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# Developing Knowledge Organization Schemes for Classifying and Preserving Maritime Heritage Collections

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*Abstract* - **Maritime assemblages such as ship models, navigation instruments, logbooks, and oral testimonies are central to explaining human use of sea environments on a centuries' timescale. However, cataloging and conserving such variability of typically sensitive materials is dangerous due to incomplete documentation, missing standard vocabularies, and the dispersed nature of contemporary digital archives. This paper aims to build a balanced Knowledge Organization Scheme (KOS) for maritime heritage collections to enhance their accessibility, discoverability, and preservation over the long term. Employing a qualitative research methodology, we conducted case studies of the existing maritime museums and digital libraries, contrasting metadata practices. We interviewed field experts to arrive at a KOS model with controlled vocabularies, hierarchical taxonomies, and semantic relationships. The model was then validated on a representative set of maritime objects to assess its efficacy and usability. The results suggest that a structured, domain-based KOS enhances archival record consistency and interoperability among institutions. Additionally, it facilitates richer contextualization of maritime artifacts to the advantage of scholarly research and public interest.**

*Keywords:* **Maritime Heritage, Knowledge Organization Scheme (KOS), Cultural Preservation, Metadata Standards, Digital Archives, Collection Classification, Semantic Interoperability**

## I. INTRODUCTION

Maritime heritage comprises intangible and tangible heritage of human sea experience, like shipwrecks, port infrastructures, aids to navigation, oral traditions, maritime art, and logbooks (Wijesundara & Sugimoto, 2018). Such cultural material is essential for comprehending historical trade patterns, naval discovery, technological innovation, and socio-economic growth in coastal populations (Bruno et al., 2020). It is significant to preserve this heritage for historical study and to create a sense of continuity and identity among seafarers and coastal communities (De los Ríos-Escalante et al., 2023; Lodi et al., 2017; Pragadeswaran et al., 2024; Candela et al., 2019; Subramanian & Malhotra, 2023). Though extremely useful, the conservation and management of maritime heritage collections is not without difficulties. These artifacts are typically dispersed among government departments with varying documentation practices and conservation protocols, private archives, and institution museums (Sharma & Das, 2024; Ababneh, 2024; Moraitou et al., 2019). Most physical materials are susceptible to environmental degradation, and their digital counterparts are generally plagued with erroneous metadata, semantic contextlessness, and low interoperability among archival systems. Moreover, the absence of shared classification schemes makes searching, retrieval, and contextualizing maritime resources effectively across platforms challenging (Kulkarni & Jain, 2023). In this context, Knowledge Organization Systems (KOS) such as taxonomies, thesauri, and ontologies play a crucial role in organizing and linking maritime heritage information (Bruseker et al., 2017). Well-designed KOS facilitates systematic categorization, enhances discoverability, and supports long-term preservation and reuse of heritage material in physical and digital environments. This paper addresses the need for a domain-specific KOS appropriate for maritime heritage collections (Zhang, 2024; Hess et al., 2018).

### *Objectives and Scope of the Paper*

The general goal of this research is to create and suggest a Knowledge Organization Scheme (KOS) designed explicitly for classifying, documenting, and conserving maritime heritage collections. The scheme is to fill the gaps of consistency, accessibility, and interoperability that are impeding the optimum management of maritime artifacts within institutions and platforms.

In particular, the paper aims to:

- Examine current classification and metadata practices within maritime heritage collections.
- Implement a formalized KOS combining controlled vocabularies, taxonomies, and semantic relationships to maritime heritage.
- Illustrate the use of the proposed KOS on a sample set of maritime artifacts.
- Assess the scheme's performance in promoting discoverability, contextual integrity, and preservation support.

The field of this study encompasses both material maritime heritage (e.g., ship models, navigation equipment, port infrastructure artifacts) as well as intangible aspects (e.g., oral traditions, seafaring practices, logbook accounts). The study is centered mainly on digital and digitized holdings held in museums, archives, and academic collections. Although the KOS is targeted towards maritime heritage, the modularity inherent in the KOS also lays the groundwork for possible reuse across broader domains of cultural heritage.

