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UTILIZATION OF MARINE MAMMALS BY PAST HUMAN SOCIETIES: A GLOBAL SYSTEMATIC REVIEW

UTILIZAÇÃO DE MAMÍFEROS MARINHOS POR SOCIEDADES HUMANAS PRETÉRITAS: UMA REVISÃO SISTEMÁTICA GLOBAL

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ABSTRACT

This study analyses the use of marine mammals from a zooarchaeological perspective through a global systematic review of indexed scientific articles. To assess the scale of human–marine mammal interactions over time, searches were conducted in four databases (Scielo, ScienceDirect, Scopus, and Web of Science) in 11 languages. The results were managed using StArt 3.0.3 and refined with 275 keywords, including scientific names of all known marine mammal species (n = 139). The review identified 60 articles reporting marine mammals in archaeological contexts. In total, 465 archaeological sites from 25 countries across five continents were recorded, representing 54 species. Pinnipeds and cetaceans were the most frequent taxa, indicating widespread and recurrent exploitation of marine mammals by past human societies worldwide.

KEYWORDS

Hunter-gatherer-fisherman; Zooarchaeology; Archaeological sites; Cetaceans; Pinnipeds.

RESUMO

Este estudo analisa o uso de mamíferos marinhos sob a perspectiva da zooarqueologia por meio de uma revisão sistemática global de artigos científicos indexados. Para avaliar a dimensão da relação entre humanos e mamíferos marinhos ao longo do tempo, foram realizadas buscas em quatro bases de dados (Scielo, ScienceDirect, Scopus e Web of Science), em 11 idiomas. Os resultados foram organizados no software StArt 3.0.3 e refinados com 275 palavras-chave, incluindo os nomes científicos de todas as espécies conhecidas de mamíferos marinhos (n = 139). A revisão identificou 60 artigos com registros de mamíferos marinhos em contextos arqueológicos. Ao todo, foram documentados 465 sítios arqueológicos em 25 países e cinco continentes, representando 54 espécies. Pinípedes e cetáceos foram os táxons mais frequentes, indicando o uso amplo e recorrente de mamíferos marinhos por sociedades humanas do passado em escala global.

PALAVRAS-CHAVE

Caçadores-coletores-pescadores; Zooarqueologia; Sítios arqueológicos; Cetáceos; Pinípedes.

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INTRODUCTION

Human societies have adopted a wide range of subsistence strategies, including sedentary, nomadic, hunter-gatherer, and agricultural lifeways (Bas et al., 2023; Lightfoot, 1993; Marlowe, 2005). Across these systems, close relationships with local environments were essential for survival. Plant and animal resources provided food, while wood and minerals were used for tools and shelter construction (Esteban et al., 2020; Lightfoot, 1993; Marlowe, 2005; Smith, 2011). In coastal settings, marine resources, including crustaceans, fish, birds, and marine mammals, played a particularly important role in subsistence economies (Fauvelle, Somerville, 2021; Lewis, Sealy, 2018).

Marine mammals have been exploited for millennia, primarily as a food source (Cooke et al., 2016; Dyke et al., 1999, 2019; Mulville, 2002; Reuther et al., 2021; Savelle, 2005), but also for a wide range of non-dietary uses (Hawkes, 1916; Huelsbeck, 1988; Stefansson, 1913; Weyer, 1961; McGrath et al., 2026). Bones and teeth were commonly used to manufacture tools and ornaments, whereas larger skeletal elements served as construction materials in shelters and other structures (Cunliffe, Brooks, 2016; Corbett, 2012; Huelsbeck, 1988; Savelle, Habu, 2004). Pinniped skins were used to produce clothing, boats, and other materials that offered protection from cold and wind (Hawkes, 1916; Stefansson, 1913; Weyer, 1961).

Archaeological remains of marine mammals provide key evidence for understanding long-term interactions between humans and marine mammals, as well as their role in past subsistence systems. However, most zooarchaeological studies remain geographically restricted, focusing on single sites or limited regions (Castilho, Simões-Lopes, 2008; Black, 2017; Fossile et al., 2020; Ferrasso et al., 2021; Pavei et al., 2015, 2019). A notable exception is the study by Dyke et al. (1999), which documented walrus *Odobenus rosmarus* (Linnaeus, 1758) remains from more than 40 archaeological sites across the Arctic, Pacific, and Atlantic coasts of Canada.

Taken individually, these studies do not capture the global scale or long-term patterns of marine mammal use by past human societies. Systematic reviews offer a powerful approach to synthesize dispersed evidence, identify knowledge gaps, and define priorities for future research (Moss et al., 2006; Ramos et al., 2020). Here, we present a global systematic review of indexed scientific literature to examine the exploitation of marine mammals by ancient human societies, identifying the principal taxa involved, the main geographic areas of exploitation, and the geological periods with the highest frequency of records.

MATERIALS AND METHODS

A systematic review was conducted to investigate the historical use of marine mammals by past human societies. The review followed two main stages. First, a broad survey of indexed scientific literature was carried out using four electronic databases: SciELO, ScienceDirect, Scopus, and Web of Science. The initial search took place in April 2022 and included articles published in English, Portuguese, and Spanish, using the term “Archaeological Sites” as the search cri-

terion. A second search was conducted in October 2024, expanding language coverage to French, Russian, Mandarin, Japanese, Hindi, Arabic, Bengali, and Urdu. Together, both searches yielded a total of 25,447 scientific articles.

In the second stage, all retrieved articles were exported to the StArt (State of the Art through Systematic Reviews), version 3.0.3 (Fabbri et al., 2012; Fabbri et al., 2016), where the screening and selection process was performed. A total of 25 keywords were applied across 11 languages, resulting in 275 keywords. In addition, the scientific names of all recognized marine mammal species, totaling 139 taxa, were included following the taxonomy proposed by the Society for Marine Mammalogy (Committee on Taxonomy, 2025). The keywords consisted of specialized terms related to archaeology and marine mammals, including archaeozoology, cetacean, dolphin, pinniped, seal, sea lion, walrus, manatee, sirenia, and taphonomy, and were selected to identify records of marine mammals in archaeological contexts.

The keywords were searched within the titles, abstracts, and keywords of the articles imported into the StArt software. Each keyword automatically assigned one point to an article, and articles that received no score were excluded from the sample. Articles with a score of one or higher were subsequently screened individually based on their abstracts. Only articles meeting the following inclusion criteria were retained: first, the presence of marine mammal remains in archaeological sites; and second, a clearly defined geographical location of the sites. This screening process resulted in the identification of 108 articles reporting apparent records of marine mammals in archaeological contexts. These articles were then read in full, and only those that satisfied all inclusion criteria were retained, resulting in a final sample of 60 articles, as detailed in Supplementary Material 2.

Data from the selected articles were systematically tabulated into three main categories. The first category included general information about the articles, such as year of publication, study focus, database source, and authorship. The second category comprised information related to the archaeological sites, including continent, country, associated aquatic environment, geographical coordinates, and chronological attribution. The third category included species level information, such as the presence of marine mammal taxa and the number of identified specimens, including bones, teeth, and baleen.

