excavations) have been identified by surveys conducted over the last years, especially close to Sacca Sessola Island.

In the south part of the pipeline route, around Poveglia Island, the map showed a concentration of archaeological sites characterised by the presence of Roman artefacts, thus strengthening the theory that Poveglia was a station of the inland shipping route used since the Late Roman period.

Finally, scientific literature (Fozzati – Pizzinato 2009) and excavation reports highlighted several sites (14) located in the south part of the case study area, between Poveglia and the Malamocco-Alberoni coastline, for the most part dating from the Middle Ages onward. Reported in front of the Malamocco inlet were also a large number of post-medieval wrecks (Fozzati 2009; Medas et al. 2010).

3.3 Specialist desktop studies: Geomorphologic study

M. Capulli

Geomorphologic studies contribute to the reconstruction of the ancient natural environment in order to define its potential for settlement in antiquity. The study of the landforms and their evolution is fundamental to evaluate such potential and for a better understanding of the settlement dynamics of an area in the past. Based on geomorphologic analysis, predictive models can then be argued to define the archaeological sensitivity associated to the place.

The geomorphologic desk based research undertaken for the present AIA included the examination of a variety of data including palaeoclimatic and oceanographic studies, geologic reports (held at the Superintendency Archive) and the Geomorphologic Map of the Venice Region.

The study has emphasised that there are two main elements to take into account when investigating human settlement in this area: the

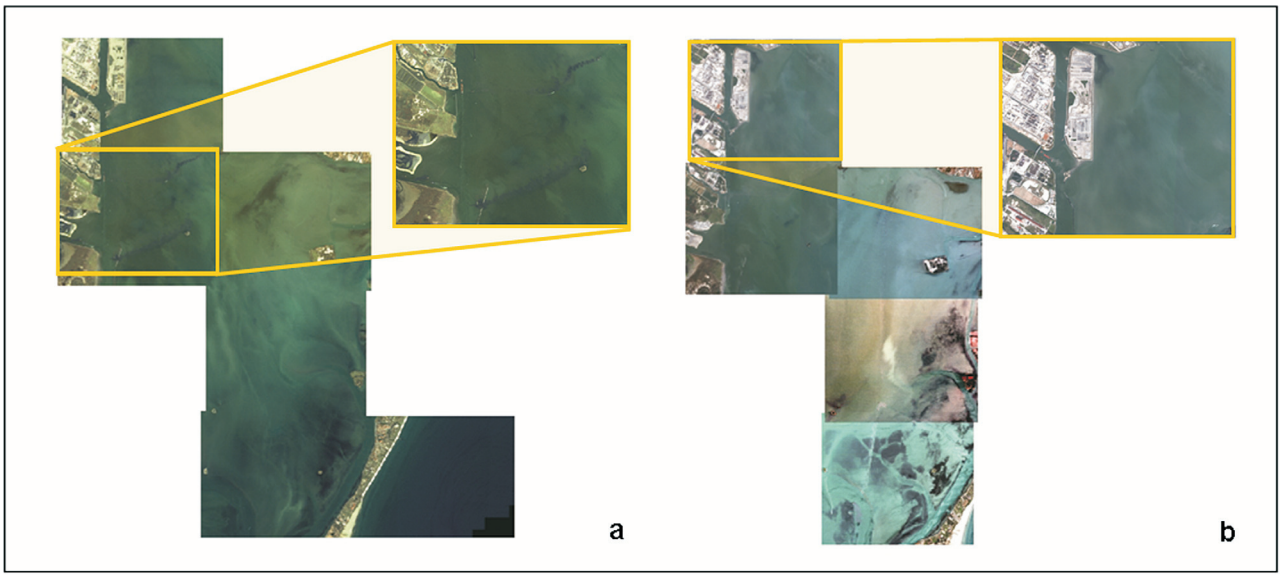

Fig. 7: Satellite scenes available to the project: 7a) One of the Ikonos 2001 scenes in True Colour – RGB of the 3-2-1 bands –; 7b) one of the Quickbird scenes in True Colour.

ancient coastline and the presence of palaeochannels.

The outcomes of coring activities undertaken in the past in the area of Fusina, near the Islands of San Clemente and Poveglia, and in the Malamocco area, confirmed that the lagoon environment formed over an extended continental area and its origin can be mainly ascribed to the Brenta River system. Specifically, proceeding across our case study area from northwest (mainland) to southeast (Adriatic Sea coast), several elements concur to show the presence of an active palaeochannel in Fusina, the run of which is still recognisable through bump formations in this area. In the San Clemente and Poveglia areas, coring samples highlighted the presence of continental deposits ascribable to palaeochannels that later on, after the marine transgression into the lagoon, became intra-lagoon canals. The Malamocco area is characterised by a coast environment, formed in recent epochs, mainly due to anthropogenic intervention. This coastline, in fact, did not have in the past the same physical continuity it shows nowadays, as the current extension was reached – among other phenomena – through reclamation activities, as evidenced by the archival documents and historical maps showing how this part of the lagoon formed after the 16th century, while previously the coastline was placed more outward, toward the Adriatic Sea (**Fig. 6**).

