Digging into a Biocultural Archive

The Potential and Urgency of Research on Historical Whale Bones Illustrated by Examples from Bremen

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Abstract/Zusammenfassung: Graben in einem biokulturellen Archiv: Das Potenzial und die Dringlichkeit der Erforschung historischer Walknochen anhand von Beispielen aus Bremen

Whales have been commercially exploited worldwide for centuries. Over the past four centuries, many northwestern European countries also engaged in whaling. These whalers frequently brought back whale bones from the animals they hunted. These bones were used for a variety of purposes, including jaw-bone arches, fences, and cattle rubbing posts. However, it is often unknown to which species these bones belong. Moreover, many of these specimens have been exposed to the elements for decades or even centuries, leading to their gradual deterioration. Here, we applied the method of

Zooarchaeology by Mass-Spectrometry (ZooMS) to two whale bones preserved in Bremen to identify their species. Both specimens were identified as »Balaenidae« and likely derived from the bowhead whale (*Balaena mysticetus*), which was extensively hunted by German whalers in Arctic waters. This case study showcases the wealth of information that can be gained from analyzing whale bones preserved in cultural heritage settings. We argue that more specimens should be analyzed before erosion and weathering make research on this valuable biocultural archive impossible.

Weltweit wurde über Jahrhunderte kommerzieller Walfang betrieben. Die Walfänger brachten häufig Walknochen von der Jagd mit, die unter anderem für Walkiefertorbögen, Zäune und Viehscheuerpfosten verwendet wurden. Allerdings ist oft nicht bekannt, zu welcher Walart diese Knochen gehören. Darüber hinaus befanden sich viele dieser Exemplare jahrzehnte- oder jahrhundertelang im Freien, was zu einem langsamen Verfall führte. Wir haben die Methode der Zooarchäologie durch Massenspektrometrie (ZooMS) bei zwei solcher in Bremen konservierter Walknochen angewandt, um die Walart zu bestimmen. Beide Exemplare wurden als »Balaenidae« identifiziert und stammen wahrscheinlich vom Grönlandwal (*Balaena mysticetus*), der von deutschen Walfängern in arktischen Gewässern ausgiebig gejagt wurde. Diese Fallstudie zeigt die Fülle an Informationen, die aus der Analyse von Walknochen gewonnen werden können. Wir plädieren dafür, mehr historische Walknochen zu analysieren, bevor Umwelteinflüsse und Verwitterung Untersuchungen dieser wertvollen biokulturellen Archive unmöglich machen.

Introduction

The first German whaling ship was equipped by Hamburg shipowner Johan Been in 1643. Following Been's voyage, German whaling enterprises were undertaken until the end of the 19th century, with another brief revival between 1930 and 1939.[1] Over 10,000 voyages have been documented, of which approximately 1,600 departed from Bremen.[2]

In 1653, the first ship departed from the port to engage in whaling activities in the North Atlantic. As whale populations started to decline, whaling grounds expanded into the South Atlantic. German whalers followed the British and Americans, who had already ventured into the South Atlantic in 1775 and 1791, respectively. Eventually, in 1836, the first whaling vessel from Bremen was sent to the South Pacific. However, the number of German Pacific voyages is small, with only 60 documented journeys, of which 44 originated in Bremen. Nevertheless, this business was apparently so important that the Free Hanseatic city of Bremen maintained a consulate in Honolulu from 1846 to 1867.[3]

Besides geographical shifts in whaling, there were also shifts in the species that were targeted. Between the 17th and early 18th centuries, the bowhead whale (*Balaena mysticetus*) was targeted. Subsequently, from the early 18th century onwards, the sperm

1 Oesau 1955, p. 65–66.

2 Koch 1799; Meyer 1965; Küchelmann 2008, pp. 132–136; 2011, p. 210; Schümann 2014.

3 Schümann 2014, pp. 282–283.

whale (*Physeter macrocephalus*) was hunted. From the 1860s onwards, with the invention of steam propulsion and the explosive harpoon, the rorquals (Balaenopteridae) were also targeted.[4] By 1872, whaling voyages ceased to be carried out from Bremen.[5]

Many whales were taken during the two centuries when whaling was conducted from Bremen. Records indicate that between 1653 and 1709, 300–350 whaling voyages from Bremen brought back 1,100–1,300 whales, which equates to just over six whaling voyages and 19 to 24 individual whales being taken per year.[6] This might seem like a small amount, but Bremen was just one of many whaling ports, and all the whaling activities combined had a devastating impact on whale populations in all major oceans.