The data were analysed to assess the frequency of species per article and per archaeological site, the distribution of archaeological sites by country and continent, and the associated aquatic environments. Due to its large geographical extent, the American continent was divided into North America and South America. Aquatic environments were identified based on information provided by the original authors; when this information was unavailable, site locations were classified according to the framework of the Flanders Marine Institute (2021). When reported, values for the Minimum Number of Individuals were recorded and analysed. The geological periods of the archaeological sites were determined based on information provided in the articles and grouped into the Upper Pleistocene, spanning from 126,000 to 11,701 years before present; the Early Holocene, from 11,700 to 8,201 years; the Middle Holocene, from 8,200 to 4,201 years;

and the Late Holocene, from 4,200 years to the present, following Walker et al. (2018) and Cohen et al. (2020).

RESULTS

The systematic review resulted in 60 indexed scientific articles with records of marine mammals in archaeological sites. All major groups, including Cetacea, Sirenia, Pinnipedia, Ursidae, and Mustelidae, were represented. In total, 465 archaeological sites were recorded across five continents (Figure 1). The American continent presented the highest number of recorded archaeological sites (n = 361; 77.6%), with 301 sites (64.7%) in North America and 60 sites (12.9%) in South America, followed by Europe (n = 68; 14.6%), Africa (n = 14; 3.0%), Asia (n = 18; 3.9%), and Oceania (n = 4; 0.9%) (Figure 1). No archaeological sites were recorded on the Antarctic continent. Archaeological sites with marine mammals were recorded in five coastal regions (Figure 1). Most were found in the North Atlantic Ocean, with the highest number of records, totalling 138 (29.68%) archaeological sites, followed by the Arctic Ocean with 125 (26.88%), the North Pacific Ocean (n = 92; 19.78%), the South Atlantic Ocean (n = 63; 13.55%), Lake Baikal (n = 12; 2.58%), in Russia, and the South Pacific Ocean (n = 5; 1.08%) (Figure 1). It is important to mention that no archaeological sites were recorded in the Indian Ocean.

Archaeological sites were found in 25 countries (Figure 2). The countries with the highest number of records were Canada with 198 (41.5%), followed by the United States of America (USA) with 92 (19.3%), Argentina (n = 31; 6.5%), Brazil (n = 28; 5.9%) and the United Kingdom (n = 21; 4.4%) (Figure 2). Our results suggest a gradual increase in studies on the zooarchaeology of marine mammals, with a higher number of publications in the last decade (Supplementary Material 2).

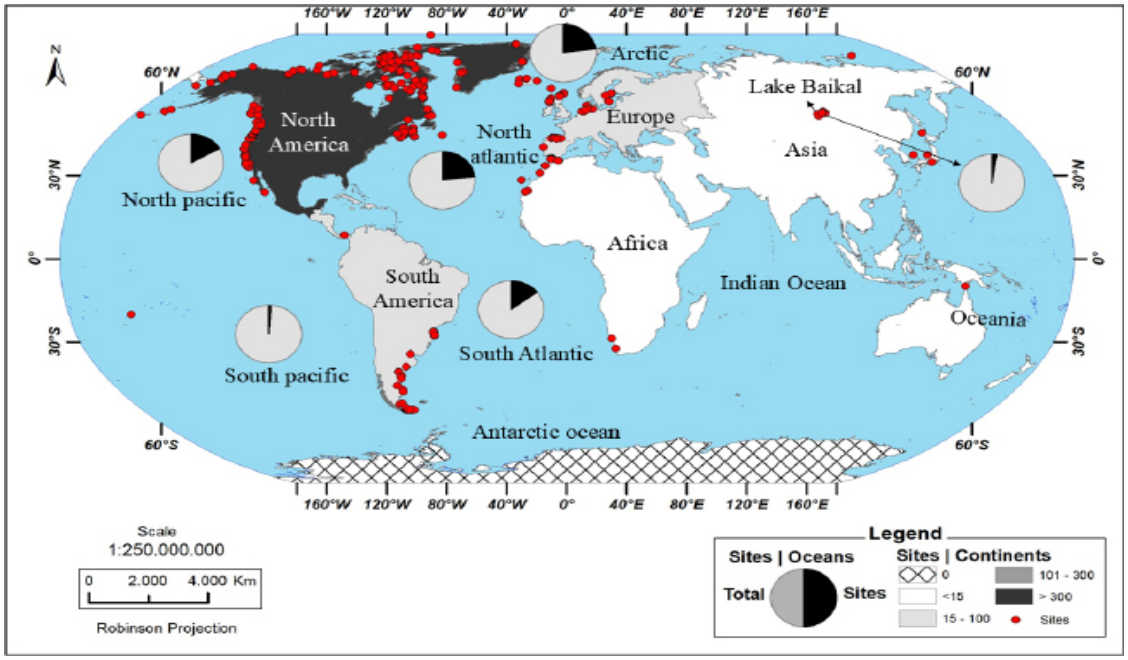


Figure 1: Distribution of archaeological sites used by ancient human societies with evidence of marine mammals recorded in the systematic literature review. The different colors of the continents are related to the number of archaeological sites with records of marine mammals recorded on each continent.

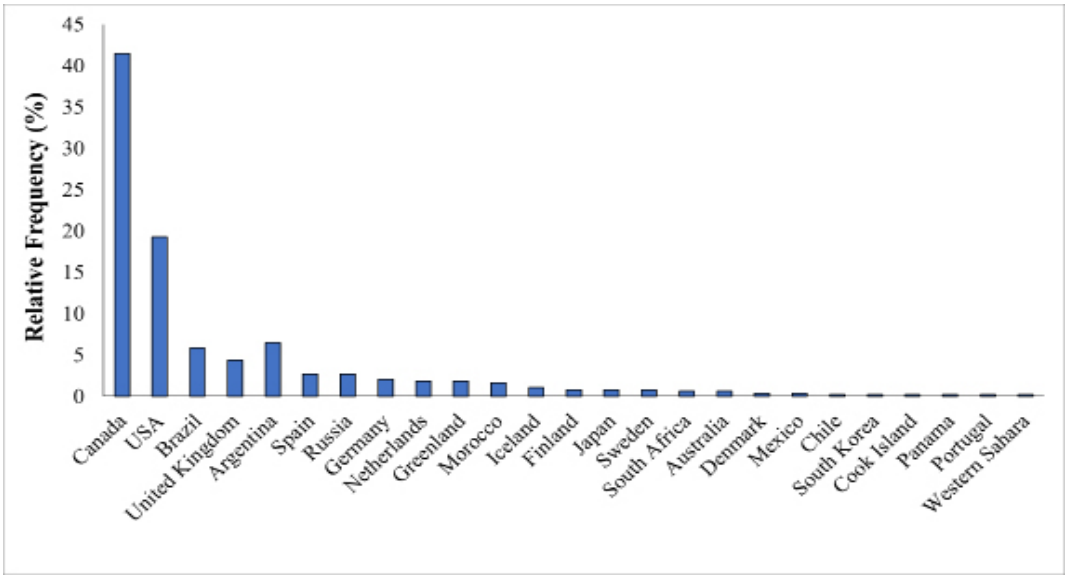


Figure 2: Relative frequency of the distribution of archaeological sites used by ancient human societies with records of marine mammals recorded in the systematic literature review according to the countries in which they are located.

