Digital Reunification and Documentation of Dispersed Artifacts from Thonis-Heracleion: A Metadata Case Study of the Amun Gereb Naos and a Framework for Future Storytelling and Virtual Interpretation

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Abstract

Thonis-Heracleion, a submerged Egyptian port city of major religious and commercial significance, presents unique challenges for archaeological interpretation due to the wide dispersion of its recovered artifacts across museums, warehouses, and storage facilities. This study addresses this problem by proposing an interdisciplinary methodological framework that integrates advanced digital documentation, metadata standards, and narrative-driven storytelling to virtually reunify Amun Gereb Naos. The research applies this framework to selected case studies, with particular focus on the digital documentation and metadata structuring of the Amun-Gereb Naos. Using international standards such as Dublin Core and CIDOC-Conceptual Refrence Model (CRM), the study demonstrates how dispersed artifacts can be systematically recorded and semantically interlinked to restore contextual integrity. A framework for narrative and storytelling integration was developed, outlining how thematic stories—such as trade, ritual practice, and daily life—can be constructed from the documented artifacts. While this study does not implement these narratives in a full digital environment, it establishes the theoretical structure through which digital tools could eventually transform fragmented finds into coherent cultural narratives."The findings confirm the feasibility of digitally consolidating dispersed underwater heritage through accessible platforms, illustrated by the creation of the Digital Thonis-Heracleion prototype in Omeka.net. This research highlights both methodological strengths and limitations while outlining future directions in immersive visualization, AI-driven interpretation, and co-curated multi-vocal narratives. Ultimately, the study contributes a transferable model for sustainable digital reunification that advances archaeological scholarship, enhances public accessibility, and strengthens the ethical stewardship of submerged cultural heritage.

Keywords: Thonis-Heracleion, Amun Gereb, underwater culture heritage, virtual reunification, narrative storytelling, digital documentation.

1. Introduction

Thonis-Heracleion, an ancient Egyptian city located at the eastern mouth of the Canopic branch and now submerged, once played a pivotal role in religious, commercial, and cultural exchanges between Egypt and the wider Mediterranean world. **(Fig. 1)**

Excavations at Thonis-Heracleion have revealed a wealth of archaeological artifacts; however, these objects are currently dispersed

across various museums, storage facilities, and warehouses in Egypt. This dispersal complicates efforts to reconstruct the city's historical, religious, and socio-economic significance in a holistic manner. While significant findings from the site have been recorded in archaeological reports and monographs (Goddio and Clauss 2006), all the archaeological artifacts and material culture within the site are not displayed within one location, as they are dispersed within various museums, warehouses, and storage rooms. Moreover, there are no studies or projects that provide a comprehensive digital framework for the virtual reunification and interpretation of these dispersed artifacts as a cohesive cultural entity. Current research predominantly emphasizes isolated discoveries or particular archaeological settings, resulting in a deficiency of comprehensive approaches that merge digital documentation, interpretive frameworks, and narrative-driven methodologies. Addressing this gap is crucial for recovering the broader cultural memory of Thonis-Heracleion's early inhabitants and for advancing digital heritage practices in underwater archaeology.

The primary aim of this research is to digitally document the Naos of Amun Gereb, which mainly help to develop interpretive frameworks that integrate them into coherent narratives, thereby revealing the heritage of the site's early inhabitants. Additionally, this research will examine and critically assess the archaeological data to better understand the historical context of Thonis-Heracleion. This analysis entails evaluating the chosen artifacts not merely as standalone objects but within their wider cultural, religious, and socio-economic contexts. This research paper seeks to reconstruct crucial aspects of the site's history and offer insights into the lives and interactions of its earliest inhabitants, thereby enhancing the digital documentation with significant contextualization.

By digitally reassembling these scattered collections, the researcher proposes the idea of a virtual museum to restore both provenance and interpretive context, rendering the site's legacy more accessible and engaging. The goal is to make archaeological information accessible, collaborative, and interactive, moving beyond just storage to analyzing and sharing knowledge on underwater sites. Moreover, this enriched environment serves not only as an innovative platform for public engagement but also as a valuable resource for scholars seeking to apply advanced digital technologies to deepen understanding and promote the broader dissemination of Thonis-Heracleion's cultural heritage. The proposed framework is grounded in the CIDOC Conceptual Reference Model (CIDOC-CRM) and Dublin Core metadata standards, which were applied in the documentation of the Amun Gereb Naos as a case study to demonstrate how standardized metadata supports interoperability, provenance tracking, and long-term accessibility.

Fig. 1: Google earth map showing the location of Thonis-Heracleion

source:https://www.tumblr.com/britishmuseum/140328319652/thonis-heracleion

2. Resrach aim, significance and questions
2.1 Research aim and Significance

The main goal of this study is to provide an analytical and digital framework for the virtual reunification of archeological artifacts unearthed from the sunken site of Thonis-Heracleion that are now spread out over different museums, warehouses, and storage rooms. The study aims to provide a holistic framework that maintains archaeological integrity while enhancing interpretative and

instructional accessibility through the fusion of material culture analysis and narrative approaches. This research is important since it adds to both digital heritage practice and archaeological scholarship. Thonis- Heracleion is one of the most important cultural heritage sites within the Mediterranean, but its archeological artifacts are scattered throughout many different museums and storage facilities. This scattering makes it harder to understand the site as a whole and hides the cultural, ritual, and historical stories that are told through its artifacts. To address these issues, the research presents a digital reunion model that is appropriate for various contexts of fragmented heritage. This study advances the discussion on how digital technologies—when combined with rigorous archaeological analysis—can extend the life of artifacts beyond their physical limitations, foster collaborative research, and engage broader audiences. By doing this, this study not only adds to the visual recording and analysis of Thonis- Heracleion, but it also shows how useful it is to use digital heritage tools in archaeological research.

2.2 Resarch questions

This study is directed by the subsequent research questions:

- What methods can be employed to apply modern digital documentation and metadata standards (such as Dublin Core and CIDOC-CRM) to effectively reunify dispersed objects from Thonis-Heracleion while preserving archaeological integrity?
- How might narrative-driven storytelling techniques improve the comprehension and accessibility of dispersed artifacts and cultural material on digital platforms?
- What are the methodological consequences of incorporating digital documentation, heritage interpretation, and storytelling into an integrative framework for CH site?