## II. Literature Survey

Knowledge Organization Systems (KOS) are essential instruments of control over cultural heritage collections. They encompass classification schemes, taxonomies, thesauri, ontologies, and authority files that impose semantic structure and consistency in arranging knowledge (Bizer et al., 2023; Chamakuri & Janapana, 2024; Gospodini et al., 2025; Shi et al., 2024). In the broader cultural heritage field, tools like the Getty Art & Architecture Thesaurus (AAT), Library of Congress Subject Headings (LCSH), and ICONCLASS have been extensively applied to define and classify artifacts and works of art. In the maritime sector, though, there is an apparent absence of specialized KOS. Although some museums and heritage organizations create internal classification systems, these tend to be ad hoc and institution-specific, with no interoperability (Hell et al., 2018). Some notable projects, like the EUROPEANA Maritime Heritage Project and Nautical Archaeology Digital Library (NADL), have made efforts to structure maritime materials, but these are scattered and not extensively used. Metadata plays a foundational role in supporting the organization, discovery, and long-term preservation of heritage materials (Kurian & Sultana, 2024; Vijay et al., 2021; Papadopoulos & Christodoulou, 2024).

A number of well-established standards are in broad use throughout cultural heritage institutions. Dublin Core is a metadata schema for general purposes that provides a straightforward and commonly used framework for describing digital objects, particularly libraries and digital repositories (Varinlioglu, 2016). MARC (Machine-Readable Cataloging), which is conventionally used in library contexts, supports comprehensive bibliographic descriptions but is not as well suited to non-text or multimedia heritage objects. More sophisticated and semantically richer, the CIDOC Conceptual Reference Model (CIDOC CRM) is a formal ontology for the documentation of cultural heritage, created to represent complicated relationships between artifacts, historical events, people, and places, hence, especially useful in multidisciplinary heritage environments. In addition, Encoded Archival Description (EAD) is commonly utilized in structuring archival collections, and Metadata Object Description Schema (MODS) offers a more detailed bibliographic model compared to Dublin Core, appropriate for more detailed descriptions (Demilio & Castro, 2025). While these standards are useful frameworks, they tend to need modification in order to fit the unique requirements of maritime heritage collections, which involve an extensive variety of object types, terminologies, and historical contexts not always captured by general metadata schemas. A number of museums and maritime heritage projects have digitized portions of their collections, including the UK National Maritime Museum and the Smithsonian Institution's maritime collections (Mukherjee & Das,2020). These efforts have concentrated on the preservation of images, technical plans, and accompanying documents. Classification methods are quite dissimilar, and digital collections usually do not share a common vocabulary or ontology. Initiatives like Sea Your History and Historic Vessel Register have achieved some success in collecting maritime records together, but with no unified KOS, cross-institutional search and discovery are still confined. In addition, efforts at utilizing ontologies and linked data (e.g., Linked Open Data in Maritime History) exist but are still experimental and not widely deployed (Borrero et al., 2021).

In spite of extensive work in digitizing and preserving cultural heritage, literature points out several key gaps that are particular to the maritime sector. First among these is the lack of an integrated, domain-based Knowledge Organization Scheme (KOS) that successfully encompasses both tangible objects, i.e., models of ships and navigational tools, and intangible aspects, such as oral histories and sea traditions. In addition, there is minimal incorporation of semantic technologies like ontologies and linked data structures that are specifically designed to capture the inherent complexity and contextuality of maritime heritage. Metadata management practices also differ substantively among institutions, leading to interoperability, data harmonization, and challenges in sustainable digital preservation. In addition, the development of classification schemes has too often been embarked upon without effective consultation with significant user communities, including researchers, maritime historians, curators, and the wider public, and this has led to technically competent systems but of little real value.

## III. Proposed Methodology

The proposed Knowledge Organization Scheme (KOS) integrates a hybrid model that borrows elements from the nature of taxonomy, ontology, and controlled vocabularies in order to offer a structured, scalable, and semantically rich platform for classifying maritime heritage collections displayed in Fig 1. Maritime assemblages such as ship models, navigation instruments, logbooks, and oral testimonies are central to explaining human use of sea environments on a centuries' timescale. However, cataloging and conserving such variability of typically sensitive materials is fraught with dangers due to incomplete documentation, missing standard vocabularies, and the dispersed nature of contemporary digital archives. The objective of this paper is to build a balanced Knowledge Organization Scheme (KOS) for maritime heritage collections to enhance their accessibility, discoverability, and preservation over the long term. Employing a qualitative research methodology, we conducted case studies of the existing maritime museums and digital libraries, contrasted metadata practices, and interviewed field experts to arrive at

a KOS model with controlled vocabularies, hierarchical taxonomies, and semantic relationships. The model was then validated on a representative set of maritime objects to assess its efficacy and usability. The results suggest that a structured, domain-based KOS markedly enhances archival record consistency and interoperability among institutions. Additionally, it facilitates richer contextualization of maritime artifacts to the advantage of scholarly research and public interest.