When analysing the archaeological sites, it was possible to identify the geological period in 311 of them (66.88%). One hundred and thirty (27.95%) covered more than one geological period and 44 (9.46%) were not dated. The oldest archaeological sites with marine mammals dates from 39,000 years B.P. for cetaceans in Spain and 37,000 years B.P. for pinnipeds in Africa. The oldest dated record was between 10,000-7,480 B.P. on Zhokhov Island, Russia for *Ursus maritimus* Linnaeus, 1958. The Mustelidae family had the oldest dated record between 12,500-8,900 B.P. in

California, USA, and Sirenia had the oldest record between 4,000-300 B.P. in the Torres Strait in Australia (Supplementary Material 1). The late Holocene (41.07%) was the geological age with the highest number of archaeological sites recorded (Figure 3).

Pinnipeds were present in 48 (80.00%) articles and 344 (73.98%) archaeological sites, and 21 species were identified. Cetaceans were present in 22 (36.67%) articles and were recorded in 117 (25.16%) archaeological sites, with 30 species identified. The species *Ursus maritimus* was present in 5 (8.33%) articles and 43 (9.25%) archaeological sites. *Enhydra lutris* (Linnaeus, 1758) was the only species of sea otter recorded, being present in six (10.00%) articles and 28 (6.02%) archaeological sites. *Dugong dugon* (Müller, 1776) was the only species of sirenian recorded, being present in one (1.67%) article and three (0.65%) archaeological sites.

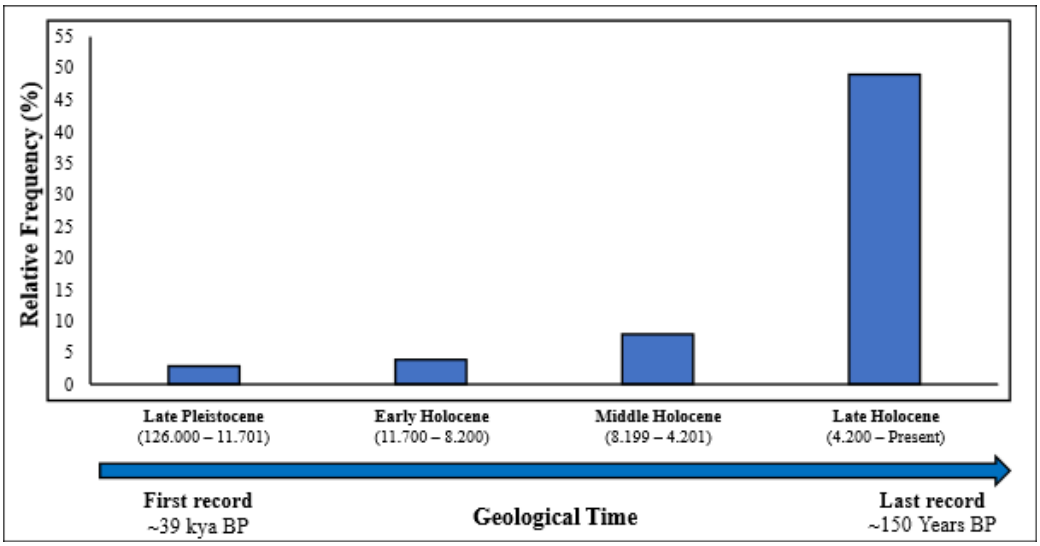


Figure 3: Relative frequency of archaeological sites used by ancient human societies with records of marine mammals recorded in the systematic literature review according to geological period.

All three families of pinnipeds were recorded (Figure 4). Phocidae was present in 29 (48.33%) articles and 206 (44.30%) archaeological sites, with 11 species recorded. Otariidae was present in 23 (38.33%) articles and 75 (16.13%) archaeological sites, with nine species recorded. Odobenidae was present in nine (15.00%) articles and 110 (23.66%) archaeological sites (Supplementary Material 1). As for the species of pinnipeds identified, *Odobenus rosmarus* was the most representative, recorded in 110 (23.66%) archaeological sites, followed by *Pusa hispida* (Schreber, 1775) (11.18%), *Phoca vitulina* Linnaeus, 1758 (10.75%), *Erignathus barbatus* (Erxleben, 1777) (9.46%) and *Callorhinus ursinus* (Linnaeus, 1758) (7.10%) (Figure 5 and Supplementary Material 2).

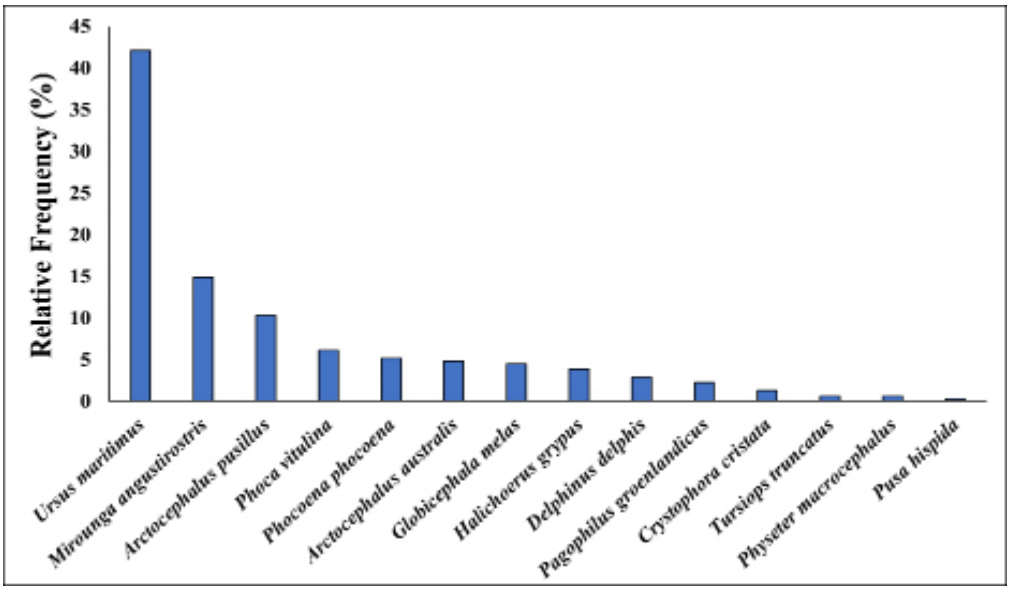


Figure 4: Relative frequency of marine mammal families recorded in archaeological sites of ancient human societies in the systematic literature review.

