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Medieval Whalers in the Netherlands and Flanders: Zooarchaeological Analysis of Medieval Cetacean Remains

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ABSTRACT

Medieval historical sources suggest that cetacean exploitation was, for large parts of Europe, restricted to the social elite. This appears to have also been the case for the Netherlands and Flanders. It remains unclear, however, how frequently active hunting was undertaken, and which species were targeted. Zooarchaeological cetacean remains are often recovered from Medieval (AD 400-1600) sites in the Netherlands and Flanders, however the majority of these specimens have not been identified to the species level, leaving a substantial gap in our knowledge of past cetacean exploitation. By applying ZooMS, as well as morphological and osteometric analyses, these zooarchaeological specimens were identified to the species level. This analysis revealed that the North Atlantic right whale (*Eubalaena glacialis*), sperm whale (*Physeter macrocephalus*), and grey whale (*Eschrichtius robustus*) were frequently exploited. Active whaling appears to have been undertaken as well, especially in Flanders and in Frisia (the northern part of the Netherlands). Zooarchaeological cetacean remains appear to be present with relative frequency at high-status sites such as castles, as well as ecclesiastical sites, confirming the historical evidence that the social elite indeed did have a taste for cetacean meat. However, cetacean products were also available outside of elite and ecclesiastical contexts.

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Introduction

Zooarchaeological cetacean material regularly appears in the Dutch and Flemish archaeological record, with numerous remains dating to the Medieval period (AD 400-1600). It has often been suggested that zooarchaeological cetacean material was merely scavenged from stranded individuals, however several historical sources from the Netherlands and Flanders seem to suggest that active whaling was undertaken during the Medieval period. Furthermore, historical sources argue that cetacean exploitation was associated with the social elite and appeared to have been a precious fasting food consumed by the clergy and nobility (Gardiner 1997).

This study undertook a quantitative analysis of Medieval zooarchaeological cetacean finds to investigate whether cetacean exploitation was indeed associated with the social elite during the Medieval period. Furthermore, a subset of zooarchaeological cetacean remains were analysed using morphological, osteometric and biomolecular methods to identify which species were exploited. It is assumed that whale exploitation began through the opportunistic use of stranded animals or beached carcasses, and later developed into more active, deliberate and targeted hunting methods with increasing socio-economic and technological complexity. In the absence of preserved whaling gear (e.g. harpoons, boats) or extensive historic records, archaeologists may infer the emergence of active whaling by examining the composition of cetacean species present at archaeological sites (Speller et al. 2016). For example, the presence of a variety of cetacean species, including large, off-shore, fast-swimming species may be more consistent with opportunistic exploitation of beached animals or carcasses, while an increase in the proportion of smaller, slow-moving, near-shore, or easy-to-capture species, may indicate deliberate acquisition (Rodrigues et al. 2018).

Cetacean remains are, however, challenging to identify to species or genus level, as the material is often too fragmented to allow detailed morphological comparison (Speller et al. 2016). To overcome this problem, ZooMS (Zooarchaeology by Mass-Spectrometry) was performed on 40 cetacean specimens (39 from the Netherlands and 1 from Belgium) recovered from

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Medieval contexts. These zooarchaeological identifications were compared with modern stranding data occurring in the Netherlands between 1969 and 2018 to both examine past and modern cetacean distributions, as well as to shed light on cetacean acquisition methods (i.e. scavenging vs active hunting).

Historical context

For various Medieval European regions stranded cetaceans were claimed by the social elite. For England, stranded cetaceans were, by law, the right of the King unless those rights were given to a local lord or ecclesiastical institution (Gardiner 1997). Similar laws were set in place for *inter alia* France, Denmark, and Norway (Ardouin, Hadjouis, and Arroyo 2009; Schnall 1993; Hybel and Poulsen 2007, 55).