In the area between the Islands of Poveglia and Malamocco, the path of the Palaeo-Brenta river has been identified (Furlanetto 2004): the river crossed the Lagoon and flowed into the sea through numerous branches, of which one pointing to the north of Poveglia (Ca' Bianca), while another reached the Alberoni area. Along these geomorphologic elements, archaeological sites or anthropogenic settlement evidences have been identified in the past, especially near the coastline. The identification of this coastal area as a potential outlet of the old Brenta River – a major entry point to the Po plain in pre-Roman and Roman periods – translated in assigning it a high archaeological sensitivity due to the high probability for discovery of new archaeological sites.

3.4 Specialist desktop studies: Remote sensing

A. Traviglia

Remote sensing[5] is being increasingly adopted, and often required, as critical component of the suite of research methodologies normally employed for assessing the archaeological 'potential' of a planned development area. Thus, its role has evolved from being a supplementary source of information limited to the domain of academic archaeological research to being a key knowledge base used by professionals in support of development planning, infrastructure construction etc.

A standard procedure in land AIAs, remote sensing is also progressively being used in the analysis of coastal and shallow aquatic/marine (lagoon or tidal) environments as its water penetration capabilities have long proved suitable for remote detection of underwater archaeological features (Barto 1981). Depth limitation, water reflective properties and water turbidity are only partially limiting the discovery opportunities its use can provide and the advantages of its application over shallow waters in favourable circumstances are manifest. Since the middle of the 2000, remote sensing checks have been consistently included in the AIAs requested by the Superintendency for the Archaeological Heritage of Veneto/NAUSICAA to developers prior to the commencement of infrastructural works, even when such works were located in lagoon or coastal areas. The AIA realised

Fig. 8: MIVIS data: a 1998 scene in False Colour visualisation.

The satellite coverage included one 2001 and one 2004 GeoEye IKONOS scenes as well as one 2003 Digital-Globe Quickbird scene (Fig. 7a-b), very high resolution data provided in the pan-sharpened format (respectively 1m and 0.7m of ground resolution) and including RGB bands coupled with Near Infrared bands (spectral ranges respectively 450-890 nm and 450-880 nm).

Acquired Hyperspectral data had been recorded by airborne sensor Daedalus AA5000 MIVIS (Multispectral Infrared and Visible Imaging Spectrometer), an imaging system that operates in the wide range of wavelengths from visible to Thermal–IR regions of the spectrum, with a high spectral resolution and elevated number of channels (102). The ground resolution of these data, which depends upon the flying altitude, was of around 3m. While the scenes were quite well defined, the light reflection over the lagoon body of water did not allow for a good near water surface penetration in sections of the images and their use was limited to only parts of the target area (Fig. 8).

for the PIF had therefore to incorporate a remote sensing examination of the case study area.

Limited to the initial part of the route of the planned pipeline – the first 10 km set in shallow waters – remote sensing analysis was undertaken along its track and in a buffer zone across both sides of it, for a width of 50 m each side, with the aim of identifying in the imagery traces and anomalies that could be related to the presence of archaeological underwater structures or, more generally, remains. The depth of the lagoon water body in the target swathe was no more than 2.50-2.80 m, making the area highly suitable for analysis through remote investigation.

Three different types of remote sensing images were acquired for the study of the target area: satellite multispectral imagery, airborne hyperspectral data and historical and modern aerial photographs.

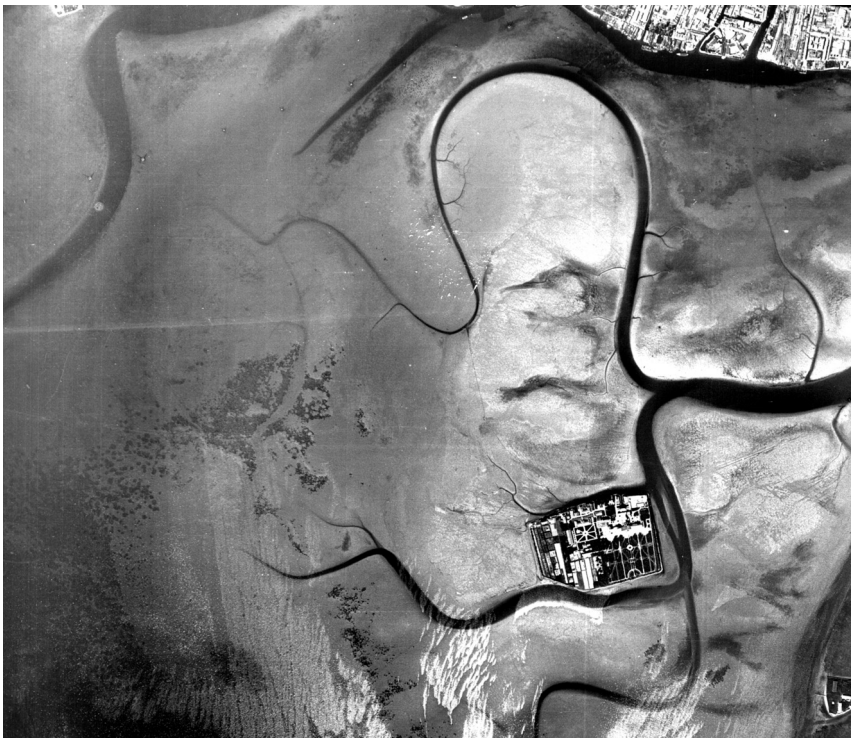

Fig. 9: Historic photograph (1955) of the Lagoon emphasising currently invisible barene (shoals) and showing no longer mapped canals.