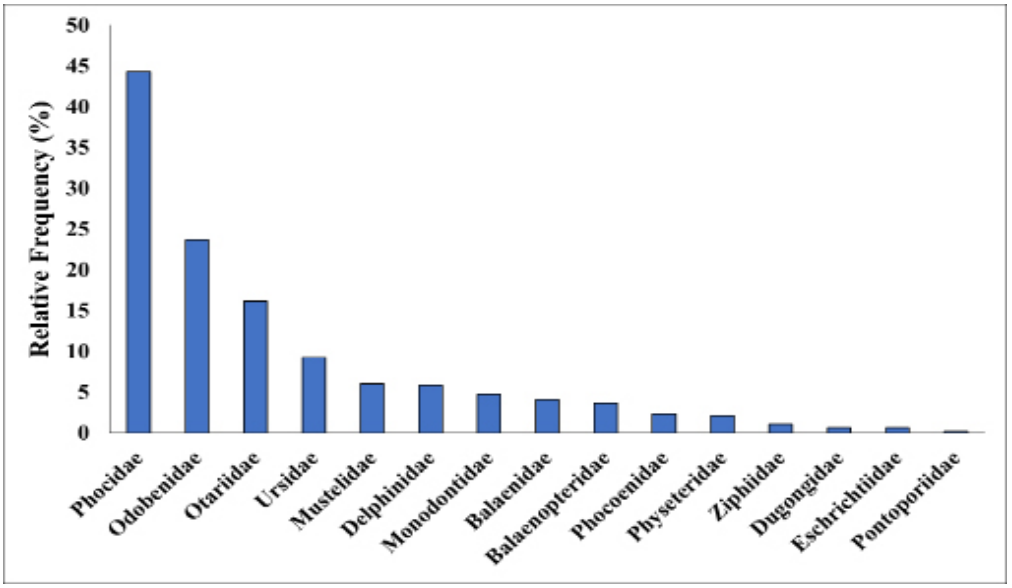


Figure 5: Relative frequency of pinniped species recorded in archaeological sites of ancient human societies in the systematic literature review.

Of the cetaceans recorded, 92.63% were Odontoceti (16 articles; 62 archaeological sites), 0.92% Mysticeti (11 articles; 33 AS), and 6.24% could not be identified. Within Odontoceti, 21 species were recorded, distributed in six families (Figure 4). Odontocetes were present in 16 (26.67%) articles and 62 (13.33%) archaeological sites. Monodontidae and Delphinidae had the highest number of odontocete records in archaeological sites (Figure 4). Monodontidae was present in three (5.00%) articles and 22 (4.73%) archaeological sites, while Delphinidae was present in 13 (21.67%) articles and 27 (5.81%) archaeological sites. Phocoenidae was present in four (6.67%) articles and 11 (2.37%) archaeological sites. Physeteridae was present in six (10.00%) articles and 10 (2.15%) archaeological sites, followed by Ziphiidae (three articles, 5.00%; five archaeological

sites, 1.08%) and Pontoporiidae (one article, 1.67%; one archaeological site, 0.22%) (Supplementary Material 2).

Mysticeti: nine species were recorded in three families (Figure 4). The Balaenidae family was present in seven (11.67%) articles and 19 (4.09%) archaeological sites. The Balaenopteridae family was present in eight (13.33%) articles and 17 (3.66%) archaeological sites. The Eschrichtiidae family was present in one (1.67%) article and three (0.65%) archaeological sites. The most representative species of Cetacea was *Eubalaena glacialis* (Müller, 1776), recorded in 15 (3.23%) archaeological sites, followed by *Physeter macrocephalus* Linnaeus, 1758 (2.15%), *Phocoena phocena* (Linnaeus, 1758) (2.15%), *Tursiops truncatus* (Montagu, 1821) (1.94%) and *Balaenoptera physalus* (Linnaeus, 1758) (1.51%) (Figure 6 and Supplementary Material 2).

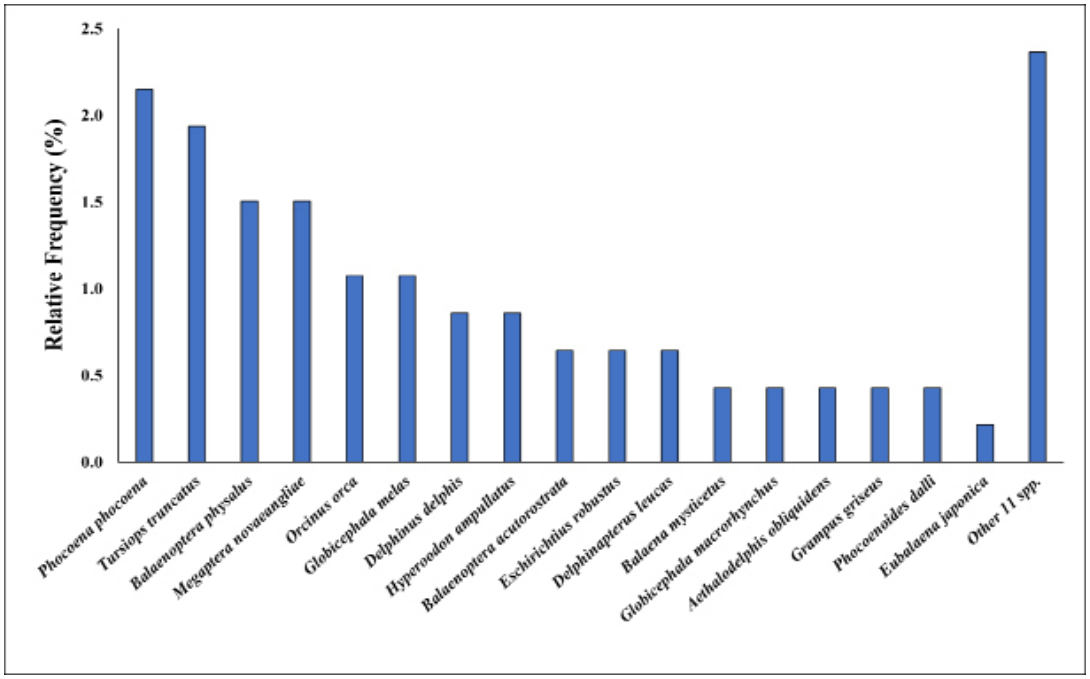


Figure 6: Relative frequency of cetacean species recorded in archaeological sites of past human societies in the systematic literature review.

Of the articles analysed in the review, only 15% (n = 9) presented a minimal number of individuals (MNI). The MNI was not present for all the archaeological sites and species recorded in these articles, making it inconsistent. Among the marine mammals in these articles, 14 species and a total of 618 individuals were recorded, with Ursus maritimus (n =260) being the most representative (Figure 7).