This was also the case for the Netherlands and Flanders. Though cetaceans were not explicitly mentioned, a letter from William II, Count of Holland and Zeeland (1234–1256) and King of the Romans (1254–1256), to Margaret of Constantinople, Countess of Flanders (1244–1278), specified arrangements made between the two rulers regarding beach finds (De Groote 1999). Based on this evidence, it appears that the social elite of the Netherlands and Flanders tried to monopolise the exploitation of cetaceans – but to what extent this occurred in practice remains unclear. A variety of historical sources for both regions will be discussed to examine this question in greater depth.

Netherlands

Several sources seem to suggest that the social elite in the Netherlands had already developed a taste for cetacean meat by the Early Medieval period, but this becomes especially pronounced during the High and Late Medieval periods (Van Dam 2003, 476, 2009; Kruyff 2009; Moesker and Cavallo 2016, 608). A church, St.-Maartenkerk, in Utrecht, the Netherlands, is known to have possessed the right to wrecks on their land from at least the 8th century until the first half of the 10th century AD (Moesker and Cavallo 2016, 608). For England, these 'wrecks' included stranded cetaceans and it is likely this was also the case for the Netherlands.

Ecclesiastical institutions gained interest in cetaceans during the Medieval period. Historical records indicate that marine mammal meat was considered both a high-status food as well as a food source consumed by the clergy (Van Dam 2003, 476). During fasting periods the consumption of mammalian meat was not allowed, but as cetaceans were perceived as fish they were a welcome addition to the menu. This confusion still lives on in the Dutch language nowadays, as the Dutch word for 'whale' is 'walvis' (whale-fish).

Moreover, until at least AD 1300, large 'fish' (such as cetaceans) were considered a delicacy in many parts of Europe (Van Dam 2003, 467). One source that seems to confirm this for the Netherlands is an account by the treasurer of the Count of Holland in the years 1395–96. He bought a seal and a porpoise that he gifted to a certain Duke Robrecht and furthermore gifted three seals to the Bishop of Liège (Van Dam 2003, 477). Duchess Catherine of Cleves, wife of Arnold, Duke of Guelders, is known to have stayed at the Valkhof, Nijmegen for several years during the mid-15th century. Records kept by her kitchen staff regarding food supplies that were bought and received, indicate that the duchess occasionally received porpoises from her family (Kruyff 2009). Similarly, the kitchen accounts of the abbey, Kartuizerklooster, in Geertruidenberg record that porpoise was bought for the members of the clergy present during the early 15th century (Sanders 1990, 92).

Although the value and desirability of cetaceans is clear, what is absent from the aforementioned historical records is if cetaceans were principally opportunistically exploited through strandings, or whether – and to what extent – they were also obtained through active hunting. In support of the latter theory, Albertus Magnus, a German Dominican friar and Catholic bishop that lived from 1200 to 1280, clearly describes active whaling undertaken in the northern parts of the Netherlands. Magnus visited Frisia and the Wadden Sea islands where he states that he witnessed the catching of a whale by the Frisian locals (Szabo 2008, 61–65). He describes how the Frisians worked in teams of several small boats, utilised music and noise to drive the animal in a specific direction, and used harpoons and a powerful ballista to catch the animal. He noted that various species were exploited, though it remains unclear which species. Magnus does however state that very large species (such as, potentially, large baleen whales) were rarely exploited. When the hunt was successful, he stated that the Frisians conserved the oil, rendered the whale blubber, and retrieved the baleen, meat and bone (Szabo 2008, 61–65). This clearly indicates that active whaling was occasionally undertaken, and that various species were exploited. Indeed, cetacean remains are frequently found in the terp sites (tell mound) in the northern part of the Netherlands (dating to 500 BC – AD 1200), suggesting that these might have derived from actively caught whales.

A taste for cetacean meat persisted until the end of the Medieval period, though it appears to not have been exclusively restricted to the social elite. For example, fresh and salted meat of seals, and meat of porpoises and swordfish were valuable goods sold at the 16th century *Amsterdamse vismarkt* (fishmarket of Amsterdam) (Ypma 1962, 30).

Flanders

For Flanders, even more sources concerned with cetacean exploitation are known. Several cetacean strandings are recorded, such as the stranding of eight whales in Oostduinkerke in 1403 (Charlier 2004) – all of these were likely to have been exploited.