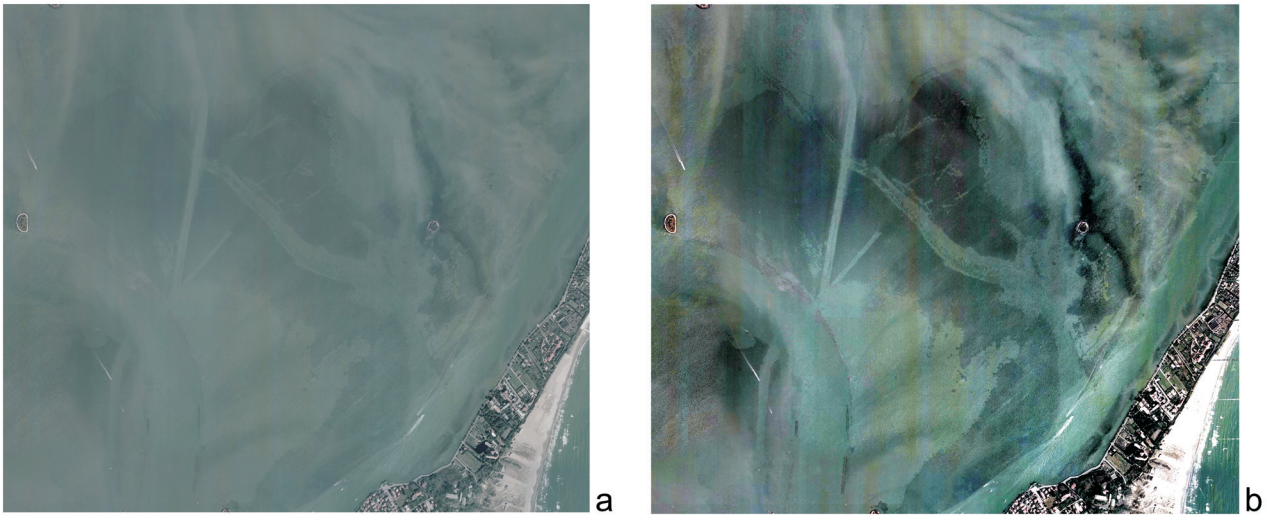

Fig. 10: High resolution images of the Lagoon. 10a) original scene; 10b) decorrelated image. Decorrelation stretch enhances subtle colour differences.

Also available to the study were a series of aerial photographs, including both historic and modern coverages. Particularly relevant to the goals of the assessment were a number of shots dating 1955, which represent an extremely interesting document of the *status quo* of the lagoon at that period: favourable light, environmental and seasonal conditions (and probably a much reduced presence of polluting agents at the time in the lagoon waters) ensured that the photographs, sharp and well contrasted, showed – with an impressive degree of accuracy – natural and manmade canals and side canals, several of which are no longer mapped on current Lagoon map or no longer visible in modern photographs (Fig. 9).

Orthophotographs available for the project included a colour scene (2006) and a B/W scene (2002). Both the coverages were acquired in high resolution; however, some of the images were characterised by spots of intense light reflection that could not be analysed.

From a methodological point of view, the remote sensing analysis was organised in two main steps: a stage of selection and pre-processing of the images followed by image analysis and feature recording.

Following a preliminary visual analysis on screen of all the imagery – with multispectral and hyperspectral images analysed both as single bands and as composites, in true and false colours, using dedicated software for image processing (ENVI 4.0) – basic emphasising techniques (such as linear, Gaussian, and equalisation stretches, filters, density slicing, and decorrelation stretch) were applied to all the images to heighten the presence of possible traces within the water body (Fig. 10).

More advanced image processing (such as Principal Component Analysis or PCA) was then applied to multi and hyperspectral data (Traviglia 2010) in order to extract information (such as the information recorded in the Infrared) that otherwise would not have been visible.

In the second stage of the study, the processed images were imported in a GIS where they were georeferenced (when needed) and examined following photo-interpretation criteria. The traces and anomalies recognised in the water body during this process were then recorded by digitising them on screen. During the digitisation process information was encapsulated within each trace; metadata recorded in this process were, for example, the degree of visibility of the feature, its archaeological reliability, or the code of the image the trace had been detected on. The features were then contrasted with other environmental and historical datasets (like geomorphologic or historic maps) to provide correct interpretation to the identified traces. This process led to recognition and tagging of 87 features within the buffer zone along the planned pipe track: the mapped features included not only potential archaeological sites, for which a direct inspection was recommended, but also environmental features, such as sections of side canals, the nature of which makes them potentially relevant during a direct check survey, as, for example, dismissed old canals were seen to preserve, at their margins, ancient remains and structures better than other high traffic areas (Fig. 11).

A series of thematic maps were then generated to accommodate all the details needed to identify the location of the recognised features: two general maps (1:18000) were created to represent the overall examined area subdivided into North and South sectors, while 19 detail maps (1:2000) were produced to portrait in high detail the identified features and the context they laid in (Fig. 12 a-b).