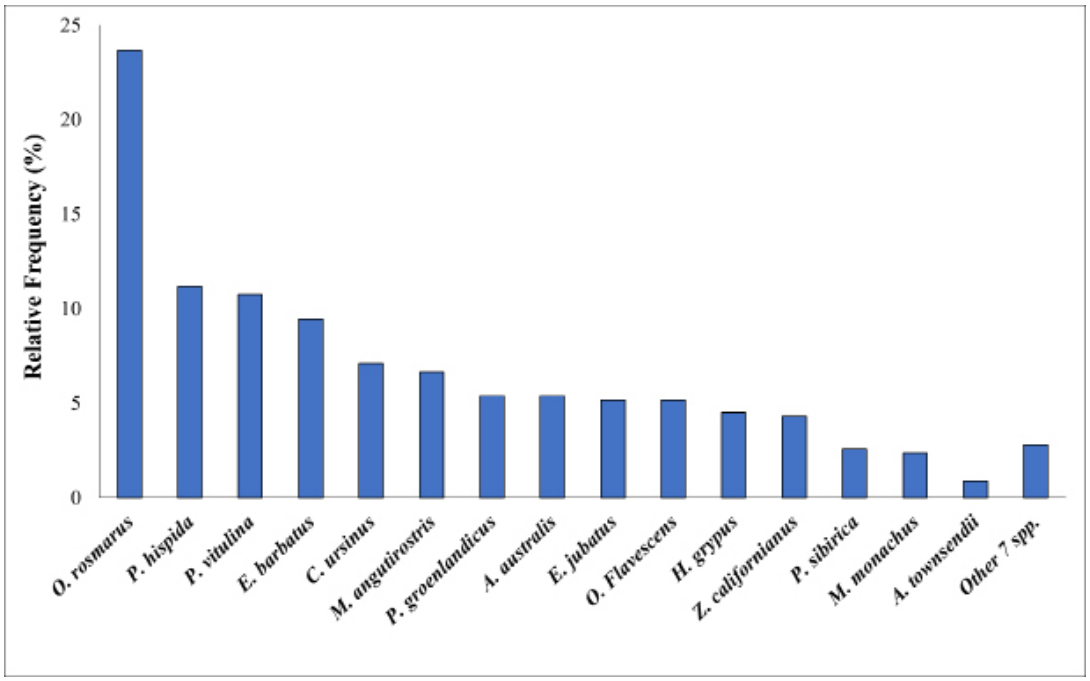


Figure 7: Relative frequency of marine mammal specimens recorded in archaeological sites of past human societies in the systematic literature review that had a minimum number of individuals.

DISCUSSION

Global systematic reviews in indexed databases are extremely powerful for bringing together large amounts of information on a given topic and broadening understanding of the subject studied (Butler; Campbell, 2004; Moss *et al*., 2006; Schaap *et al*., 2023). Here, a broad systematic review was carried out in four of the most comprehensive global databases (Scielo, ScienceDirect, Scopus, and Web of Science), in eleven different languages, English, Portuguese, Spanish, French, Russian, Mandarin, Japanese, Hindi, Arabic, Bengali and Urdu. The software *State of the Art* (*StArt*) version 3.0.3 (Fabbri et al., 2016) was used to identify studies more easily and safely using a scoring system. On the other hand, it was possible to observe that published studies were not found in the systematic review and were not used in this study. In this context, researchers should be encouraged to report their studies on marine mammal archeology in indexed journals with greater visibility, this would enable greater insights into the relationship between past human societies and marine mammals.

A full analysis of the 60 scientific articles on the use of marine mammals by ancient human societies revealed that all groups of marine mammals have been recorded in archaeological sites on almost every continent. Pinnipeds were the most representative mammals, comprising around 60% of the species described today. Of the cetaceans, approximately 32.25% of the species have been identified, followed by 20% of sirenians. In addition, there is a single species of marine ursid and one of the three species of marine mustelids. Among the families recorded in this study, Phocidae was the most significant, being present in 206 (44.30%) archaeological sites, followed by Odobenidae, Otariidae, Ursidae and the cetacean families Monodontidae and

Delphinidae. Most of the articles used in the systematic review were published in the last decade (58.33%). This significant increase in publications indicates an increase in the number of zooarchaeological studies in recent years.

In the North Atlantic Ocean, we can highlight the records of archaeological sites with marine mammals in the Baltic Ocean, mainly with records of *Halichoerus grypus* (Alghren *et al*., 2022; Storå, 2002). On the east coast of Canada, a large number of records of Phocidae can be highlighted (Black, 2017; Desjardins, 2020; Dyke *et al*., 1999; Dyke, 2019). The abundance of Phocidae in Canada can be explained by the extensive use of this resource by human societies that inhabited the region at least 33,000 years B.P. (Coltrain et al., 2016; Krupnik *et al*., 2012; Savelle, 1994). The United Kingdom is also a region in the North Atlantic Ocean with a large number of recorded archaeological sites, mainly in the Outer Hebrides, Orkney, and Shetland Islands in Scotland (Mulville, 2002). The large number of recorded archaeological sites with marine mammals in the United Kingdom can be explained by the fact that they were a highly sought-after resource, both for making utensils and tools and for using oil (Álvarez-Fernández, 2011; Clark, 1947; Mulville, 2002). Also on the European continent, more specifically on the north coast of Spain, there are records of the consumption of marine mammals since the Pleistocene (Álvarez-Fernández, 2011).

In the Arctic Ocean, there are records in the Bering Sea and the Chukchi Sea (Crockford; Frederick, 2007; Reuther *et al*., 2021). Also in the Arctic Ocean, in Greenland, on the Russian island of Zhokhov, and in the Canadian states of Quebec, Nunavut, and the Northwest Territories, the highest Number of Identified Specimens (NISP[1]= 234,864) of marine mammals have been recorded, especially of Phocidae, Monodontidae, and Odobenidae, indicating a high utilization of these groups in these localities (Desjardins, 2020).

In the North Pacific Ocean, records of *Zalophus japonicus* stand out in the Sea of Japan (Lee *et al*., 2019; Sakahira; Niimi, 2007), in Canada, in the state of British Columbia, records of *Enhydra lutris* stand out (Elliott *et al*., 2020; Szpak et al. 2012) and in the United States of America, in the states of Alaska, Washington and especially in Southern California, on the islands of San Miguel, Santa Rosa, and Santa Cruz, with a large number of of pinnipeds, mainly *Callorhinus ursinus* and *Zalophus californianus* (Burton *et al*., 2001; Burton *et al*., 2002; Hofman et al., 2018; Porcasi; Fujita 2000).

In the South Atlantic Ocean, we can highlight the large number of records of *Arctocephalus australis* and *Otaria flavescens* in Argentine Patagonia, especially in *Tierra del Fuego* and *Península Valdés* (Blasi *et al*., 2013; Borella *et al*., 2003; Borella *et al*., 2014; Muñoz, 2008; Zenteno *et al*., 2015; Saporiti *et al*., 2013). In the south of Brazil, Babitonga Bay and *Santa Catarina* Island have seen numerous records of cetaceans, mainly *Eubalaena australis*, *Tursiops truncatus*, *Stenella frontalis* and *Pontoporia blainvillei*, and pinnipeds such as *A. australis* and *O. flavescens* (Castilho; Simões-Lopes, 2008; Fossile *et al*. 2020).

In the South Pacific Ocean, we can highlight the only record of Sirenia (in Torres Strait,

[1] The Number of Identified Specimens (NISP) corresponds to the total number of identified faunal remains attributed to a given táxon (Grayson, 1984).

Australia) found in the review of the 60 articles analysed here. This result may indicate a low use of Sirenia by past human societies (Urwin *et al*., 2016). The Indian Ocean has historically been extensively occupied and used for both navigation and fishing (Patnaik; Chauhan, 2009), however, it was the only ocean besides the Antarctic where no archaeological sites were recorded in the articles analysed here. On the other hand, there are records of the use of *Dugong dugon* in archaeological sites in the United Arab Emirates, but this information is restricted to articles that are not indexed in any of the databases reviewed in this study (Méry *et al*., 2009).