3. The submerged archaeological site of Thonis- Heracleion

The submerged city of Thonis-Heracleion, located near Abu Quir Bay in Alexandria, Egypt, (**Fig. 1**) holds significant archaeological and historical importance as an ancient port that played a crucial role in maritime trade during antiquity. It was a pivotal ancient Egyptian port city, serving as the principal maritime gateway into the Nile Delta and the key point of entry for Greek and other foreign merchants before they could proceed inland to Naukratis (Robinson and Goddio, 2015). Acoustic seabed classification and sonar imagery have identified morphological features consistent with submerged urban remnants, including rocky outcrops and structural remains attributed to Thonis-Heracleion (Goddio, 2006) (Hamouda et al., 2015). The acoustic surveys delineated areas of high backscatter corresponding to archaeological remains and city borders, with estimated sizes of approximately 600 × 1000 meters for Heracleion and about 550 × 800 meters for East Canopus. These findings, supported by sediment analysis and geophysical data, provide valuable insights into the extent and submerged nature of these ancient cities, illustrating the importance of underwater geophysical techniques in archaeological exploration (Hamouda et al., 2015).

Topographical and archaeological surveys reveal that Heracleion had a structured town plan with a temple to the south, a vast port with basins to the north and east, and a central Grand Canal connecting the port area to a lake in the west. Additional channels linked the port to the river. (**Fig. 2**) (Goddio and Clauss 2006)
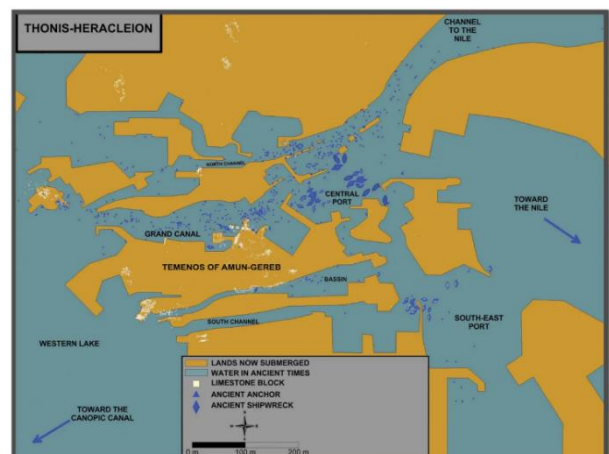

Fig. 2: The topography of the submerged city of Thonis-Heracleion, including its canals, harbor basins."; source; Map courtesy of Franck Goddio©Franck Goddio

Its significance has been confirmed by major underwater archaeological discoveries, most notably the unearthing in 2001 of a black granodiorite stele erected by Pharaoh Nectanebo I (c. 380 BC) in the temple of Amun-Gereb. **(Fig. 3)** This decree ordered that one-tenth of trade revenues—including gold, silver, and imported goods—be dedicated to the temple of Neith in Sais, underscoring both the economic and religious dimensions of maritime commerce (von Bomhard, 2015; Yoyotte, 2001) Thonis-Heracleion stele demonstrates a deliberate dual placement, reflecting the city's strategic function in controlling and taxing Mediterranean trade while reinforcing its partnership with Naukratis in Egypt's economic and political landscape (von Bomhard, 2015) (Robinson and Goddio, 2015).
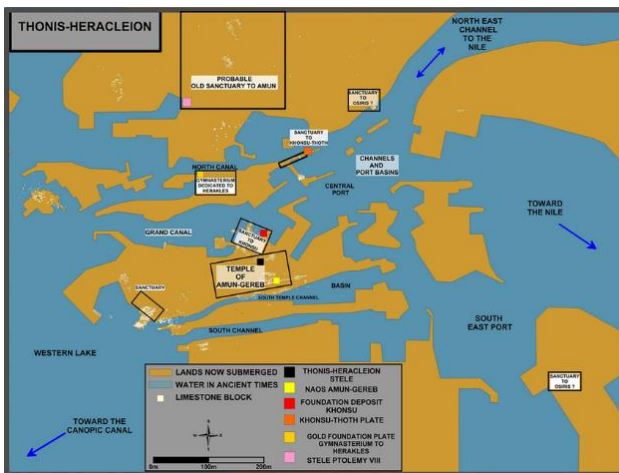

Fig. 3: Thonis-Heracleion organised around the temenos of the main god of the city: Amun Gereb. Map: Franck Goddio © Franck Goddio/Hilti Foundation

This complex archaeological background and the dispersion of artifacts across multiple museums and storage facilities highlight the challenges of reconstructing the city's cultural meaning in a holistic manner. These challenges form the rationale for the innovative methodological framework presented in the following section, which integrates digital documentation, metadata standards, and narrative-driven interpretation to virtually reunify the fragmented heritage of Thonis-Heracleion.

4. Methodology

The present research utilizes a comprehensive methodological approach that combines cutting-edge digital documentation, heritage interpretation, and narrative-focused storytelling to explore the scattered artifacts from the submerged archaeological site of Thonis-Heracleion. The main aim of the study is to create a conceptual framework and showcase its applicability through chosen case studies. The methodology demonstrates the integration of emerging digital technologies and narrative strategies to connect various archaeological artifacts, thereby uncovering the cultural heritage of the site's earliest inhabitants. This case study emphasizes the importance of digital data acquisition and documentation within the methodological framework as a crucial phase. This stage highlights the practical potential of digital technologies, serving as a foundation for more comprehensive methodological integration in future investigations. In this study, only the digital documentation and metadata component is practically implemented through the digital Thonis-Heracleion prototype (omeka.net). The other components, including photogrammetry, immersive VR/AR, and narrative-driven storytelling, are included at a conceptual level to outline future directions rather than as fully executed elements.