The generated maps, together with the descriptive tables and accessory

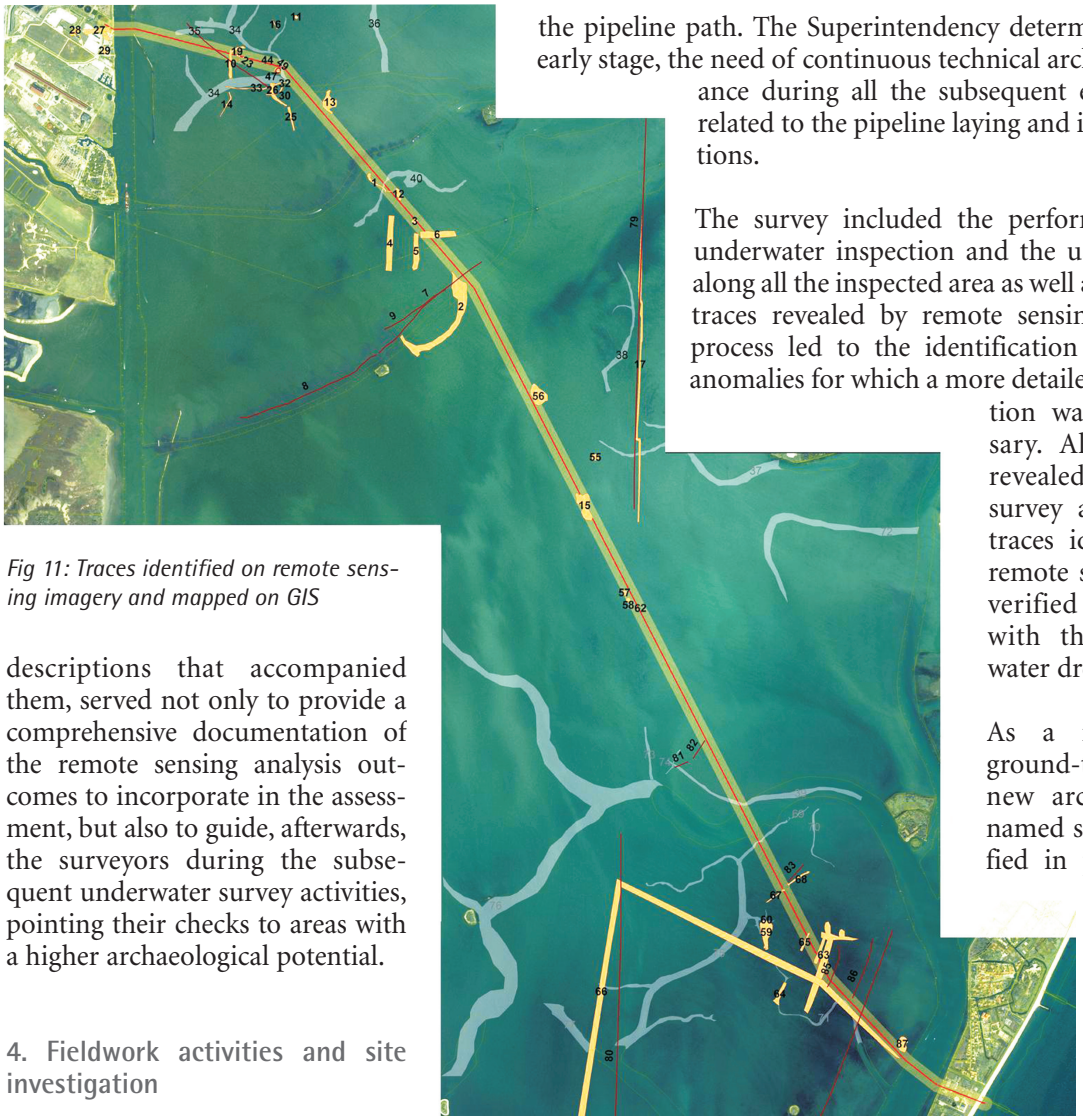

Fig 11: Traces identified on remote sensing imagery and mapped on GIS

descriptions that accompanied them, served not only to provide a comprehensive documentation of the remote sensing analysis outcomes to incorporate in the assessment, but also to guide, afterwards, the surveyors during the subsequent underwater survey activities, pointing their checks to areas with a higher archaeological potential.

4. Fieldwork activities and site investigation

M. Capulli – A. Pellegrini – R. Rizzotto

The collection, examination and combination of all the available datasets led to identify and define several areas of potential archaeological risk set along the pipeline track that were codified based on the risk level that could be encountered at their location. On the basis of this study, the Superintendency requested an underwater survey to be undertaken along the pipeline path. The Superintendency determined also, at that early stage, the need of continuous technical archaeological assistance during all the subsequent excavation phases related to the pipeline laying and installation operations.

The survey included the performing of a visual underwater inspection and the use of iron probes along all the inspected area as well as the check of the traces revealed by remote sensing (Fig. 13). This process led to the identification of a number of anomalies for which a more detailed direct examination was deemed necessary. All the anomalies revealed by the ground survey and some of the traces identified through remote sensing were thus verified by excavation with the support of a water dredge.

As a result of these ground-truth activities, a new archaeological site, named site 'A', was identified in proximity of the pipeline path. The site, consisting of a structure occupying an area of about 5.5 × 15 m, was located in the north part of project area, near the *Canale Vecchio di Fusina* (Old Fusina Canal) about 1500 m north-east of Fusina, 750 m east of the Malamocco-Marghera Canal and 1700 west of the Island of San Giorgio in Alga (Fig. 14).