In this region a stronger case can perhaps be made to argue that active whaling was practiced. One of the oldest sources suggesting whaling was already undertaken during the Early Medieval period is *The Life of St. Vedastus*, dating to around 875. Herein a group of Flemish fishermen from a monastery organised a contest with another group to hunt a whale. The story indicates that the hunt was communally organised and that the participants paid a fee into a 'contubernium' (a co-operative society) and agreed on sharing the catch, with the group that prayed to St. Vaast catching the whale (Chevallier 2014).

Prayers to saints appear to have been commonly undertaken by whalers to ensure a successful hunt. A similar situation is recorded when Flemish fishermen tried to catch a whale in the 10th century AD, and only by praying to St. Bavon the hunt ended successfully. Another case occurred in the 12th century when fishermen prayed to St. Arnulf to ensure a successful hunt, as registered in *The life of St. Arnulf* (Chevallier 2014).

For Flanders, several sources seem to indicate that cetacean meat was a prized product as well, especially from the 12th century onwards. In 1121, the Count of Flanders gifted 'pinam de cetam' (tail of a whale) to the Abbey of Sint-Winoksbergen in Bergen (Steevens 2014). Additionally, from the accounts of the kitchen of the Sint-Pieters Abbey in Ghent dating to 1485, it is clear that porpoise was also consumed there (Mortier 2016, 224).

The accounts by the bailiff of the County of Flanders provide valuable information concerning the extent of cetacean exploitation. They indicate that the Count of Flanders regularly used his 'wreck of sea' rights to claim stranded cetaceans, with one account from the *Brugse Vrije* dating to 1403 indicating that a large fish (*vieux porc de mer*) stranded on the island of Cadzand. The fish was sold at Bruges for 36 Parisian pounds. Just over half of that went to the finders and the people who transported the animal to Bruges, while 15 pound 14 sous remained for the Count (De Groote 1999).

Bruges might have been a centre for whale meat as John II (John le Bon), King of France (1350–1364), during his imprisonment in London from 1357 to 1358, bought whale from Bruges (Van Neer and Ervynck 1993, 87). Whale meat was also available in Calais as, in 1300, the Count of Artois bought 33 pieces of whale meat from the market there (De Smet 1981).

In addition, in 1371, the Flemish Count Louis of Male sent whale meat to his daughter Margareta at the Burgundian Court. Whale meat appears to be prized at the Court, as Charles the Bold, Duke of Burgundy, served whale meat at his wedding with Margareta, Countess of Flanders in 1468 (De Haan and Oosterman 1996, 51). The Duke of Burgundy, Count of Flanders is also known to have had a ship undertaking whaling in the North Sea in 1456 (De Smet 1981).

These sources all point to the fact that whale meat was indeed often consumed by the social elite from the 12th century onwards. Following the 12th century, active whaling practices are also more frequently mentioned. Historical sources describe that four whale hunting ships had their homeport in Blankenberge in 1147 (Charlier 2004).

Other sources indicate that whaling was a specific activity which required the permission of nobility. In 1163, several towns were granted the rights to hunt cetaceans in the Charter of Newport (De Gryse 1940-1945; Van Neer and Ervynck 1993, 86). Additionally, in 1340, the town of Wenduine was granted the right to hunt cetaceans, more specifically the harbour porpoise (*Phocoena phocoena*). A picture of a harpooned porpoise was also present in Wenduine's coat of arms (Charlier 2004).

It appears that cetacean meat was not exclusively restricted to the nobility and clergy in Flanders. Sources indicate that in 1024 taxes had to be paid for every hundredth part of whale meat at the city of Arras (Steevens 2014). Other cities, such as Boulogne, Calais and Damme are also known to have sold whale meat at the local markets between the 11th and 12th centuries (De Smet 1981). This indicates that cetacean meat was widely available at Medieval Flemish markets, though the cost probably restricted access to the rich and in this way can therefore still be associated with social elite.