4.1 Data Acquisition and Heritage Documentation

For preserving submerged CH sites whose cultural materials are spread out throughout different museums, it is important to collect and record digital data. Researchers at the Antikythera Shipwreck have created methods that turn computed tomography (CT) scans and high-resolution photogrammetry into metrically accurate 3D meshes. These meshes can be used for conservation diagnostics and virtual conservation immersive reconstructions. Anastasovitis and Roumeliotis, 2023 At the Baiae Underwater Archaeological Park, systematic campaigns have employed dense stereo photogrammetry, integrated acoustic surveys, and bathymetric references to digitally document underwater heritage with high precision (Bruno et al., 2015). These case

studies show that digital data gathering is more than just recording models. When combined with structured documentation frameworks, it makes it possible to virtually bring together historical artifacts and encourages sustainable approaches to interpreting them. Antikythera and Baiae are mentioned as examples of excellent practices that show what could be possible with improved digital documentation in the future. However, these methods are still out of reach. The current study is confined to the development of a foundational metadata framework utilizing Omeka.net, organized by Dublin Core and CIDOC-CRM, specifically applied to the Amun Gereb Naos case study. The initial phase is to choose to examine at significant artifacts from Thonis-Heracleion, which are spread out across different museum collections and storage facilities. Instead of digitizing the entirety, a selctselective example is used to show important cultural aspects including religious ceremonies, trade networks, and everyday life. These approaches are based on Goddio's revolutionary work, which used geophysical and remote sensing technology to map parts of the underwater CH site of Thonis Heracleion. (Goddio (2007; Fabre and Goddio 2013)

4.2 Conceptual Database Framework

The research proposes a structured database informed by international metadata standards to consolidate disparate artifacts. The framework is based on the CIDOC Conceptual Reference Model (CIDOC-CRM) and Dublin Core metadata standards, which provide semantic interoperability and robust preservation foundations necessary for cross-institutional integration. This conceptual model demonstrates how metadata and digital representations from multiple repositories could be interlinked, supporting future expansion and scholarly collaboration (Doerr, 2003; Kakali et al., 2007; Mazurek et al., 2018). The SeaLiT project provides a case study on developing an ontology for maritime history by extending the CIDOC Conceptual Reference Model (CIDOC-CRM). Using a bottom-up approach, it analyzed archival sources such as crew lists, payrolls, and ship registers, with input from maritime historians to ensure domain relevance. The ontology was iteratively refined and validated by experts, enabling flexibility for incorporating new data. Built with semantic web standards (RDF, RDFS, OWL), the framework supports interoperability, advanced querying, and data integration, thereby advancing research in maritime history (Fafalios et al., 2023).

4.3 Narrative and Storytelling Approaches

Narrative serves as a central interpretive tool that transforms historical artifacts into thematic stories. Selected archeological finding are examined through narratives highlighting cultural exchanges, maritime networks, and religious traditions at Thonis-Heracleion. This approach not only supports academic analysis but also engages broader audiences by animating the daily lives and beliefs of the site's early Greek inhabitants. Digital storytelling techniques effective in maritime and underwater heritage contexts guide this practice, ensuring accessibility and scholarly depth (Rizvic et al., 2017; Wyatt et al., 2021). Within cultural heritage research, the integration of artefacts into story-driven virtual reality (VR) environments—through points of interest (POIs), 360° video, and scholarly reconstructions—has been shown to enhance presence, engagement, and immersion, as demonstrated by (Škola et al. 2020) and the Baiae underwater heritage case study. This body of research illustrates how VR-based narrative design can effectively convert archaeological findings into compelling, context-rich heritage experiences.

Building on this foundation, the present study outlines a framework for narrative integration, demonstrating how the documented material from Thonis-Heracleion can be reassembled into interpretive storylines that connect religious ritual, commerce, and cross-cultural exchange.Moreover, Within the context of Omeka, these narratives could be structured as curated "Exhibits" that group artifacts thematically—for example, The Cult of Amun-Gereb or Greek Mercenaries in Egypt—with accompanying interpretive texts weaving the

objects into cohesive cultural stories. While this study does not implement these narrative pathways in practice, their inclusion within the framework establishes the structural model for future research, ensuring that narrative-driven storytelling can build upon the metadata foundations established here.

4.4 Strategies for Virtual Presentations of CH

While a fully interactive virtual museum lies beyond the present scope, this research outlines conceptual strategies to enhance digital presentations. These include interactive maps, timelines, and curated narrative routes situating artifacts within reconstructed spatial and cultural contexts of the submerged city "Thonis Heraklieon." Similar virtual heritage projects demonstrate that such immersive and scalable visualization techniques greatly augment both research interpretation and public appreciation of the site's historical significance. (Masci et al., 2024; Scianna et al., 2021). Virtual presentation uses thorough architectural material, including reports, photographs, and drawings, to produce accurate 3D models in AutoCAD and 3ds Max with texture mapping and lighting for photorealistic display. Photogrammetry and specialized software digitized artifacts for perfect reconstruction in the virtual environment based on excavation data. Re-contextualizing the items in their historical locations improved research and education, allowing a complete investigation of the site's social and cultural past. (Elgewely & Wendrich, 2015) In addition to these strategies, artificial intelligence (AI) and immersive digital visualization should be understood as complementary layers that can build upon the metadata and documentation foundations established in this study. The application of AI-driven interpretation and immersive digital visualization constitutes a promising direction for future development (Hutson and Chahine, 2025). Rather than being implemented at this stage, such techniques are positioned as natural extensions that could enhance the project's scalability—enabling automated artifact recognition, predictive interpretation, and more interactive user experiences in virtual environments. In the study by (Chen, Jesus, and Vilarigues 2025), the researchers applied AI and AR digital applications to analyze Amadeo de Souza-Cardoso's works. Hyperspectral imaging was used to analyze artwork, and desktop and mobile AR apps were created to show the results. To assess application efficacy and user experience, varied users participated in usability experiments. The desktop app was for scientific and conservation objectives, while the mobile AR app engaged the public and museum visitors to improve artwork interaction and virtual presentation for cultural knowledge.