The Arctic Circle was the only geographical region where cetaceans were recorded in abundance, especially Monodontidae. Despite the abundance of records, this group was most likely a secondary resource for human societies when compared to pinnipeds, which were more abundant in the region, especially for the Inuit, who inhabited the Canadian Arctic region extensively (Friesen; Arnold, 1995; Douglas *et al*., 2004). Several Inuit groups developed sophisticated hunting technologies, including the use of boats and harpoons for cetacean hunting (Birket-Smith, 1971; Boas, 1964). They also had extensive knowledge of the migratory patterns of Monodontidae, which allowed them to use specific strategies for hunting these resources, such as setting up seasonal camps to capture, slaughter, and process these animals (Savelle, 1994; Savelle, 1995).

The predominance of pinniped records (80%) in archaeological sites around the world compared to cetaceans can be explained by the life cycle of pinnipeds, which, unlike cetaceans, use terrestrial environments for resting and reproduction. During the breeding season, many pinniped species, especially the Otariidae, group together in large colonies of several hundred animals (Bonin *et al*., 2014; Cassini, 1999), which makes them more vulnerable to capture and slaughter. This pattern of the pinnipeds' life cycle would make it easier to capture individuals, especially phocids, which have more limited movement on land than otariids (Backhouse, 1961; Beentjes, 1990; Ray, 1963). The capture and slaughter of pinnipeds probably took place without the need for tools made specifically for hunting these animals. Cetaceans, on the other hand, require more specialized tools for their hunting, capture, slaughter, and transport, such as boats, nets, and harpoons (Huelsbeck, 1988). In addition to a high level of cooperation and organization on the part of the hunters, cetacean hunting was probably a group activity (Savelle; McCartney, 1999). While some populations developed hunting and navigation technology for the active hunting of cetaceans, this cannot be said for every population, many were opportunistic gatherers, only utilizing stranded carcasses (Mesfin *et al*., 2022). The differentiation between active exploitation and opportunistic scavenging is a difficult line to draw, the lack of preservation of the tools used and the fact that many of the societies present in this study either disappeared or drastically changed their lifestyle, making this analysis very difficult (Mesfin *et al*., 2022). Besides technological aspects, geography and food availability also play a part, areas with coves and inlets in which the entry of cetaceans is a regular event would incentivize active exploitation due to this geographical aspect facilitating the capture, the lack of other food sources would also incentivize the exploitation of marine mammals despite it being much more laborious to hunt (Huelsbeck, 1988; Morello *et al*., 2012; Porcasi; Fujita, 2000; Savelle, 1994).

The Delphinidae family is another group of Cetacea with a prominent presence in archaeological sites (5.81%), Delphinidae has been recorded on all continents except Antarctica and Oceania (Itoh *et al*., 2011; Fossile *et al*., 2020; Klein *et al*., 1999; Porcasi; Fujita, 2000; Prummel; Heinrich, 2005). The capture of Delphinidae almost everywhere on the planet is associated with the distribution pattern of the family, which has a cosmopolitan distribution occurring in all the world's oceans (Rice, 1998). On the other hand, the Monodontidae family is represented by only two species (*Monodon monoceros and Delphinapterus leucas*), which are restricted to the Arctic Ocean, (Heide-Jørgensen *et al*., 2013; O'Corry-Crowe *et al*., 1997).

Cetaceans were the oldest recorded in the archaeological sites, at least 39,000 years B.P., followed by pinnipeds, which have been used for at least 37,000 years B.P. The results also suggest that the geological period of greatest use of marine mammals was the late Holocene, around 4,000 years B.P. The results show a gradual increase in the number of archaeological sites with records of marine mammals over geological time. This could be associated with a greater distribution and abundance of earlier human populations in the late Holocene and/or better preservation of more recent archaeological sites over geological time.

The processing of carcasses results in the selection of anatomical parts that consequently reflects the deposition of the archaeological site (Binford, 1981). Furthermore, taking into account the temporal magnitude of different archaeological sites, it is inevitable to think about the underestimation of the quantity of preserved remains. The preservation of anatomical remains in archaeological sites is related to factors such as physical and chemical factors and adverse climatic conditions, for example, open-air sites tend to have a negative impact on the preservation of organic material in relation to shelter sites, which tend to preserve more remains (Pineda; Saladié, 2022). It is important to mention that open air and sheltered archaeological sites were recorded in the present research.

Many of the bones deposited in archaeological sites are impacted by soil diagenetic actions and bioturbation, causing taphonomic processes to directly impact the preservation of organic remains in an archaeological site (Behrensmeyer, 1984; Lyman, 1994). A phenomenon that culminates in bone degradation and fragmentation is weathering. This phenomenon is produced by climatic aspects, humidity and soil chemistry and directly influences the preservation of remaining bones on the surface (Behrensmeyer, 1978). Furthermore, the disposal of these carcasses attracts terrestrial carnivores that can fragment, completely destroy and even carry away bones, causing false interpretations and underestimation of the material in archaeological sites (Lyman, 1994).

The present paper presents a lack of records of the utilization of marine mammals in certain regions of the world, such as the western coast of south America and the Eurasian portion of the Arctic circle. This gap can be caused by numerous reasons, for example, the Russian portion of the Arctic circle has few articles reporting the utilization of marine mammals while being a region with traditional populations that historically utilized such resources, this can be caused by motives such as the archaeological research having a different focus than recording the marine

mammal remains, articles being published in non-indexed forms (e.g., dissertations and book chapters), the archaeological sites not being accessible due to changes in the environment, to name a few reason. Changes to the environment affect archaeological sites worldwide, especially those close to the shore. Changing sea-level and ice coverage (in the polar regions) can occult or even destroy archaeological sites (Anderson *et al*., 2017; Bailey; Cawthra, 2023). This must be taken into consideration when analysing the utilization of marine mammals based solely based on archaeological sites, that due to their proximity to the coast are exceptionally vulnerable to the aforementioned changes.

In conclusion, this global systematic review demonstrates the breadth and diversity of marine mammal use by past human societies across continents, mainly throughout the Holocene. The evidence compiled here highlights not only the central role of pinnipeds and cetaceans in subsistence and material culture but also the geographical and temporal variability of this relationship. It should be acknowledged that some relevant studies may not have been captured in this review, particularly those published in non-indexed journals or those that did not include the selected keywords in their titles, abstracts, or keywords, potentially influencing the completeness of the dataset. Even so, the observed gaps in the archaeological record emphasize the importance of expanding research efforts, especially in underrepresented regions and through the integration of non-indexed sources. By revealing the deep-time connections between humans and marine mammals, this study underscores the value of zooarchaeology in understanding long-term socio-ecological dynamics and provides a foundation for future interdisciplinary research linking archaeology, ecology, and conservation.