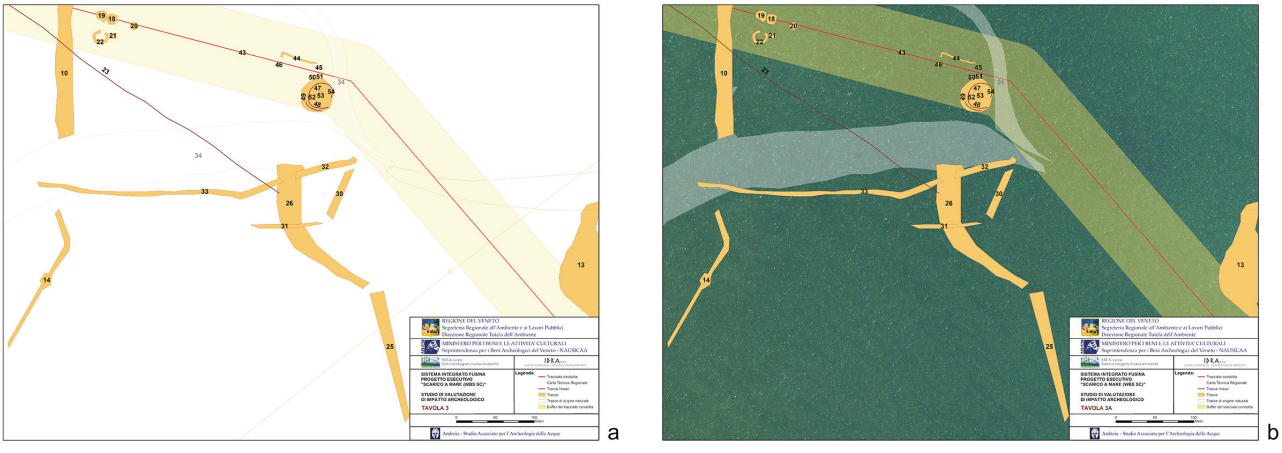

Fig. 12: One of the generated 1:2000 detail maps showing a sector of the pipeline track. 12a) a map as 'pure cartographic' product; 12b) same map using a satellite imagery in the background.

The archaeological complex was made up of several wooden poles, cut stones and fictile fragments, such as ceramic and roof tiles (*imbrices* and *tegulae*). During the initial stages of the excavation, the site did not appear in any way dissimilar from other quite common archaeological contexts identifiable in the Venetian Lagoon, characterised by wooden structures, made of poles and beams fixed in the ground, associated with stratified layers formed by landfill, backfilling and artefact fragments (mainly bricks and pots). Bad conservation state or limited investigations – consisting only of sampling and partial excavations – normally prevent or limit the possibility of identifying the nature and typology of such sites; however, for the most part, sites with analogous characteristics, well known especially in the north part of the Lagoon (Capulli et al. 2008), have been interpreted as reclamation works, swampy land consolidations, boundary demarcations, hydraulic works such as

Fig. 13: Ground-truth activities in the Lagoon.

canal levees and embankments, and building foundations draining and insulation (Fozzati – Toniolo 1998). The completion of the preliminary excavations clarified that this site did not belong to the same typology of structures.

The excavation uncovered about 80 wooden poles still vertically embedded, each with an average height of 30-40 cm along the west side of the site and 130 cm along the east side. About 50 of them were positioned along the south-east margin of the site, at close range, embedded at a depth ranging between -150 and -200 cm on the mean sea level[6] and diameters ranging from 4 to 12 cm. The poles seem to be arranged without any apparent order. In the north side of the site there are also numerous poles with remarkable diameters, embedded at variable depths. The remaining poles are located along the central and east part of the site, again embedded without an apparent order and mainly having a diameter of 30-40 cm, placed at deeper, varying levels. Large stones (probably trachyte), showing roller marks, were identified in the central and east section of the site. In some cases these stones were arranged close to one another, kept together through a sort of joint; over them was a layer of slabs of the same kind of stone. Two other large white stones (probably sandstone), measuring 220 × 115 × 15 cm and 205 × 80 × 15 cm, pulled together to form a "T" shaped structure, were identified in the central area of the site. A trench excavated next

Fig. 14: The site 'A' area overlaid on the Lagoon Chart, scale 1:25.000. (buffer); the yellow mark indicates the continuation of the pipeline in the Adriatic Sea (not investigated as part of the project presented here).

to them in the median area of the site revealed that the white stones were laid over a layer of trachyte stones, similar to the ones of the upper levels, arranged in three rows; under one of these rows, a wooden pole was identified. Artefacts associated with this structure (notably *amphorae* dating to 7th-9th century AD) pointed to a post-classic chronological horizon: it was probably older material reused as filler in a later construction, a common technique in Late Antiquity and Early Middle Ages. Radiometric analyses undertaken on wooden samples confirmed that the chronologic horizon of the site should be placed between the last quarter of the 8th and the last quarter of the 10th century AD[7].

Unfortunately, the investigation could not be completed in this phase of work, as this preliminary excavation was undertaken with only the goals of defining the extent of the site and determine its consistency and approximate chronology, leaving to a later phase an in-depth analysis. Therefore at the current stage of the research only limited data are available about the site.