This kind of information is based on whaling logbooks, which have been used to assess past whaling endeavours, number of whales taken, and species targeted. However, these logbooks can potentially be prone to errors, resulting in distorted data.[7] First, whales could have been wrongly identified by the whalers, resulting in an over- or underrepresentation of a certain species. Secondly, some species have only recently been recognized as distinct species. The Bryde's whale (*Balaenoptera brydei edeni* and/or *Balaenoptera brydei brydei*) was previously classified as a sei whale (*Balaenoptera borealis*) until 1972. The taxonomy of the Bryde's whale is still a subject of debate.[8] As a result, this has led to an overrepresentation of the sei whale in whaling logbooks. Furthermore, whaling logbooks could also be tempered with, providing false data. For instance, Soviet whaling logbooks are known to provide false data and therefore cannot be used to accurately estimate past populations sizes.[9] Moreover, cases of whales being struck but lost were often not considered.[10]

An alternative approach to examining early whaling activities is through the analysis of the remaining bones. Historical bones can provide a wealth of data in order to assess past whaling activities.[11] Unfortunately, whale bones were often discarded during these whaling endeavours. Occasionally, whale bones were brought back home by the whalers. Whalebone has been utilized for various architectural purposes, such as cattle rubbing posts, jawbone arches, posts and post rows, tomb slabs, chopping blocks, chairs, stools, benches, boundary stones, and bridges.[12] Some of these, such as jawbone arches and post rows, can still be spotted in modern landscapes, including in Bremen (fig. 1). The features and artifacts located outside are subject to weathering due to exposure to environmental conditions. The degradation and potential destruction of these historical artefacts can deprive us of a valuable biocultural archive, which can among others be used for research on marine environmental history, marine historical ecology or eco-

4 Ellis 1993; Münzing 1978; 1987, pp. 80–81.

5 Schümann 2014, pp. 165–166.

6 Küchelmann 2011, p. 210.

7 Kruse 2017.

8 Cooke 2018; Jefferson et al. 2007, p. 54; WoRMS Editorial Board 2023, ID 137089, 242603.

9 Ivashchenko et al. 2013.

10 Vighi et al. 2021.

11 See e.g. Barrett 2019; Mulville 2005; Orton 2016; Poulsen 2016.

12 Küchelmann 2011; 2023; Küchelmann/Friesen 2023; Mulville 2002; Redman 2004; 2009; 2010a; 2010b; 2013; 2014; Savelle 1997; van den Hurk 2020.

nomical history to assess past whaling activities. This makes researching and protecting this biocultural archive a pressing matter.