5. An Archaeological Analytical Framework for Material Culture and Narrative Integration

It is noteworthy that texts of the stelae of Heracleion shows not only the identities of both towns, confirming that Heracleion of the Greeks was Thonis of the Egyptians, but also mentioning the volume of taxation, goods, and products, as well as the customs of Thonis-Heracleion. **(Fig. 4)**

Fig. 4: Black Granite Thonis-Heracleion stele; source: Christoph Gerigk ©Franck Goddio/Hilti Foundation

The recovered ceramics indicate the intense activity of exchange between Egypt and the Mediterranean as well as throw light on the kind

of consumed products, like amphora that include hazelnut shells. It's dated from the end of the 4th/early 3rd century B.C. Egyptian ceramic, along with luxury imported Greek products, was used together. Another example is the local production inspired by black glazed pottery**. (**Goddio and Clauss 2006) **(**von Bomhard 2012) Greek settlements, consisting of either mercenaries or tradesmen, existed in Heracleion from the 7th to the 4th century B.C.; fragments of helmets, spearheads, arrowheads, javelins, spheres, and Athens-style tetradrachms have been found at the site to support this theory. (Grataloup, 2010) (Fabre and Goddio, 2013). These provide a clear image about trade and economy, as Thonis-Heracleion's geographical position supported commercial exchanges with the Eastern Mediterranean. Thonis-Heracleion was Egypt's primary gateway to the north; custom posts and emporiums, through which products were imported by the Greeks, would pass for trading posts in Naukratis. **(**Goddio and Clauss 2006) (Pfeiffer 2010)

Archeological records gave an idea of the religious life within Thonis-Heracleion, as there was a temple of Amun Gereb in Herakleion. **(Fig. 3)** This data is closely connected with the inscription on the pink granite naos found within the vicinity of the temple and is confirmed by historical accounts. **(Fig. 5)** The Canopus decree stated, "Osiris was brought in procession from the main temple of Amun-Gereb in Heracleion to his sanctuary in Canopus on a ceremonial barge.", also the bronze *Hemhem* crown which Yoyotte attributes to Chonso, most likely belonging to a cult statue.

Fig. 5: Amun Gereb Naos; source: Goddio and Clauss, 2006, cat. No. 116; Christoph Gerigk © Franck Goddio/Hilti Foundation

Additionally, numerous small votive offerings were dedicated to Chonso. (Goddio and Clauss 2006), (Fabre and Goddio 2015) Yoyotte suggests that Chonso, who was equated with Heracles, has a chapel inside the Amun Gereb temple. Heracles is also closely connected with Heracleion. However, the foundation deposit's gold plaque (Goddio and Clauss 2006) (Fabre and Goddio, 2015) didn't specify the name of the monument, but epigraphic study connected it with Heracles. In addition, Yoyotte believes that King Pumiathion was the patron who contributed to the construction of the façade of the great temple area, basing this on the Hemistater of Pumiathion and the number of Greek bronze coins that represent Heracles. All the above-mentioned details correspond with historical accounts; as Herodotus stated, the Hieron of Heracles was located on Thonis. Thus, Thonis-Heracleion is associated with the Amun Gereb and Chonso Heracles cults. (Goddio and Clauss, 2006) (Höckmann 2010)

Artifacts found from the Grand Canal (**Fig. 3**) include ceramic amphorae "Lekythoi" terracotta figurines, and, deities' imageries of Egyptian gods, as well as numerous votive offerings and cult instruments: votive barques, lamps, bronze ritual objects, mirrors, cups, food offerings (animal remains), strainers, and ladles. A unique example of mixing style is represented by a bronze amphora with a figure of the god Bes attached **as** an applique. They are all associated with the Dionysian procession and connected with the religious procession that took place on the canal, which served the sanctuary by linking Canopus and Heracleion. **(**Fabre and Goddio 2015)**, (**Goddio and Clauss 2006)**, (**Zöe 2010) All previous archeological artifacts aid in reconstructing and visualizing the religious rituals, cultural activities, commercial exchanges, and every-day life that formerly characterized Thonis-Heracleion.

The Amun-Gereb and Chonso-Herakles religious cults are displayed in Thonis-Heracleion. The great number of cult

instruments and votive offerings that were found along the Grand Canal at Heracleion have a contextual Greek iconographic origin with Egyptian motives. For instance, ladles were objects called kyathos by the Greeks (from the verb *kuo*, 'draw') used to decant wine into drinking cups. According to Yoyotte, the motif decorated its end with a "head of a duck", which was of Egyptian origin. It can be interpreted that the followers of Dionysus added a libation of wine to their sacrifices and oblations when the procession of the ceremonial barge was in his way, returning Osiris to his temple. (Goddio and Clauss 2006) All the above mentioned, archaeological evidence from Thonis-Heracleion, illustrates a vibrant hub of religious worship, commerce, cultural exchange, and daily life—ranging from trade goods, religious artifacts, ritual instruments and votive offerings—collectively illuminates the city's dual role as Egypt's principal Mediterranean gateway and a vibrant center of cultic life. These discoveries highlight the connection of economic activity, cross-cultural interchange, and religious traditions that helped define the city's identity. By situating artifacts within their broader socio-economic and ritual contexts, this research establishes a foundation for reconstructing the lived experiences of Thonis-Heracleion's early inhabitants. This analytical framework not only contextualizes material culture but also provides the basis for employing narrative-driven digital methodologies. In the following section, and as stated within the methodology that outlines how narrative will function as a primary interpretative instrument, converting disparate objects into unified stories that can be re-experienced via digital platforms, including virtual museums and immersive storytelling environments.

This analysis of material culture therefore provides the essential historical and thematic content—encompassing trade, religious syncretism, and daily life—that will populate the narrative-driven digital storytelling framework proposed in this study. By explicitly linking archaeological synthesis with digital interpretation, this section serves as the contextual foundation upon which the virtual reunification and storytelling strategies of the following sections are constructed.