5. Site interpretation

M. Capulli – A. Pellegrini – R. Rizzotto – A. Traviglia

Material culture found at the location and analysis of the structures did not provide any indication relative to the nature of the site. Consultation of the georeferenced historical maps suggested that a vast area of *barene* was located in the approximate position of the site as well as in the area in front of modern Fusina and along its coast, north and south of it, in a period between the 16th and 18th centuries. Specifically, the 'site A' area appears located in proximity of an ancient canal – differently named depending on the historical maps –, which can be identified as the west continuation of the Old Canal of Fusina, in proximity of the modern coast line. Clearly, as the majority of these maps were not drawn up

Fig. 15: Stone structures identified at site A.

with topographic methods, their georeferencing is affected by a margin of error that can be estimated between 300 to 600 m according to maps. For this reason, the graphic expedient of including a 600 m circular buffer around the 'site A' location was introduced, so that the buffer area was considered as the potential overlap area between the actual site A location and the same spot in the historic maps. (Fig 15)

Although the landscape depicted in the historic maps may not reflect the environmental situation existing centuries before the drafting of such maps, i.e. at the time of the approximate tentative chronology for site A, they show a landscape (or, rather, a waterscape) quite different from the current one, with easily mappable (and, therefore, visible at the time) *barene* protruding from the coastline, in physical, uninterrupted contact with it, suggesting the possibility that what nowadays is a lagoon area and was a *barena* in the 16th or 17th century could have been an area of dry land just a few centuries before the maps drafting. The map of Angelo Cortivo[8] (dated to 1521) records, for example, an interesting detail: the map places the 'site A' buffer in a *barena* in proximity of the Old Canal of Fusina and a small object, which could be tentatively interpreted as a construction, is recorded just outside the space occupied by the buffer. The max 300-400 m. margin of error in the georeferencing of that specific map might mean a higher proximity and overlap between the represented potential building and the identified archaeological area.

Based on the outcomes of the limited excavation, at first the presence of stone blocks had led to the hypothesis that a floor had been uncovered; however, the trachytes blocks positioned not only under the sandstone blocks but also above them, all *in situ*, led to re-

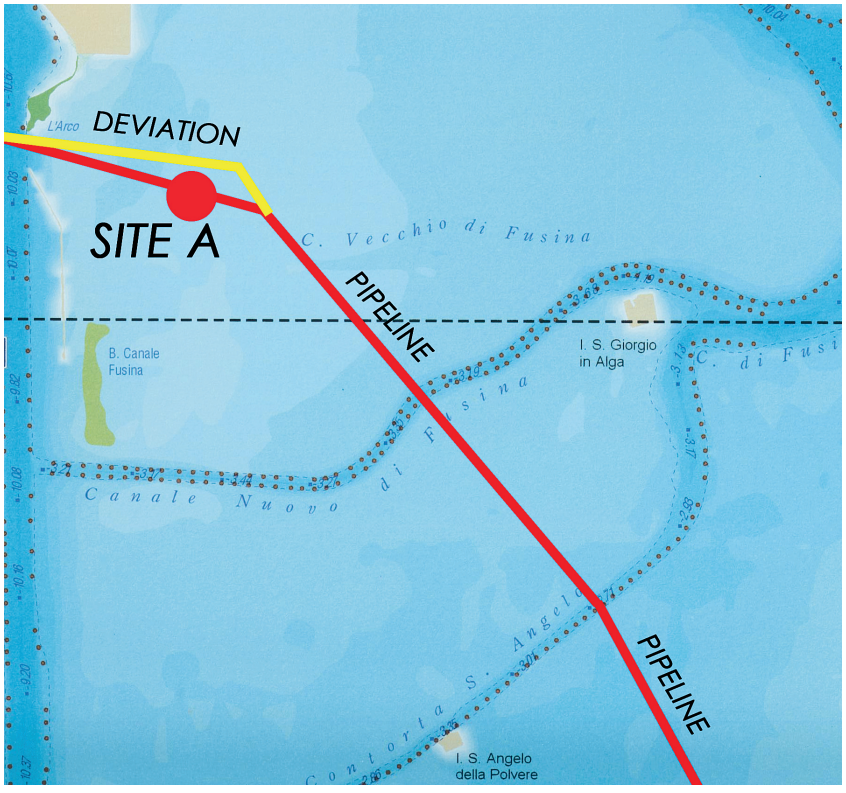

Fig. 16: The pipeline's original track and its deviation.

viewing this interpretation. Later, the site has been provisionally interpreted as an ancient wharf or pier; this would explain the presence of large wooden poles on the side of the structure realised in stone blocks. In any case, some structural features, the information extracted by the historical maps, and the location of the site in an area that is described by historical sources as the Brenta River mouth – noticeably seat of numerous religious centres – are clear indication of the importance of the site. The building complexity and the solidity of the construction mark it as a durable, continually inhabited (or used) structure of primary importance; this suggests that it was built by public financing and for public use rather than private. Further analyses might suggest that it could even have been a building of some sort; it cannot be excluded that it could be the same building (possibly in a later refurbishment) still standing and represented on the 1521 map.

6. Conclusions

M. Capulli – A. Pellegrini – A. Traviglia – R. Rizzotto

An important end product of the PIF AIA was the decision of the PIF works management team (in consultation with NAUSICAA) to create a by-pass along the original pipe trajectory, an exclusion zone overlapped to the site A area, in order to avoid or mitigate any future adverse effect to the archaeological site (**Fig. 16**).