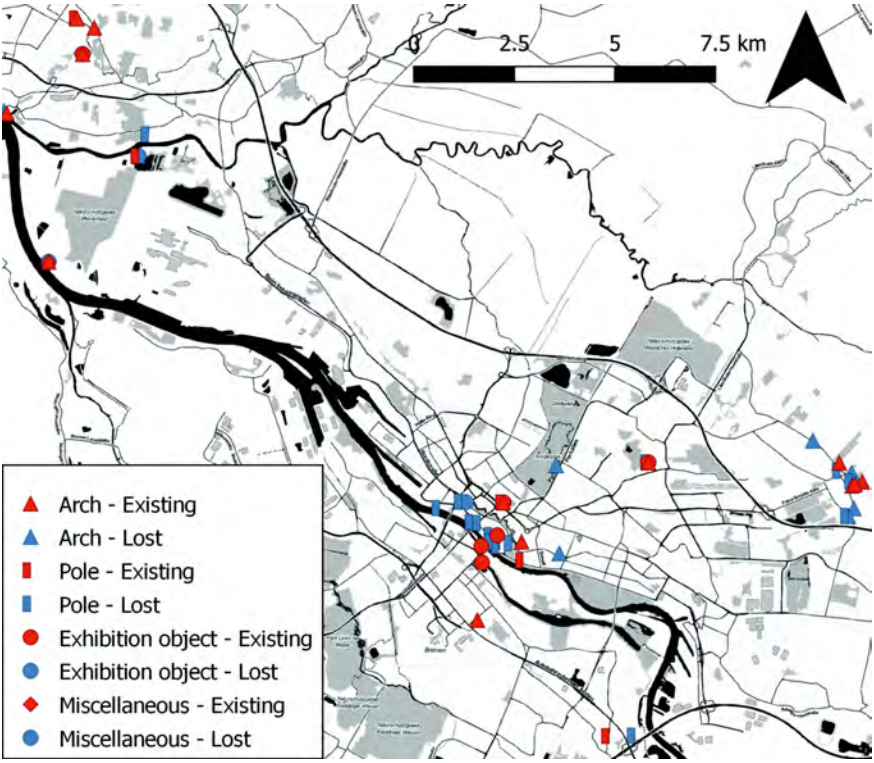

Fig. 1: Whale bones in Bremen and Schwanewede-Leuchtenburg. At present, there are 85 known objects, consisting of 190 individual bones. (Map: Youri van den Hurk & Hans Christian Küchelmann)

In order to assess the potential of the osteological features, species identification of the specimens is necessary. Morphological species identification of these whale bones is often difficult due to the limited amount of available reference material and published identification criteria.[13] While many species display a similar osteological morphology, which limits identification using conventional morphological comparison methods, another challenge is the frequently fragmented state of cetacean bone material. To overcome this problem, Zooarchaeology by Mass-Spectrometry (ZooMS) has the potential to contribute. ZooMS is a rapid, low-cost identification method based on the collagen or other proteins preserved in bones. It has been frequently applied to zooarchaeological specimens, but it has not been used very often on specimens from the cultural heritage sector. In order to test the applicability of ZooMS on historical specimens, a

13 Speller et al. 2016; van den Hurk et al. 2022.

ZooMS analysis was undertaken on two segments of whale mandibles from Bremen and Schwanewede-Leuchtenburg, both of which have been located in the open and endured weathering for over a century.

Material, Methods, and Historical Background

The first analyzed sample (WH638) originates from Schulweg 7, Schwanewede-Leuchtenburg, in the county of Osterholz-Scharmbeck (53.18971° N 8.64875° E; KnA 766). Mandible sections were set up as fence posts by Kommandeur (whaling ship captain) Hinrich Hashagen (*de grode Kaptein*) somewhen between 1840 and 1872 (fig. 2a).[14] Three of the fence posts survive to this day,[15] along with a jawbone arch that still serves as a gate frame to the estate (fig. 2b).[16]

Fig. 2a–b: 19th-century whale bones from Schwanewede-Leuchtenburg, Schulweg 7; a) fence post, inv. no. KnA 766; b) whalebone arch in June 2009. (Photos: Hans Christian Küchelmann)

The second specimen is from Gut Hodenberg, located at Hodenberger Straße 10 in Bremen-Oberneuland (53.08923° N 8.94354° E). It was erected between 1897 and 1936 as an arch next to a pathway by the owner, Robert Rickmers, a rice merchant from Bremen (fig. 3).[17] Rickmers was not involved in whaling enterprises himself, but he was an antiquities collector. Therefore, it is possible that the arch moved from another location to Gut Hodenberg. One of the jawbones is (hopefully) still standing, while the other one broke down approximately in 2006 due to weathering, showcasing how fragile these precious

14 Bruns/von der Mosel 1982, pp. 84–87.

15 One of these is now in the collection of the Museum Schloss Schönebeck Bremen, a second one in the private collection of Jürgen Oltmann, Schwanewede-Leuchtenburg and the third one in the collection of Hans Christian Küchelmann (inv. no. KnA 766).

16 Bruns/von der Mosel 1982, pp. 75, 84–85; Missler 2002, p. 210; Redman 2009, pp. 86–87.

17 Prüser 1936, p. 163.

biocultural specimens are. A sample of the broken specimen was analyzed (WH639, inv. no. KnA 815).