In summary, historical sources from both the Netherlands and Flanders indicate that cetacean exploitation was already a widespread —and in some regions well-organised— practice during the Early Medieval period, and indeed associated with the social elite. Historical sources, however, are likely to underrepresent the exploitation of cetaceans outside of ecclesiastical, high-status, or commercial contexts, where the everyday lives of rural and urban inhabitants and their diets are rarely recorded.

This study assessed the frequency and distribution of cetacean remains in archaeological sites in the Netherlands and Flanders to test the hypothesis that cetacean exploitation is associated with the social elite. Furthermore, from these historical sources, little is known about which species were exploited. Therefore, a second goal was to undertake species identification of a subset of zooarchaeological cetacean remains and compare these taxonomic identifications to modern cetacean stranding records in the region.

Materials and Methods

First, a chronological assessment of the frequency and location of cetacean remains through the Medieval period was conducted. Zooarchaeological data from archaeological sites in the Netherlands from each time period have been collected by the Rijksdienst voor het Cultureel Erfgoed (the Cultural Heritage Agency of the Netherlands) in the database 'BoneInfo'. This database contains site information from archaeological reports, dissertations, theses, articles and grey literature and is freely accessible to anyone with an interest in zooarchaeology (Rijksdienst voor het Cultureel Erfgoed 2019). The database also contains information regarding Medieval sites. For this study this database offered the unique opportunity to examine all sites with cetacean remains in comparison to those without cetacean remains, and to identify periods and sites in which cetaceans were relatively more frequently exploited.

For this study, all Dutch Medieval sites were accessed and information regarding site type, dates of occupation and location were collected. Furthermore, all sites were grouped into six categories, including: settlements (rural, small settlements, farms, etc.), terps (terp/wierde, tell sites in the coastal areas of Friesland and Groningen, in the Netherlands), urban (middle to large sized settlements; of which most developed only from the High Medieval period onwards), high status sites (castles and other settlements with clear high status occupation), ecclesiastical (monasteries, churches, etc.) and other (cemeteries, graveyards, tanneries, etc.). This analysis was undertaken for all 869 Medieval sites that were available through BoneInfo and all the Medieval sites from which cetacean remains were uncovered (46 sites in total for which 31 sites were also recorded in BoneInfo, bringing the total number of Medieval sites analysed here to 884). The remaining 15 sites with cetacean remains were identified through an extensive study of zooarchaeological reports.

In addition to the cetacean material identified through the meta-analysis, a subsample of 40 zooarchaeological specimens was analysed using collagen peptide mass fingerprinting (ZooMS; Supplementary Table 2). The majority of the specimens did not have taxonomic assignments but were merely identified as 'whale' or 'large whale'; seven specimens had species-level assignments. These 40 specimens were selected as they originate from a geographically and chronologically divers range of contexts and represent cetaceans of different size categories. Most of these specimens are the only cetacean remains originating from their respective sites.

Samples of approximately 30 mg were taken from each bone and processed 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 demineralised in 0.6 M hydrochloric acid, and the resulting collagen gelatinised through incubation in 100 µl of 50 mM ammonium bicarbonate at 65°C for 1 h. The collagen was digested through incubation with 0.4 µg of trypsin overnight at 37°C and 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, with calibration standards and run on a Bruker ultraflex III MALDI TOF/TOF mass spectrometer. Averaged spectra were created from the replicates for each specimen using mMass software (Strohalm et al. 2008), and then compared to published m/z markers for mammals, as presented in Buckley et al. (2009), Kirby et al. (2013), Buckley et al. (2014) and Hufthammer et al. (2018).

For those of the 40 specimens that were complete or mostly complete, morphological and osteometric analyses were also undertaken, based on the Osteological Reference for Cetaceans in Archaeology-Manual (ORCA-Manual; van den Hurk, unpublished). Measurements on the vertebral bodies of analysed specimens were taken based on the measurements outlined in Buchholtz and Schur (2004). Morphological and osteometric analyses allowed for some specimens to be identified to the species level, and others only to the genus or sub-family level.