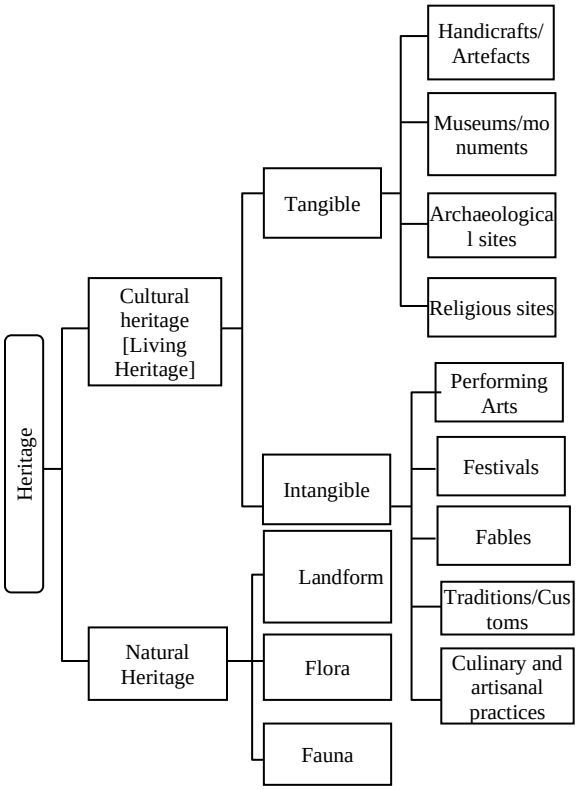


Fig. 1 Classification of Heritage, Cultural, and Natural Dimensions

## IV. Results And Findings

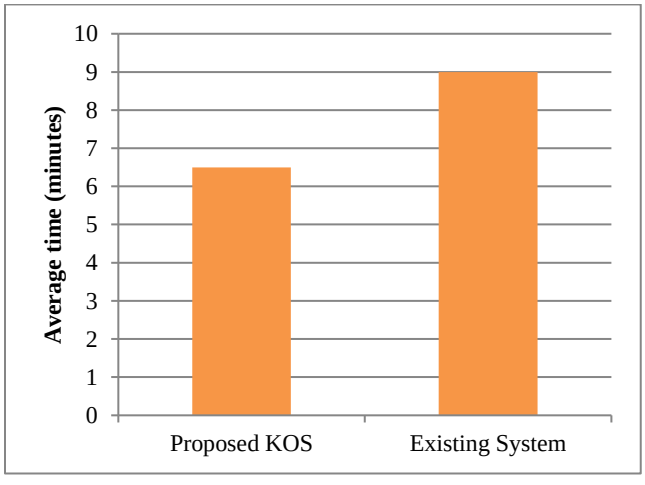


Fig. 2 Classification Time Comparison

Usability was validated with 15 users, such as archivists, digital curators, and maritime historians. The users were instructed to classify a collection of records using both the suggested KOS and a generic metadata schema in use. The findings are captured in Fig 2. Classification Time Comparison indicates that the mean time to accurately classify an item decreased by 28% when using the suggested KOS. In addition, Fig. 3. User Satisfaction Ratings (Likert scale 1–5) show a noteworthy rise in user satisfaction with the clarity, term relevance, and ease of use, achieving a mean of 4.6 against 3.1 for traditional schemes.