Fig. 3a–b: Partially broken down jawbone arch from Gut Hodenberg, Bremen-Oberneuland in 2011; the arch broke down around 2006. (Photos: Hans Christian Küchelmann)

For both specimens, the exact date of their installation is uncertain. Captain Hinrich Hashagen was one of the last captains to sail out for whaling until 1870, but he had been active since the 1840s.[18] He engaged in whaling in the North Atlantic. The Schwanewede-Leuchtenburg specimen was acquired sometime between those years. The Hodenberg arch has been erected after 1860, but it is possible that it originally stood elsewhere before being relocated to Robert Rickmers' house.

Since there is a possibility that both specimens post-date 1860 (the time during which rorquals were also hunted), a wide range of species should be considered, making any large whale species a potential candidate.

18 Ahlers 1911, pp. 13–14.

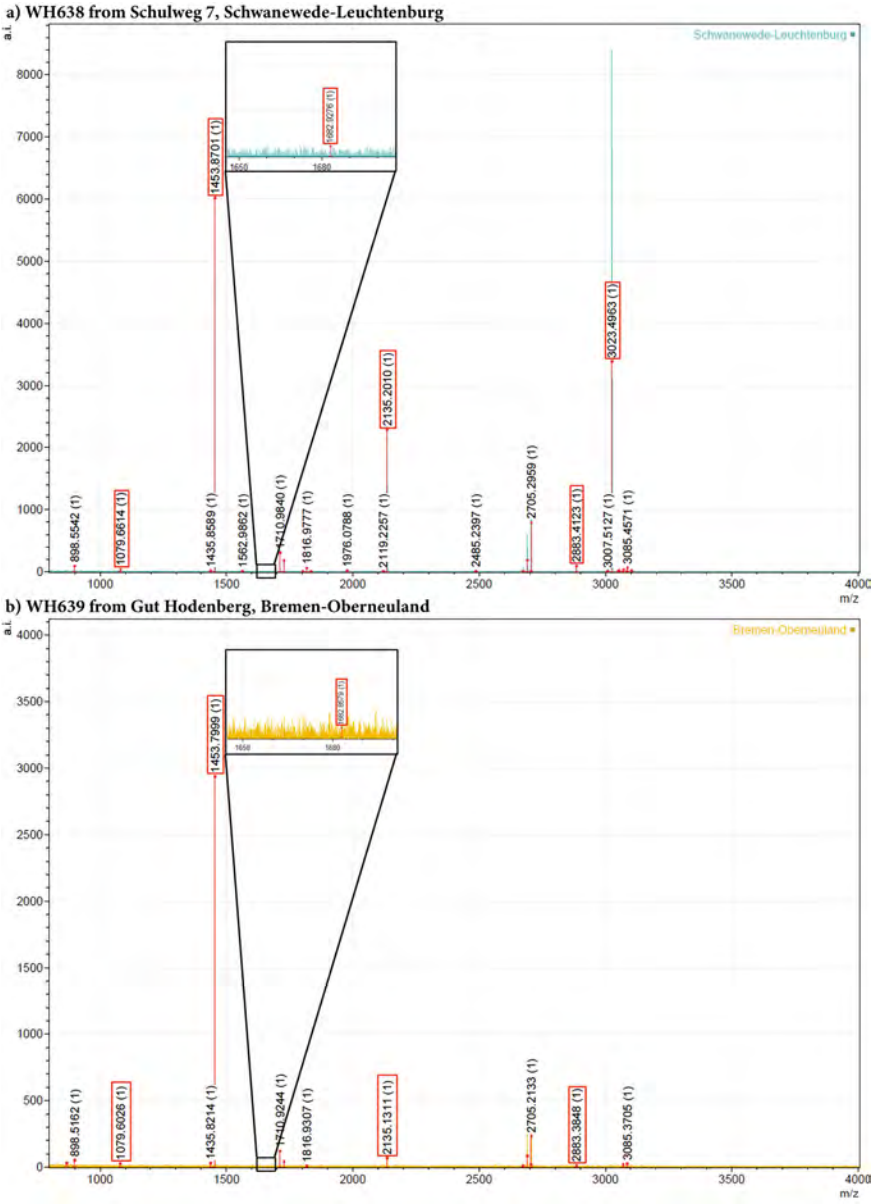

Fig. 4: ZooMS results for the two specimens; peaks with red squares are indicative of Balaenidae. (Graph: Youri van den Hurk)

In recent years, biomolecular analyses such as DNA or ZooMS have been shown to be useful methods for identifying osteological cetacean remains to the species level.[19]

19 For example Buckley et al. 2014; Frasier et al. 2022; Rodrigues et al. 2018; Rosenbaum et al. 2000; Speller et al. 2016.