Results

Chronological Assessment of Cetacean Exploitation

The analysis of Medieval archaeological contexts uncovered 52 sites with evidence for cetacean exploitation (Figure 1; Supplementary Table 1). A chronological assessment of sites based on the spatial contexts with cetacean remains (assigned to ecclesiastical, high status, terp, urban and rural sites; for both the Netherlands and Belgium; Figure 2), indicates a peak in cetacean exploitation around the 9th and 10th century AD. Following this, the number of sites with cetacean remains drops gradually, followed by a sharp decline for the beginning of the 13th century AD. This second sharp decline is an artefact of multiple terp-sites not being dated precisely and therefore ending roughly at the end of the 12th century AD, at which point dykes were created allowing people to leave the terps. The expectations based on historical sources suggested that there would be a peak in cetacean exploitation for the 12th century; however, the zooarchaeological remains do not support this. In

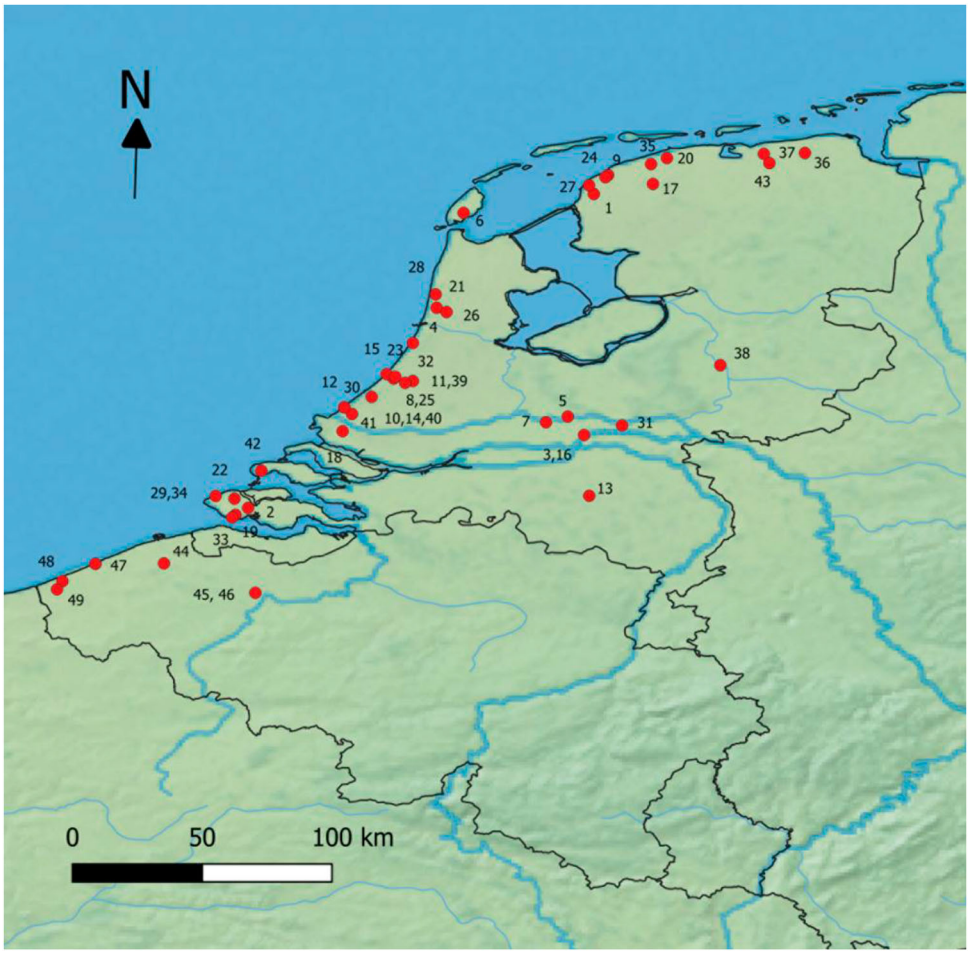

Figure 1. Medieval sites (AD 400-1600) located in the Netherlands and Belgium with zooarchaeological cetacean remains. For list of sites see Supplementary Table 1.

fact, the decline in number of sites with cetacean specimens suggests that following the 12th century, cetaceans were less frequently exploited.