6. Virtual Reunification of Dispersed Archeological Artifacts
6.1 "Dispersed Artifacts: Collection Overview and Virtual Reunification Strategies"

The aforementioned artifacts of Thonis-Heracleion illustrate the challenges of dispersion. The artifacts from identical archaeological contexts are currently dispersed throughout multiple sites, including the Excavations Warehouse in Alexandria, the National Museum, the Maritime Museum, the Greco-Roman Museum, and more storerooms. This distribution has compromised provenance and contextual integrity, hindering both scholars and the public in reconstructing the site's cultural, religious, and economic heritage. For instance, ritual goods associated with the Amun-Gereb temple are allocated throughout several storage sites, while quotidian objects and trade-related commodities are likewise distributed. This fragmentation highlights the need for virtual reunification, an approach that digitally consolidates dispersed collections to restore interpretive coherence. Similar projects, including the digital reunification of the Pergamon Altar fragments (Antikensammlung Berlin & Fraunhofer IGD, 2016) and the incorporation of underwater heritage artifacts at Baiae, illustrate the practicality and academic significance of digitally consolidating scattered materials into cohesive research and presentation platforms. (Stefanile et al. 2020)

Table 1. Dispersed artifacts from Thonis-Heracleion across museums, warehouses and official storage rooms.

Artifact Type	SCA Number	Material	Date
Helmet crest	EWA (SCA 224)	Silver	4th century B.C.
Helmet	EWA (SCA 1026)	Bronze	5th / 4th century B.C.

Artifact Type	SCA Number	Material	Date	Artifact Type	SCA Number	Material	Date
Arrow head	EWA (SCA 498)	Bronze	6th / 2nd century B.C.	Statuette of a woman	EWA (SCA 1033)	Lead	End 5th / mid 4th century B.C.
Javelin tip / spear tip	EWA (SCA 1049)	Bronze	5th / 4th century B.C.	Statuette of Isis Lactans	EWA (SCA 972)	Bronze	Late Period – Early Ptolemaic
Thonis-Heracleion stele	National Museum (SCA 277)	Black Granite	6th / 2nd century B.C.	Statuette of Osiris	EWA (SCA 1081)	Bronze	Late Period – Early Ptolemaic
Amphora	EWA	Ceramic	End 5th / mid-4th century B.C.	Statuette of Harpokrates	EWA (SCA 995)	Bronze	Late Period – Early Ptolemaic
Glazed Mug	EWA (SCA 251)	Ceramic	Ptolemaic period	Statuette of Bastet	EWA (SCA 930)	Bronze	6th / 2nd century B.C.
Amun Gereb Naos	Maritime Museum, Alexandria (SCA 457)	Pink Granite	Ptolemaic period	Image of Nechbet	Roman Theatre (SCA 895)	Bronze	6th / 2nd century B.C.
Naos	Maritime Museum, Alexandria (SCA 456)	Pink Granite	Ptolemaic period	Votive Baraque	EWA (SCA 405)	Lead	Ptolemaic Period
Hem Hem crown of Chonso	EWA (SCA 401)	Bronze	End of Late Period – Early Ptolemaic	Incense burner	EWA (SCA 1073)	Bronze	6th / 2nd century B.C.
Statuette of Chonso with lunar disk	EWA (SCA 387)	Bronze	Late Period	Candelabra	EWH (SCA 1054–1061)	Bronze	6th / 2nd century B.C.
Ptolemy III foundation plaque	Greco Roman Museum, Alexandria (SCA 876)	Gold	246–222 B.C.	Lamp and handle	EWA (SCA 1024–1028)	Bronze	Ptolemaic Period
Hemistater from Cybrus	National Museum (SCA 287)	Gold	c. 355–354 B.C.	Simpulum	EWA (SCA 1034)	Bronze	Ptolemaic Period
Herakles Coin	EWA (SCA 614)	Silver	336–323 B.C.	Bowl	EWA (SCA 966)	Bronze	6th / 2nd century B.C.
Lekythos	National Museum (SCA 247)	Clay	End 5th / mid 4th century B.C.	Brazier	EWA (SCA 912)	Bronze	6th / 2nd century B.C.

Artifact Type	SCA Number	Material	Date
Oblatory dish (top)	EWA (SCA 374)	Black Granite	6th / 2nd century B.C.
Mirror	EWA (SCA 934)	Bronze	6th / 2nd century B.C.
Strainer	EWA (SCA 1029)	Bronze	Ptolemaic Period
Spoon	EWA (SCA 1044)	Bronze	6th / 2nd century B.C.
Amphora with Bes appliqué	Archaeological stores of Maritime Museum, Alex., archaeol. stores (SCA 1235)	Bronze	1st half of the 4th century B.C.

Source: Data compiled from museums collections and published sources, including (Goddio & Clauss 2006; Goddio and Fabre, 2015)

The previously gathered archaeological artifacts illustrated in **Table 1**, unearthed from Thonis-Heracleion and now dispersed across various museums, warehouses, and official storage rooms, signify a methodical endeavor to identify and classify cultural treasures across multiple archives. This table consolidates data on artifact type, current location, material, and historical origin, offering a comprehensive inventory that unifies pieces dispersed throughout excavation warehouses, national museums, and regional organizations. All artifacts listed in this table were documented by the author through museum courtesy and collected from published references (Goddio & Clauss, 2006). However, it is crucial to note that this table does not include all Thonis-Heracleion archeological material, as this research's first goal is to digitally document some dispersed archeological artifacts, not all site discoveries. This chosen documentation

supports the study goal of building interpretive frameworks that incorporate these objects into cohesive narratives to reveal the site's early inhabitants' cultural and social legacy. Through future research and categorization, a complete digital record of all objects is possible. This categorization solves the fragmentation difficulties of submerged cultural assets and facilitates comparative analysis of material culture within an integrated framework. This methodological approach aligns with international standards for cultural heritage documentation (ICOM, 2017; UNESCO, 2001), ensuring that artifacts retrieved from underwater excavations are contextualized within the comprehensive historical and archaeological narrative of Thonis- Heracleion (Goddio & Clauss, 2006).