Project relocation (full or partial) is conventionally a recommended safeguard procedure in AIA (when feasible) to manage unavoidable adverse impacts on archaeological resources. Avoidance is clearly the preferred and preferable archaeological heritage management measure as it ensures full *in situ* protection of the archaeological site for future investigation. Additionally, it is frequently the least expensive measure to implement. The same approach noticeably applies to both terrestrial and underwater environments and the decision of repositioning a section of the Fusina pipeline track, while not interfering significantly with the PIF's costs and management, allowed for the full preservation of the site that will be further studied in the time ahead.

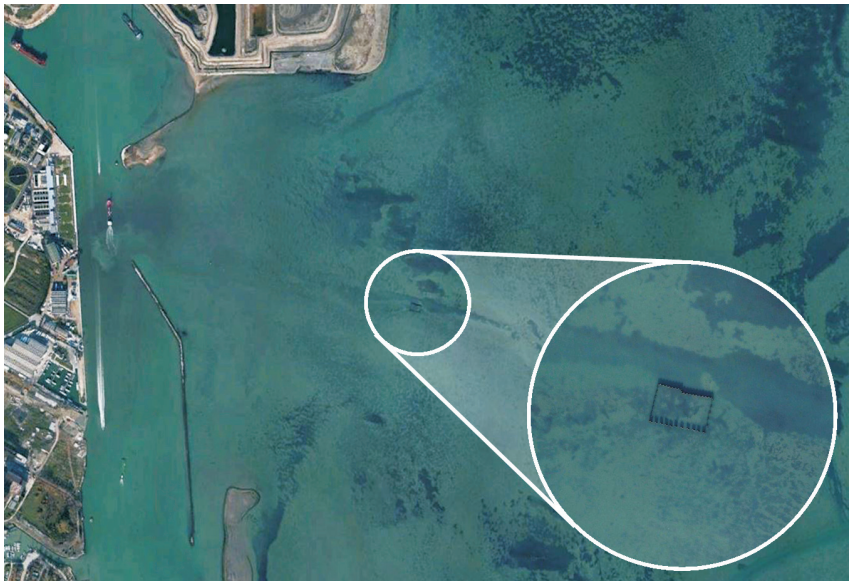

Fig. 17: The site A surrounded by sheet pile walls.

In addition, a mitigation strategy measure taken to reduce negative effects of the pipeline construction, operation and maintenance on the archaeological site was to surround it with sheet pile walls that would inhibit navigation on site, forbid site accessibility and guarantee site conservation (**Fig. 17**).

Regardless of the type of environment over which an archaeological assessment is conducted, approaches that accommodate cultural heritage safeguard in the planning or initial phases of works and developments allow not only for better management of the endangered heritage, but also for more efficient, fast and less expensive solutions integrated at an early stage in the project, thus minimising encumbrances for developers and ensure the timely completion of the project.

Acknowledgements

The archival research (historic maps) was realised by Dr Patrizia Bortolozzo (State Archive of Venice); the geomorphologic study was undertaken by Dr Gianfranco Valle. We take here the opportunity to thank them for their precious collaboration. We would like to thank also Dr Livia Senic for her support in the study of the archaeological sources.

Notes

[1] The impact assessment was performed by the authors on behalf of the society *Idra Lavori Subacquei.*

[2] The project was undertaken by the S.I.F.A. society, on behalf of the *Segreteria Regionale all'Ambiente e ai Lavori Pubblici-Direzione Regionale Tutela dell'Ambiente* (Regional Secretariat for Environment and Public Works - Regional Directorship for Environmental Protection), *Veneto Region.*

[3] The study was undertaken under the scientific direction of the – back then – Director of NAUSICAA, dott. L. Fozzati.

[4] The dataset was realised by E. Canal for the *Servizio Informativo del Magistrato alle Acque - Consorzio Venezia Nuova* (Information Service of the Magistracy for Waters – New Venice Consortium) that curated the associated cartographic documentation.

[5] While in the domain of Underwater archaeology Remote sensing is mainly intended as the group of techniques used for underwater remote data gathering and survey, such as side-scan sonar or sub-bot-

tom profiler, in this instance the term is intended as the archaeological research methodology that uses aerial, radar and satellite imagery to pinpoint potential sites of interest on landscapes or waterscapes.

[6] In the Lagoon of Venice the measure of the tide level is done referring to the mareographic zero of the *Punta della Salute* (Venice). The mean sea level is at -23cm from this reference.

[7] Based on the results of the analysis of the wooden pole n. 80, the Beta Analytic Laboratory established that the probability that the sample can be dated between 863 and 978 A.D. is 90%.

[8] "*La gronda di terraferma nei pressi di Fusina con le isole prospicenti*". 1521, *Savi ed Esecutori alle Acque* (Ministers and Executors of the Waterways), Brenta, drawing. n. 1, Venice Archive State.

References

Barto Arnold, J. 1981: Remote sensing in underwater archaeology. International Journal of Nautical Archaeology 10, 51-62.

Bondesan, A. – Meneghel, M. (Eds.) 2004: Geomorfologia della Provincia di Venezia. Note illustrative della Carta geomorfologica della Provincia di Venezia (Padova).

Canal, E. 2013: Archeologia della laguna di Venezia. 1960-2010 (Verona).

Caniato, G. – Turri, E. – Zanetti, M. (Eds.) 1995: La laguna di Venezia (Verona).