Site type analysis indicates that the majority of remains are identified in terp and rural sites, and this pattern dominates from AD 400 until around AD 1200. The social elite (both ecclesiastical and high-status sites) develop their interest in cetacean exploitation from the beginning of the 8th century AD. Urban sites also display evidence for cetacean exploitation from the AD 700 onwards, suggesting that the commercialisation of cetacean exploitation

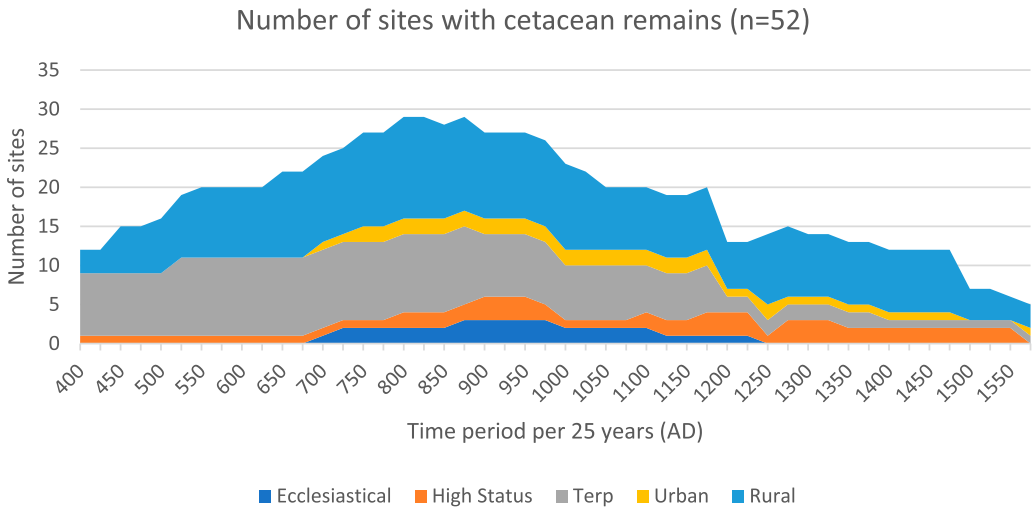

Figure 2. Temporal overview of sites with cetacean remains based on site types from both the Netherlands and Belgium per 25-year period. Sites spanning multiple periods are counted as 1 entry for each 25-year period.

began relatively early and continued consistently into the Middle and Late Medieval period.

When comparing the Dutch sites with and without cetacean remains, some interesting patterns emerge (Figure 3). First, the proportion of sites that contain cetacean remains is not uniform through time. Although the total number of Medieval sites overall increases for the High and Late Medieval period (AD 1066–1250 and AD 1250–1500 respectively, Figure 3), the number of sites with cetacean remains declines. As a result, there is a lower proportion of sites with cetacean remains during the High and Late Medieval period, in comparison to the Early Medieval period (AD 400-1066).

The spatial data analysis (comparing with all the Medieval sites in the BoneInfo database; Figure 4), indeed suggests that peasants were less frequently exploiting cetacean remains from the 11th century onwards, while the social elite's interest (based on high-status and ecclesiastical sites) appears to have increased from this period onwards (Figure 5).

ZooMS Identifications

The vast majority of the cetacean material uncovered in the analysis is not taxonomically identified. In order to assess which species of cetaceans were exploited in the Medieval period, 40 suspected cetacean bones were analysed using ZooMS at the University of York. Of these, 37 could be successfully identified to the family, genus or species level (Figures 6–8; Supplementary Table 2; Supplementary Figures 1–5); three samples contained insufficient collagen to allow for a confident identification. Of these 37 specimens, one specimen (WH608) from Oosterbeintum was identified as a terrestrial mammal (likely sheep (*Ovis aries*), red deer (*Cervus elaphus*), fallow deer (*Dama dama*), or elk (*Alces alces*)). More detailed morphological analysis of the specimen confirmed it was a piece of antler, most likely from red deer. In addition, the specimen from Plantage in Leiderdorp (WH620), was morphologically identified as a large whale scapula (Moesker and Cavallo 2016), yet ZooMS analysis identified it as a member of the Elephantidae family. Further morphological analysis indicated that the bone was sub-fossilised and was likely the proximal posterior portion of a tibia of a mammoth. Interestingly a large hole was drilled in the bone, however, it is not clear whether this was done during the Medieval period or earlier.