6.2 " Digital Archiving Standards and Metadata Frameworks for Archaeological Heritage"

Adopting standardized digital archiving protocols is essential for ensuring the long-term accessibility and scholarly interoperability of dispersed artifacts. Digital archiving secures both the physical and contextual information of cultural heritage objects while enhancing integration among institutional and national repositories. International guidelines demonstrate that comprehensive documentation—including physical description, provenance, condition reports, associated documentation, and visual records— is essential for effective heritage management (ICOM, 2017; UNESCO, 2001). Metadata standards like Dublin Core and the CIDOC Conceptual Reference Model (CIDOC-CRM) are acknowledged for facilitating semantic interoperability. They are also essential for ensuring long-term preservation across diverse databases (Doerr, 2003; Kakali et al., 2007; Mazurek et al., 2018). This research applies these principles to a specific case study from the Thonis- Heracleion assemblage: pink granit Naos of Amun Gereb. This object serves as an example to illustrate the structuring of artifact documentation. Both Dublin Core and CIDOC-CRM fields were applied in the process. This case illustrates the application of international

standards. It also highlights the possibility of developing a comprehensive digital archive that supports virtual reunification and collaboration across institutions. (Fafalios et al., 2023; Goddio & Clauss, 2006).

Table 2: Structured Metadata Schema (Dublin Core and CIDOC-CRM) for the Amun Gereb Naos (Thonis-Heracleion)

Metadata Field (Dublin Core)	Value (Amun Gereb Naos)	CIDOC-CRM Mapping
Title	Amun Gereb Naos	E35 Title
Identifier	SCA 457	E42 Identifier
Persistent Identifier	https://www.franckgoddio.org/projects/sunken-civilizations/heracleion/interactive-map/thonis-heracleion/naos/	E42 Identifier
Type	Artifact – Religious Architecture (Shrine)	E55 Type
Format	Physical object; Pink granite monolithic cultic shrine	E57 Material
Dimension	H. 174 cm, W. 93 cm, D. 100 cm	E54 Dimension
Material	Pink Granite	E57 Material
Coverage (Spatial)	Thonis- Heracleion (Abuqir Bay, Egypt)	E53 Place
Coverage (Temporal)	Ptolemaic Period Early third century B.C till mid-second century BC.	E4 Period
Provenance / Source	Recovered during the underwater excavations of Thonis- Heracleion, conducted by the Institut Européen d'Archéologie Sous-Marine (IEASM) in collaboration with the Supreme Council of Antiquities (SCA) in the early 2000s. Within the vicinity of the Amun-Gereb temple, adjacent to the southern temple canal at Thonis-Heracleion	E7 Activity (Excavation Event)
Current Location	Maritime Museum, Alexandria (SCA 457)	E78 Collection / E40 Legal Body
Description	Monumental pink granite naos dedicated to the deity Amun Gereb, discovered in Heracleion and linked to cultic practices during the Ptolemaic period.	E33 Linguistic Object (textual description)
Condition report	The Pink Granite Naos shows heavy corrosion, particularly on its upper parts, causing detachment of granite layers and loss of many original engravings. The decorative torus molding has largely disappeared, especially at the right-hand jamb, with asymmetrical erosion patterns. The inscriptions on the lintel and jambs are mostly illegible due to corrosion and physical damage; however, partial texts were recovered using	E26 Physical Feature

Field	Value	CIDOC class
	Reflectance Transformation Imaging (RTI), revealing divinatory epithets of Amun-Gereb.	
Creator	Unknown ancient Egyptian craftsman; stylistically influenced by naoi of the Nectanebo period, demonstrating high mastery of stonemasonry.	E39 Actor
Contributor	Institut Européen d'Archéologie Sous-Marine (IEASM), Supreme Council of Antiquities (SCA)	E39 Actor
Publisher (Digital)	Digital archive project on Thonis-Heracleion	E39 Actor
Rights	© Supreme Council of Antiquities (SCA) / Institut Européen d'Archéologie Sous-Marine (IEASM).	E30 Right
Relation	Related Naos: Pink Granite Naos (SCA 456), Cultic Artifacts: Statuette of Chonso with lunar disk (SCA 387), *Hem Hem* crown of Chonso (SCA 401), Statuette of Isis Lactans (SCA 972), Statuette of Osiris (SCA 1081), Statuette of Harpokrates (SCA 995), Statuette of Bastet (SCA 930), Votive Baraque (SCA 405), Incense burner (SCA 1073), Candelabra (SCA 1054 - 1061), Lamp and handle (SCA 1024-1028)	E22 Man-Made Object
Date	Excavated in early 2000s; digitally catalogued 2025	E52 Time-Span
Language	English (catalogue record)	E56 Language
Bibliography	Goddio & Clauss, 2006, p.127, cat. no. 391	E31 Document

Source: Data compiled from published sources, including (Goddio, 2021; Goddio & Clauss 2006)

Table 2 presents a metadata schema that exemplifies the practical application of international standards in the documentation of individual artifacts. The table demonstrates how dispersed finds from Thonis- Heracleion can be digitally documented using the technique applied to one of the masterpieces, the Amun Gereb Naos (Fig. 5), within both Dublin Core and CIDOC-CRM fields, ensuring the reunification of the site's material record. Importantly, this contribution underscores the foundational effort required to systematically collect, organize, and standardize detailed information about each artifact in accordance with international criteria. Such a process not only validates the research's role in bridging gaps between dispersed collections but also highlights the necessity of building a robust and transferable model that can guide future documentation initiatives and facilitate sustainable heritage knowledge management. References include (Doerr, 2003 ; Kakali et al. 2007; Mazurek et al. 2018).

To test the applicability of the proposed methodology, the researcher applied two complementary components: data acquisition and documentation through a conceptual database framework, and narrative and storytelling approaches. The first component was implemented in practice through the creation of Digital Thonis- *Heracleion* (https://thonisheracleion.omeka.net/), a

prototype developed on the Omeka.net platform. **(Fig. 6 and 7)**, Omeka was selected for its support of Dublin Core as a default metadata standard and its flexibility for customization and CIDOC-CRM mappings (Kakali et al., 2007; Doerr, 2003). The archeological artifact of Amun Gereb Naos was selected as an initial trial of the dispersed Thonis- Heracleion artifacts. Metadata fields were systematically documented, covering descriptive, contextual, and administrative elements. To enhance contextualization, multiple photographs of the Naos were uploaded together with a cartographic reconstruction of the city's topography, based on geophysical surveys and archaeological mapping. This map highlights the precise location of the Naos. This initial trial demonstrates how international metadata standards can be embedded into practical digital documentation, ensuring both interoperability and scalability.