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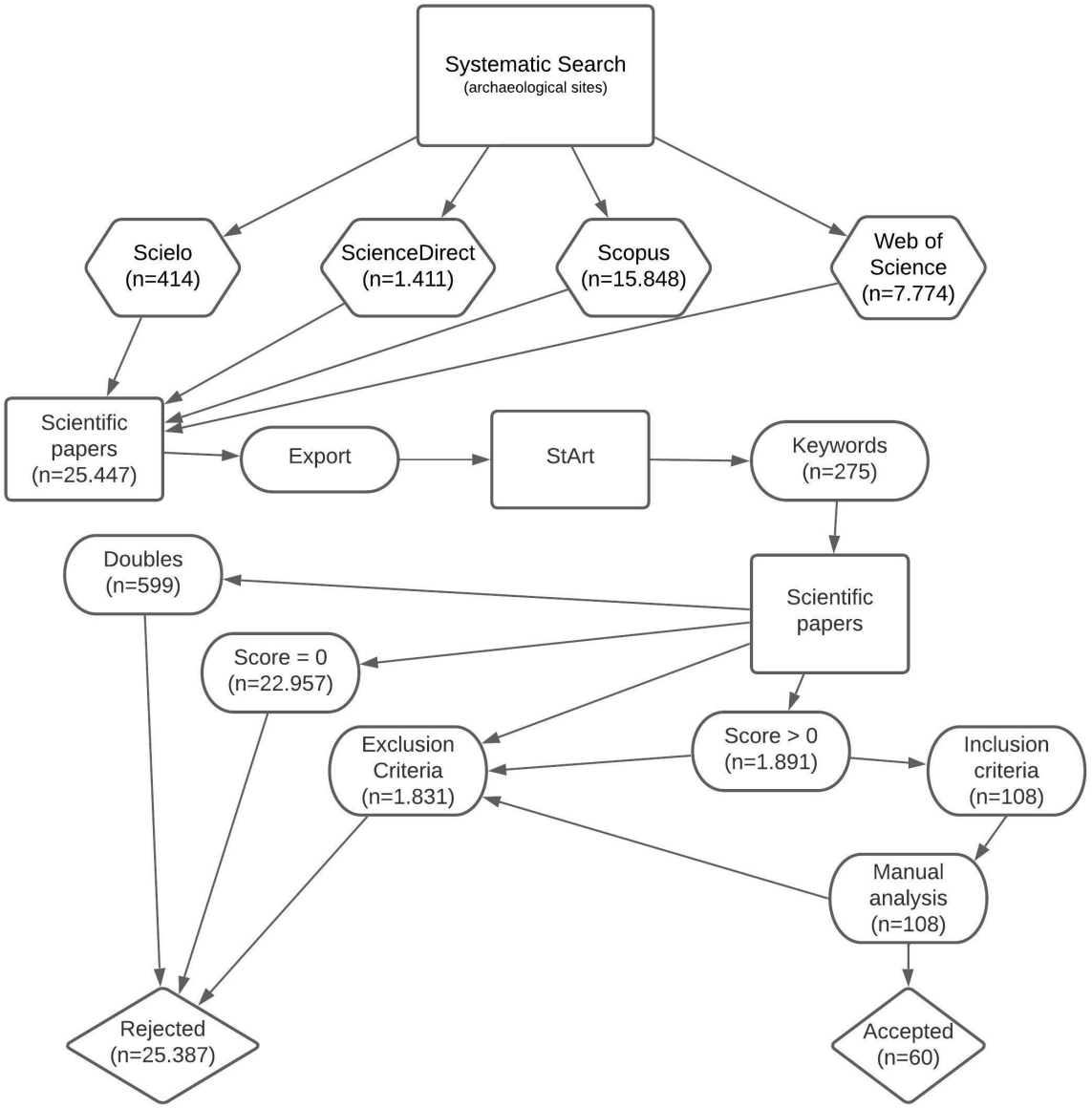
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ZENTENO, Lisette; BORELLA, Florencia; GÓMEZ OTERO, Julieta; PIANA, Ernesto; BELARDI, Juan B.; BORRERO, Luis A.; SAPORITI, Fabiana; CARDONA, Luis; CRESPO, Enrique. Shifting niches of marine predators due to human exploitation: the diet of the South American sea lion (Otaria flavescens) since the late Holocene as a case study. Paleobiology, v. 41, n. 3, p. 387–401, 2015.

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Utilization of marine mammals by past human societies: a global systematic review

Flow Chart of the systematic review of scientific articles carried out in this study.



SEIBERT, Lucas; ELIAS, Guilherme Alves; PAVEI, Diego Dias; CASTILHO, Pedro Volkmer; MACHADO, Rodrigo; CAMPOS, Juliano Bitencourt. Utilization of marine mammals by past human societies: a global systematic review.

Year of publication of the articles found in the systematic review carried out in this study. The oldest article found in the systematic review carried out here on the presence of marine mammals was published in 1993, while the most recent was published in 2022. The greater number of publications in the last decade.

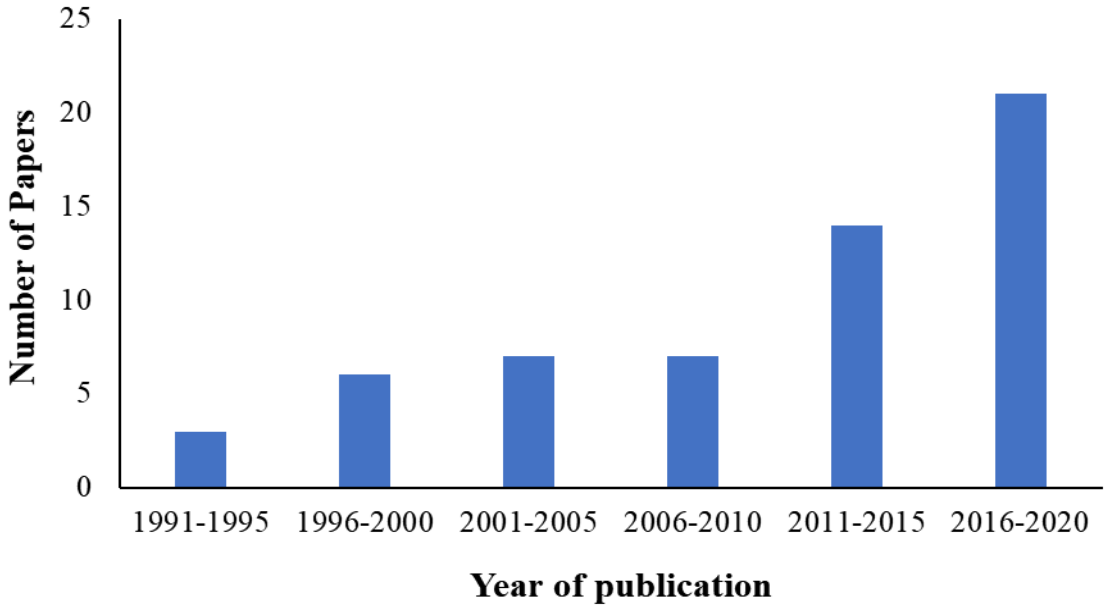


Table: Marine mammals recorded in the archaeological sites used by ancient human societies analysed in the systematic bibliographic review of this study.