The remaining 35 specimens were all confirmed as cetacean. Of the seven specimens that were previously morphologically identified to species level, ZooMS determined that the original identifications for four of these were incorrect (Supplementary Table 2), while a fifth bone was one of the three samples for which ZooMS failed. Original identification based on morphology was therefore accurate for only two specimens, highlighting the challenges that arise when attempting to identify cetacean bones to species level.

Moreover, two specimens lacked diagnostic collagen peptides, allowing identification only to a particular group of species (e.g. WH625 from Katwijk (Zanderij) was identified as fin (*Balaenoptera physalus*), humpback (*Megaptera novaeangliae*), grey (*Eschrichtius robustus*), or bowhead/right whale (*Balaena mysticetus*/*Eubalaena glacialis*)). Additionally, five specimens could only be identified to particular groups of taxa, as the collagen sequence within these groupings is too similar to allow for a more precise identification. This is especially the case for a large group of the Delphinidae members. Remains of members of the Delphinidae family are notoriously hard to identify to the species level, however morphological and osteometric data can potentially be used to complement the ZooMS identifications.

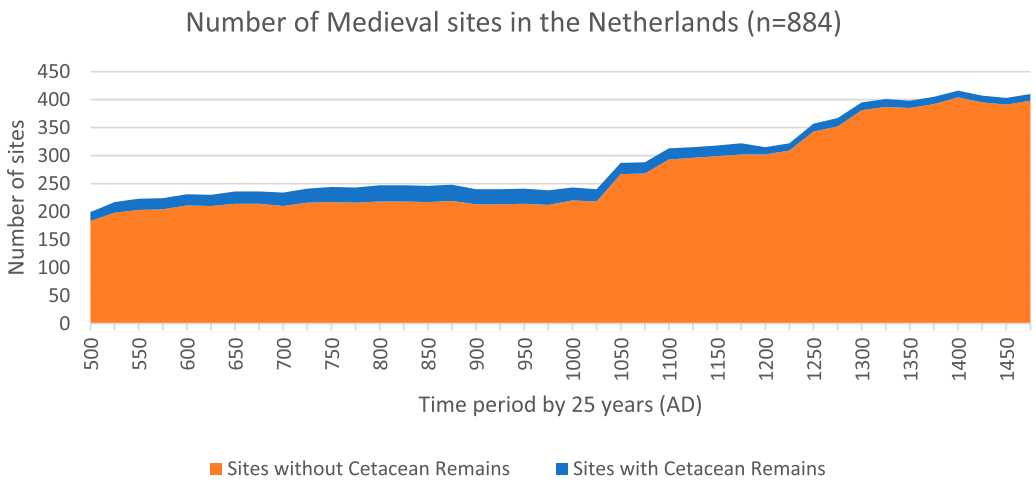

Figure 3. Comparison between Medieval sites with and without cetacean remains. Data available through BoneInfo (Rijksdienst voor het cultureel Erfgoed 2019).