Critical reflection on the Omeka prototype: The Omeka.net platform facilitated this trial effectively by allowing systematic metadata entry, integration of Dublin Core fields, and direct linking of digital files to the artifact record. The specific contribution of this study lies in aligning Dublin Core with CIDOC-CRM, as demonstrated in Table 2, and in testing the upload of associated media through the backend interface illustrated in Figure 7. This shows how provenance, contextual meaning, and interoperability can be reinforced even in an early-stage prototype. At the same time, limitations were observed: Dublin Core, while sufficient for descriptive and administrative information, does not capture complex archaeological events, relationships, and interpretive narratives without semantic enrichment. Omeka's interface is intuitive for browsing and exhibits, and manageable for individual researcher input, but further development would be required for multi-institutional collaboration, bulk ingestion, and advanced 3D/VR integration.
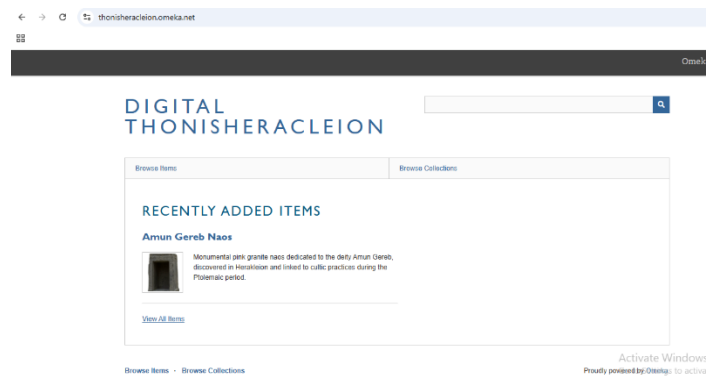

Fig. 6: Public interface of the Digital Thonis-Heracleion Omeka.net prototype, showing recently added items (Amun Gereb Naos) © Author
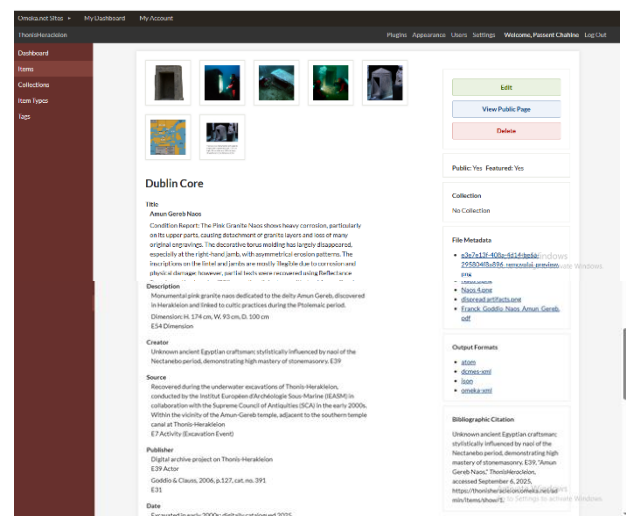

Fig. 7: Backend metadata entry page in Omeka.net for the Amun Gereb Naos, illustrating Dublin Core fields and associated digital files. © Author

The other steps of the methodological framework—narrative and storytelling, as well as digital presentation—were explored, with narrative and storytelling serving as an interpretive approach that complements documentation by transforming archaeological data into cultural narratives. This approach emphasizes themes such as economic exchange, cultural interaction, and religious practices, thereby engaging both scholarly and public audiences (Rizvic et al**.,** 2017; Wyatt et al., 2021). While applied here in a descriptive capacity, the digital presentation highlights the practical potential of digital technologies, paving the way for greater methodological integration in future endeavors. The findings point to significant potential for further development through immersive digital storytelling. As demonstrated in (Škola et al. 2020), VR-based techniques such as hyper-

storytelling and interactive reconstructions can enhance presence, engagement, and immersion, offering a promising direction for future research on Thonis-Heracleion.

Taken together, the prototype and interpretive strategies establish a coherent methodological framework that integrates standardized digital documentation with narrative-driven approaches. The present study confirms the feasibility of documenting dispersed cultural heritage through accessible digital tools, while laying the groundwork for future expansion into immersive and interactive storytelling.

7. Discussion
7.1 Methodological Strengths

The methodology developed in this research demonstrates significant strengths, combining both applied and theoretical contributions to the study of dispersed underwater cultural heritage among many locations as highlighted. The first component was implemented in practice through the creation of Digital Thonis-Heracleion (https://thonisheracleion.omeka.net/), a prototype developed on the Omeka.net platform. This prototype provided a digital infrastructure for reuniting dispersed artifacts from Thonis-Heracleion, currently distributed across museums, warehouses, and official storage rooms. Within this framework, the study applied a structured metadata schema that integrates Dublin Core with CIDOC-CRM, exemplified through the Amun Gereb Naos case study. This ensured semantic precision, interoperability, and sustainable documentation, while also demonstrating how metadata can reconnect fragmented archaeological contexts through rigorous archival practice.

A further methodological strength lies in the theoretical integration of advanced digital archaeological techniques into the proposed framework. Although not applied here, methods such as photogrammetry, 3D reconstruction, and immersive VR/AR are positioned as natural extensions for future phases. Their conceptual inclusion demonstrates the adaptability of the framework

and ensures scalability to emerging technologies (Fortuna et al., 2024).

Equally significant is the theoretical emphasis on immersive narrative and storytelling as interpretive tools. By embedding narrative-driven strategies within the framework, the investigation emphasizes the value of transforming fragmented artifacts into coherent cultural stories. Although narrative applications were not implemented in this study, they are framed as strategic future directions, drawing on comparative projects such as the Phalasarna AR reconstruction and the Arkaevision vr initiative, which demonstrate the value of storytelling for enhancing accessibility and engagement (De Nino et al., 2020; Interreg Europe, 2025).