For our analysis, we collected samples of the two whale bones, each weighing approximately 30 mg, and processed them in the BioArCh laboratory at the University of York, UK. Collagen extraction, purification, mass spectrometry, and peptide mass fingerprinting identifications followed the method outlined in Rodrigues et al. (2018). Briefly, the bone was demineralized in 0.6 M hydrochloric acid, and the resulting collagen was gelatinized through incubation of 100 µl of 50 mM ammonium bicarbonate at 65 °C for one hour. The collagen was digested by incubating it with 0.4 µg of trypsin overnight at 37 °C and then purified using a 100 µl C18 resin ZipTip® pipette tip (EMD Millipore). Each sample was spotted in triplicate with a matrix of α-cyano-4-hydroxycinnamic acid on a 384-spot MALDI target plate. Calibration standards were included, and the samples were run on a Bruker ultraflex III MALDI TOF/TOF mass spectrometer. Averaged spectra were created from the replicates for each specimen using mMass software,[20] and then compared to published m/z markers for mammals.[21]

Results

The results of the ZooMS analysis indicate that the Schwanewede-Leuchtenburg specimen derives from a member of the Balaenidae family (fig. 4a). Since Captain Hinrich Hashagen exclusively engaged in whaling activities in the North Atlantic, and all the whale bones found on his estate were likely from whales he personally hunted, it is probable that this specimen is either a North Atlantic right whale (*Eubalaena glacialis*) or a bowhead whale (*Balaena mysticetus*). The bowhead whale is the more probable option, considering its extensive hunting during the 19th century.

The specimen from Bremen-Oberneuland was also identified as Balaenidae. The fin whale (*Balaenoptera physalus*) and the Balaenidae have similar ZooMS spectra, differentiated only at COL12502-519, where fin whales present a peak at m/z 1652 and the Balaenidae at m/z 1682. For the Bremen-Oberneuland specimen, a very weak m/z 1682 signal was observed (fig. 4b). Therefore, zoologically in regard to the Balaenidae, North Atlantic right whale (*Eubalaena glacialis*), southern right whale (*Eubalaena australis*), or bowhead whale (*Balaena mysticetus*) are all possible candidates. Additionally, even the North Pacific right whale (*Eubalaena japonica*) cannot be ruled out completely.[22] Of the 161 whaling ships that called at Honolulu, Hawaii in 1845, six were of a Bremen registry[23], indicating that they might have brought home North Pacific right whale bones. In case of the Hodenberg sample the preservation status of the surviving bone material is so poor that the ZooMS analysis was hardly able to identify the family. Historical background information for the Hodenberg bones is likewise thin and not robust, making this historical monument a particularly good example for the loss of biological and historical information, even in a situation where physical bone remains are still extant.

20 Strohalm et al. 2008.

21 As presented in Buckley et al. 2009; 2014; Hufthammer et al. 2018; Kirby et al. 2013.

22 Scarff 1991.

23 Schümann 2014, pp. 220–310.

Conclusion

The results of this case study show that ZooMS is an effective method for achieving taxonomic family level and potentially even species identification on osteological specimens from cultural heritage sites. Unfortunately, the Balaenidae species cannot be distinguished using ZooMS. The method has the potential to reconstruct past historical whaling activities based on osteological remains, adding to data that could be extracted from historical whaling logbooks. The fact that over a century of exposure to the elements has seriously affected the preservation of the whale bones, with one of the two specimens having fallen over and showing serious degradation of its biomolecular structure, showcases how fragile this biocultural archive is.

Numerous other whale bones in the European landscape have been damaged due to weathering, destroyed or taken away.[24] This calls not only for a more efficient protection of these important pieces of cultural heritage, but also makes their biomolecular analysis an urgent matter to retrieve highly valuable biomolecular data before that opportunity is lost forever.

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24 Küchelmann 2011; 2023; Küchelmann/Friesen 2023; Redman 2004; 2009; 2010a; 2010b; 2013; 2014.

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