Capulli, M. – Fozzati, L. – Lezziero, A. – Pellegrini, A. 2008: La dinamica insediativa della Laguna di Venezia: alcuni casi di studio della Laguna nord, in: Auriemma, R. – Snježana, K. (Eds.), Terre di mare – L'archeologia dei paesaggi costieri e le variazioni climatiche, Atti del Convegno Internazionale di Studi, Trieste 8-10 novembre 2007, 349-357.

Carlon, C. – Fozzati, L. – Marcomini, A. 2003: Un sistema di valutazione del rischio ambientale per i siti archeologici lagunari. Quaderni di scienza della conservazione 3, 133-144.

D'Agostino, M. – Medas, S. 2006: I relitti medievali di San Marco in Boccalama. Campagna di scavo e rilievo 2001. NAVIS 3, 59-67.

Direzione Progetto Venezia 2012: Il Progetto Integrato Fusina e l'utilizzo della Fitodepurazione, Regione Veneto available at: http://repository.regione.veneto.it/public/d5b0eba7ec88cea6e874e58d620683b1.php?lang=it&dl=true [last access 10-07-2015].

Dorigo, W. 1994: Per flumina et fossas. La navigazione endolitoranea fra Chioggia e Aquileia in età romana e medievale. Aquileia Nostra 65.

Dorigo, W. 1995: Fra il dolce e il salso: origini e sviluppi della civiltà lagunare, in: Caniato, G Turri, E. Zanetti, M. (Eds.), La laguna di Venezia (Verona) 137-191.

Fersuoch, L. 1995: San Leonardo in Fossa Mala e altre fondazioni medievali lagunari (Venezia).

Fozzati, L. (Ed.) 2003: La galea di San Mar co in Bocca Lama. Valutazioni scientifiche per un progetto di recupero. Archeologia delle Acque, Saggi 1 (Venezia).

Fozzati, L. 2009: Archeologia subacquea e archeologia preventiva, in: Nava 2009, 193-205.

Fozzati, L. – Arenoso Callipo, C. – D'Agostino, M. 1998: Archeologia delle Acque nella laguna di Venezia, in: Volpe, G. (Ed.), Archeologia subacquea. Come opera l'archeologo sott'acqua. Storia delle acque (Firenze) 183-216.

Fozzati, L. – Pizzinato, C. 2009 (Eds.): Malamocco. Studi di archeologia lagunare e navale (Venezia).

Fozzati, L. – Toniolo, A. 1998. Argini-strade nella laguna di Venezia, in: Pesavento Mattioli, S. (Ed.), Bonifiche e drenaggi con anfore in epoca romana: aspetti tecnici e topografici, Atti del seminario di studi, Padova, 1995 (Modena) 197-208.

Fozzati, L. – Asta, A. 2014: Archeologia a Venezia (Venezia).

Furlanetto, P. 2004: Le antiche direttrici fluviali e lagunari dell'area centro sud in epoca antica: una proposta di lettura archeologica, in: Bondesan – Meneghel 2004, 294-298.

Galasso, G. 2010: Archeologia preventiva; la valutazione del rischio archeologico, in: Serra D'Agostino 2010,10-22.

Malnati, L. 2005: La verifica preventiva dell'interesse archeologico. Aedon – Rivista di arti e diritto on line 3 (Bologna).

Medas, S. D'Agostino, M. Caniato, G. (Eds.) 2010: NAVIS 4. Archeologia, Storia, Etnologia Navale. Atti del I Convegno Nazionale, Cesenatico, Museo della Marineria, 4-5 aprile 2008 (Bari).

Mozzi, P. – Furlanetto, P. 2004: La geomorfologia tra Naviglio Brenta e Bacchiglione, in: Bondesan – Meneghel 2004, 269-298.

Nava, M.L. (Ed.) 2009: Archeologia Preventiva, Esperienze a confronto (Venosa, PZ).

Serra, M. – D'Agostino, S. (Eds.): Archeologia preventiva; manuale per gli operatori (Albanella, SA).

Stefanile, M. 2010: Archeologia preventiva e archeologia subacquea; la valutazione preventiva di interesse archeologico in ambiente subacqueo, in: Serra – D'Agostino 2010, 23-25.

Traviglia, A. – Cottica, D. 2010: Remote Sensing applications and archaeological research in the Northern Lagoon of Venice: the case of the lost settlement of Constanciacus. Journal of Archaeological Science 38.9, 2040-2051.

Credits of figures

Figs. 1, 13: Massimo Capulli; Figs. 2, 4, 5, 14-16: Alessandro Pellegrini; Fig. 3: after W. Dorigo 1995: 147; Fig. 6: Image courtesy of G. Valle, re-elaborated data from Mozzi – Furlanetto 2004; Figs. 7-12, 17: Arianna Traviglia.

Addresses

Massimo Capulli
University of Udine
Italy
massimo.capulli@uniud.it

Alessandro Pellegrini
Andreia Studio Associato
Italy
studio@andreia.it

Arianna Traviglia
University of Sydney, Australia
University Ca' Foscari of Venice, Italy
traviglia@unive.it

Riccardo Rizzotto
Andreia Studio Associato
Italy
studio@andreia.it

Postal address

(all four authors)
Via Roma 121
I-31056 Roncade (Treviso)
Italy