7.2 Consequences for future researches

This study highlights methodological innovations, particularly the digital reunification of dispersed artifacts via standardized metadata frameworks and narrative-driven virtual curation. Future research on submerged heritage sites, such as Thonis- Heracleion, should focus on integrating immersive visualization technologies, AI-driven analytics, and improved metadata enrichment workflows to enhance interpretive clarity, scholarly collaboration, and public engagement. The advancement of VR and AR tools designed for underwater archaeology, including application-specific immersive VR documentation environments, significantly improves professional data interaction, analysis, and interpretation, as evidenced by recent case studies (Cobb & Azizbekyan, 2024; Carrozzino, Lanfranco, Rignanese, Adornato, & Bergamasco, 2024). Secondly, the application of AI techniques in heritage documentation, especially concerning heritage site conservation and artifact recognition, presents opportunities for predictive modeling, automated classification, and the establishment of ethical, reproducible frameworks for heritage maintenance (Casillo et al., 2025). Integrating neural network-based metadata enrichment models that combine computer vision with semantic knowledge graphs can

enhance the depth, interoperability, and discovery capabilities of digital heritage archives (Ignatowicz et al., 2025). While these long-term strategies are important, the most immediate priority for future research is to strengthen data acquisition through systematic 3D scanning and photogrammetry, as this provides the robust digital foundation upon which narrative-building, AI enrichment, and immersive applications can be effectively developed in subsequent phases. These strategies, when taken as a whole, advocate for a research plan in the field of underwater cultural heritage that is technologically advanced, interpretively robust, institutionally sustainable, and inclusive.

7.3 Limitations:

This study presents several limitations that indicate potential areas for future research and development. The lack of a comprehensive suite of metric capture techniques, including dense stereo photogrammetry, CT scanning, and hyperspectral imaging, limited the accuracy of geometric recording, material characterization, and the development of fully interactive 3D models (Fortuna et al., 2024). The constraints restrict conservation applications and the scientific reuse of the dataset. Subsequent phases should prioritize standardized capture protocols, encompassing systematic documentation of capture parameters and error metrics, to guarantee reliability and comparability across collections.

The challenges of access and provenance are equally significant. Artifacts from Thonis-Heracleion are distributed among museums, warehouses, and storerooms **(see Table 1).** The varying levels of accessibility, incomplete accession histories, and fragmented documentation result in gaps in provenance and introduce sampling bias, especially due to the overrepresentation of well-catalogued or accessible objects.

Legal and ethical constraints significantly influence the parameters of digital dissemination. Institutional policies and legislation regarding Egyptian cultural heritage limit the availability and publication rights of high-resolution images and 3D scans, potentially affecting reproducibility and long-term accessibility (ICOM, 2017; UNESCO, 2001). Resolving these issues necessitates the establishment of clear rights metadata, formalized agreements, and tiered access models that reconcile scholarly openness with ethical and legal obligations.

It is essential to acknowledge the interpretive and governance challenges. Narrative-driven storytelling, though effective for engagement, inherently embodies curatorial choices that shape audience perception. Future research should incorporate diverse narratives, outline interpretive assumptions, and engage stakeholders, including local communities and domain experts, in the co-curation process to prevent overly narrow perspectives. The sustainability of the digital reunification effort relies on long-term funding, strong governance structures, and interdisciplinary collaboration among marine archaeology, conservation science, database engineering, and UX design. Recognizing these constraints underscores the need for structured institutional collaboration and targeted research, which are outlined in the following section.

8. Recommendations for Institutional Collaboration and Research

Collaboration and focused research are needed to digitally unify Thonis- Heracleion archeological artifacts scattered across museums, warehouses, and storage facilities. To overcome dispersion, government institutions must formalize access agreements. Harmonized metadata techniques that link Dublin Core and CIDOC-CRM are essential for documentation interoperability across platforms and repositories. Advanced digital documenting methods like photogrammetry and CT scanning improve documentation accuracy and immersive storytelling. This research highlights the need to adopt the proposed framework within specific guidelines that conform to Egyptian legislation and international heritage norms (ICOM, 2017; UNESCO, 2001). Future work should include

multi-vocal narratives that involve archaeologists, conservators, and local communities in meaningful co-curation to prevent limiting perspectives. Finally, long-term sustainability requires stable funding, strong governance, and evaluation mechanisms that ensure scholarly reliability and public impact, therefore making this study's framework a model for future cultural heritage initiatives.

9. Conclusion

This study proposes a framework for the virtual reunification of dispersed artifacts from the submerged site of Thonis-Herakleion, integrating material culture analysis with narrative methodologies and digital heritage strategies. This involves tackling the issues related to the disorganization of collections distributed among various museums, warehouses, and storage facilities. This study illustrates the role of digital tools and standardized metadata in providing integration to a site's cultural legacy, preserving archaeological context, and improving interpretive accessibility for enhanced storytelling.

The incorporation of recognized metadata standards, including Dublin Core and CIDOC-CRM, alongside persistent identifiers, guarantees scholarly precision and sustained interoperability. This methodological contribution ensures the documentation of artifacts and promotes collaborative research. The integration of storytelling and immersive presentation techniques demonstrates the capability of digital heritage to engage varied audiences. It is essential to recognize that the current research is a preliminary phase, confined to a documentation prototype (the Omeka.net platform) and a conceptual theoretical framework. Even though immersive VR/AR apps, photogrammetry, and AI-driven interpretation weren't completely used, the fact that they were thought of means that the framework is ready for the future.

The clear way forward is to turn this prototype into an extensive digital ecosystem that includes immersive visualization, AI-based interpretation, and multi-vocal storytelling. Collaboration between multidisciplinary institutions could achieve this.

This study does not encompass a fully realized virtual museum; however, the proposed framework offers a scalable and transferable model for the digital reunification of dispersed heritage assets. This framework's application to Thonis- Heracleion illustrates how digital technologies can transform archaeological practice, effectively connecting research, preservation, and public engagement. This study highlights the importance of ongoing collaboration between museums, archives, and research institutions to enhance digital documentation and accessibility for cultural heritage site presentations. "This study offers a comprehensive method for digitally resurrecting lost narratives, allowing cultural memories to surpass physical limitations for more sustainable and impactful digital presentation."

Abbreviations

CH: Culture Heritage:

CRM: Conceptual Refrence Model

EWA: Excavations warehouse, Alexandria

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