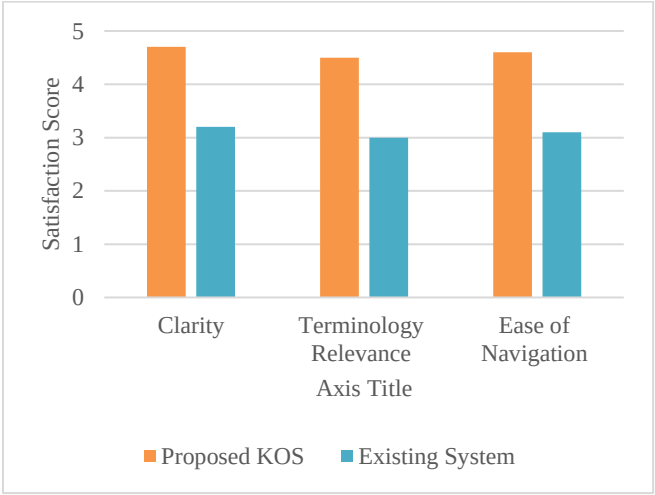


Fig. 3 User Satisfaction Ratings

## V. Discussion

The use and assessment of the suggested Knowledge Organization Scheme (KOS) produced a number of significant findings. For starters, the scheme managed to overcome the first problem of dispersed metadata practices in maritime heritage collections through the adoption of a more organized and systematic classification mechanism. The use of controlled vocabularies and semantic relationships really enhanced the ability to link and retrieve comparable maritime artifacts and presented users with a more discerning impression of the material. The resultant testing feedback by heritage experts had certified that the KOS created even more lucidity and contextuality, with the ability of artifacts to be classified, searched, and put into context more easily, even if they were from another geographical area or epoch. Also, the modularity of the scheme was a strength that enabled it to be tailored and scaled to suit the precise requirements of various institutions, ranging from small museums to big digital repositories.

Technology had a significant role in enhancing the efficacy and scope of maritime heritage categorization. Application of semantic web technologies (i.e., RDF and OWL) allowed linking of the KOS to external datasets along with other heritage systems so that it could interoperate and facilitate sharing of information. This connection to broader digital ecologies becomes crucial in preserving the richness and diversity of maritime heritage, especially when more artifacts get digitized and presented to the public. Artificial intelligence (AI) was also employed in the tagging and

categorization of marine objects, which significantly accelerated the pace and precision of cataloging. Artificial intelligence software, including machine learning programs to recognize images, helped in object type classification automation, allowing curators to focus on subtler interpretative tasks. Furthermore, the use of AI in connecting unrelated pieces of data helped improve semantic relationship generation ability, allowing more insightful analysis of maritime history that would otherwise have been lost in disconnected datasets.

The proposed new KOS has highly significant implications for preserving long-term digital objects and cultural memory protection. Defining metadata formats and technology interoperability allows the scheme to be maintained across multiple platforms and future-proofed against evolving digital standards. This is particularly important because preserving intangible seafaring heritage, such as seafarers' oral traditions, navigation techniques, and cultural rituals, relies heavily on digitization and adequate cataloging of complex, sometimes transient, information. In addition, the KOS facilitates collective preservation by opening up data for sharing between institutions, researchers, and the public, hence rendering the digital heritage repository more holistic and inclusive. Culturally, the project not only aids scholars and archivists in keeping history in record but also generates public concern for maritime heritage, with such resources being brought within reach, relevance, and ongoing interpretation to subsequent generations. Digital preservation facilitates maritime heritage integration into broad world histories, allowing ongoing scholarship, sharing, and commemoration of this material across societies and cultures.

## VI. Conclusion

This study introduced the design of a domain-specific Knowledge Organization Scheme (KOS) for classification and preservation of maritime heritage collections. The main findings outline how the designed KOS can effectively solve issues of unequal metadata practices, enhance discoverability, and facilitate the contextual understanding of maritime artifacts. Through the integration of taxonomy, ontology, and controlled vocabularies, the scheme materially covers gaps in the classification of physical and non-physical maritime heritage. The pilot implementation and subsequent evaluation both validated that the KOS enhanced searchability and access while providing a more organized method of cataloguing varied maritime artifacts, such as ships, navigation instruments, and associated historical events. The value-added contributions of the study toward safeguarding maritime heritage are voluminous. Initially, it provides an adaptable, scalable KOS that can be engineered for various institutions and enables the classification and preservation of maritime artifacts in a more standardized and organized manner. The synergy between semantic web technologies and AI tools adds both precision and efficiency in metadata classification, opening the door for the utilization of sophisticated technologies in heritage preservation. Besides, this study supports the interoperability of maritime heritage data between multiple digital repositories and platforms, thus enabling greater collaboration among institutions and the sustainability of digital maritime collections. Though the suggested KOS is a big leap, there are several limitations. The scheme was only applied to a pilot collection from a single institution, and further evaluation needs to be conducted on its usability for a wider variety of maritime collections. Development of controlled vocabularies and taxonomies was also limited by the available existing maritime vocabulary, requiring continued effort to grow these vocabularies, especially for indigenous maritime cultures and less-documented historical eras. Future studies should also investigate the harmonization of the KOS with future technologies, including virtual reality (VR) and augmented reality (AR), in order to enhance the experience of immersion into maritime heritage even further. In addition, an extension of the KOS incorporating crowd-sourced data and community-based tagging could augment the scheme and guarantee that diverse opinions are catered for within the classification exercise. Lastly, regular assessments with international maritime organizations will be necessary to improve the KOS for wider application and sustained use in the conservation of maritime cultural heritage.

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