Taxa	Presence in Articles	Frequency in Articles (%)	Presence in	Frequency at Archaeological Sites (%)	Number of Identified Specimens	Frequency of Anatomical Parts (%)
Carnivora Pinnipedia	51	80.00	362	73.98	257.220	87.20
Pinnipedia undet	4	6.67	9	1.94	4.015	1.36
Otariidae	24	40.00	93	20.00	22.795	7.72
Otariidae undet	7	11.67	18	3.87	55	0.02
Arctocephalus sp.	1	1.67	1	0.22	1	0.0003
Arctocephalus australis (Zimmermann, 1783)	4	5.00	25	1.51	199	0.07
Arctocephalus pusillus (Schreber, 1775)	2	3.33	3	0.65	4.759	1.61
Arctocephalus townsendi (Merriam, 1897)	3	5.00	4	0.86	39	0.01
Arctocephalus tropicalis (Gray, 1872)	1	1.67	1	0.22	3	0.001
Callorhinus ursinus (Linnaeus, 1758)	8	13.33	33	7.10	13.058	4.43
Eumetopias jubatus (Schreber, 1776)	6	10.00	24	5.16	4.264	1.45
Otaria flavescens (Shaw, 1800)	5	8.33	24	5.16	198	0.07
Zalophus californianus (Lesson, 1828)	5	8.33	20	4.30	178	0.06
Zalophus japonicus (Peters, 1866)	3	5.00	4	0.86	11	0.004
Phocidae	28	46.67	200	43.01	222.390	75.41
Phocidae undet	7	11.67	81	17.42	201.127	68.20

Crystophora cristata (Erxleben, 1777)	1	1.67	3	0.65	12	0.004
Erignathus barbatus (Erxleben, 1777)	6	10.00	44	9.46	6.288	2.13
Halichoerus grypus (Fabricius, 1791)	6	10.00	21	4.52	208	0.07
Histriophoca fasciata (Erxleben, 1777)	1	1.67	1	0.22	1	0.0003
Mirounga angutirostris (Gill, 1866)	4	6.67	31	6.67	103	0.03
Monachus monachus (Hermann, 1779)	2	3.33	11	2.37	30	0.01
Pagophilus groenlandicus (Erxleben, 1777)	6	10.00	25	5.38	2.526	0.86
Phoca largha Pallas, 1811	1	1.67	1	0.22	2	0.001
Phoca vitulina Linnaeus, 1758	11	18.33	50	10.75	4.964	1.68
Pusa hispida (Schreber, 1775)	9	15.00	52	11.18	6.968	2.36
Pusa sibirica (Gmelin, 1788)	3	5.00	12	2.58	174	0.06
Odobenidae	9	15.00	110	23.66	8.020	2.72
Odobenus rosmarus (Linnaeus, 1758)	9	15.00	110	23.66	8.020	2.72
Cetacea	22	36.67	117	25.16	29.393	9.97
Cetacea undet	14	23.33	55	11.83	1.892	0.64
Mysticeti	11	18.33	33	7.10	272	0.09
Mysticeti undet	1	1.67	1	0.22	5	0.002
Balaenidae	7	11.67	19	4.09	207	0.07
Balaena mysticetus Linnaeus, 1758	2	3.33	2	0.43	136	0.05

Eubalaena australis (Desmoulins, 1822)	1	1.67	1	0.22	41	0.01
Eubalaena glacialis (Müller, 1776)	3	5.00	15	3.23	29	0.01
Eubalaena japonica (Lacépède, 1818)	1	1.67	1	0.22	1	0.0003
Balaenopteridae	8	13.33	17	3.66	57	0.02
Balaenopteridae undet	1	1.67	1	0.22	35	0.01
Balaenoptera acutorostrata Lacépède, 1804	2	3.33	3	0.65	3	0.001
Balaenoptera musculus (Linnaeus, 1758)	1	1.67	1	0.22	2	0.001
Balaenoptera physalus (Linnaeus, 1758)	4	6.67	7	1.51	8	0.003
Megaptera novaeangliae (Borowski, 1781)	3	5.00	7	1.51	9	0.003
Eschrichtiidae	1	1.67	3	0.65	3	0.001
Eschirichtius robustus (Lilljeborg, 1861)	1	1.67	3	0.65	3	0.001
Odontoceti	16	26.67	62	13.33	27.229	9.23
Delphinidae	13	21.67	27	5.81	8.379	2.84
Delphinidae undet	8	13.33	14	3.01	7.707	2.61
Aethalodelphis obliquidens (Gill, 1865)	2	3.33	2	0.43	171	0.06
Delphinus sp.	2	3.33	2	0.43	2	0.001
Delphinus delphis Linnaeus, 1758	4	6.67	4	0.86	179	0.06
Globicephala melas (Traill, 1809)	5	8.33	5	1.08	10	0.003
Globicephala macrorhynchus Gray, 1846	2	3.33	2	0.43	2	0.001

Grampus griséus (G. Cuvier, 1812)	2	3.33	2	0.43	2	0.001
Lissodelphis borealis (Peale, 1849)	1	1.67	1	0.22	1	0.0003
Lagenorhyncus albirostris (Gray, 1846)	1	1.67	1	0.22	1	0.0003
Orcinus orca (Linnaeus, 1758)	3	5.00	5	1.08	8	0.003
Pseudorca crassidens (Owen, 1846)	1	1.67	1	0.22	1	0.0003
Stenella sp.	2	3.33	2	0.43	30	0.01
Stenella frontalis (G. Cuvier, 1829)	1	1.67	1	0.22	51	0.02
Stenella longirostris (Gray, 1828)	1	1.67	1	0.22	1	0.0003
Steno bredanensis (Lesson, 1828)	1	1.67	1	0.22	6	0.0020
Sotalia guianensis (P.J. Van Beneden, 1864)	1	1.67	1	0.22	1	0.0003
Tursiops truncatus (Montagu, 1821)	8	13.33	9	1.94	206	0.07
Pontoporiidae	1	1.67	1	0.22	17	0.01
Pontoporia blainvillei (Gervais and d'Orbigny, 1844)	1	1.67	1	0.22	17	0.01
Monodontidae	3	5.00	22	4.73	18.225	6.18
Monodontidae undet	2	3.33	2	0.43	18.219	6.18
Delphinapterus leucas (Pallas, 1776)	3	5.00	3	0.65	6	0.002
Physeteridae	6	10.00	10	2.15	14	0.00
Physeter macrocephalus Linnaeus, 1758	6	10.00	10	2.15	14	0.005
Phocoenids	4	6.67	11	2.37	604	0.20

Phocoenideae undet	1	1.67	1	0.22	1	0.0003
Phocoenoides dalli (True, 1885)	1	1.67	2	0.43	2	0.001
Phocoena phocoena (Linnaeus, 1758)	3	5.00	10	2.15	601	0.20
Ziphiidae	3	5.00	5	1.08	7	0.002
Berardius bairdii Stejneger, 1883	1	1.67	1	0.22	1	0.0003
Hyperoodon ampullatus (Forster in Kalm, 1770)	2	3.33	4	0.86	6	0.002
Carnivora not Pinnipedia	11	18,04	71	14,70	8.114	2,75
Ursidae	5	8,20	43	8,90	7.186	2,44
Ursus maritimus Linnaeus, 1758	5	8,20	43	8,90	7.186	2,44
Mustelidae	6	9,84	28	5,80	928	0,31
Enhydra lutris (Linnaeus, 1758)	6	9,84	28	5,80	928	0,31
Sirenia	1	1,64	3	0,62	229	0,08
Dugongidae	1	1,64	3	0,62	229	0,08
Dugong dugon (Müller, 1776)	1	1,64	3	0,62	229	0,08