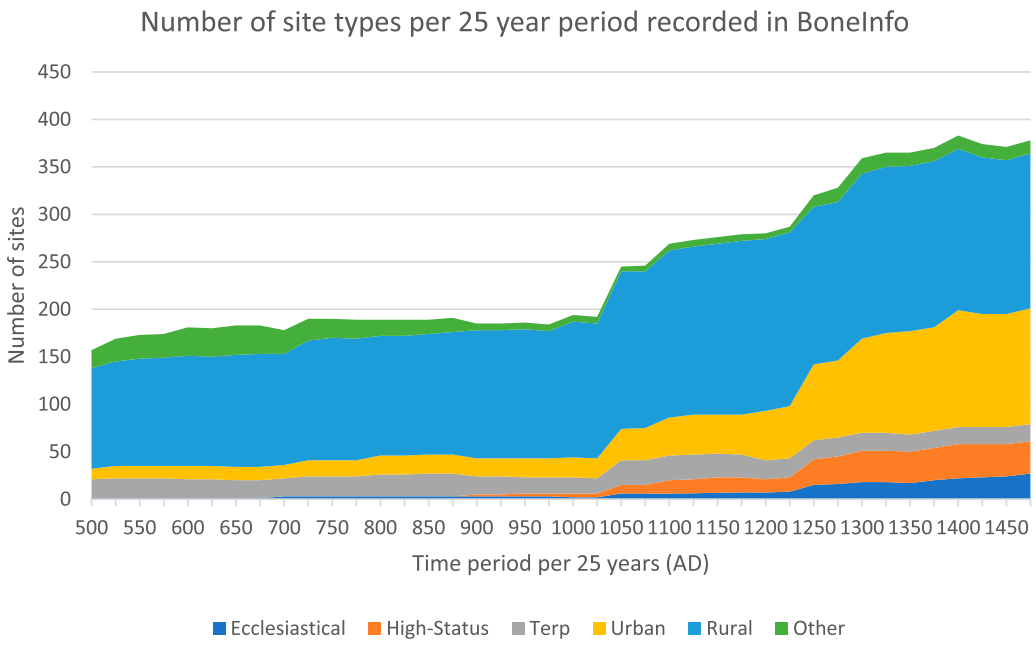

Figure 4. Number of site types per 25 year period recorded in BoneInfo (including sites both with and without cetacean remains) from the Netherlands

Results of morphological and osteometric analyses

Based on osteometric (based on Buchholtz and Schur (2004)) and morphological analyses, and comparison to data that was incorporated in the ORCA-Manual (van den Hurk, unpublished; Figures 9 and 10), seven of the ZooMS-identified specimens could be more precisely assigned to species and element (Table 1 for the vertebral specimens and the osteometric data). While there is substantial variation in size within a species, it is assumed that the general proportions of the osteological features are approximately the same for each individual of a particular species and can aid identification.

Three specimens (WH618, WH621, and WH673) were identified using ZooMS as Globicephalinae, a group of six dolphin species commonly referred to as 'blackfish'. Three of these species are relatively regularly sighted in the European Atlantic: the long-finned pilot whale (*Globicephala melas*), Risso's dolphin (*Grampus griseus*) and false killer whale (*Pseudorca crassidens*) (Shirihai and Jarrett 2006). The height, breadth, and length of the vertebral bodies for all the vertebrae of specimens for these three species held in the Smithsonian Institution are provided in Figure 9, and as can be noted, there is considerable difference, especially in the length of the vertebral bodies for the three species, which allowed the identification of the archaeological samples to species level.

The specimen from Egmond aan den Hoef (WH618; find number 713 (which together with find number 714 probably belonged to one individual) was originally identified as common bottlenose dolphin). However, when the length of the central vertebral body was compared to its height and breadth, this specimen was identified as a Risso's dolphin, most probably one of the last lumbar vertebrae or one of the first caudal vertebrae (Figure 9).

The specimens from Santpoort-Zuid (Castle Brederode; WH621; find number 1531-2), previously identified as killer whale (*Orcinus orca*), likely derived from one of the last thoracic or one of the first lumbar vertebrae of a long-finned pilot whale, based on the morphology and the ratios of the height, length, and breadth of the vertebral body (Figure 9).

While the third specimen (not a vertebra), originally identified as a right humerus of pilot whale from Englum (Prummel, Gent, and Kompanje 2012; WH673), was by ZooMS confirmed to be Globicephalinae. Morphological and osteometric analysis at the Smithsonian, confirmed the specimen as a left humerus of a pilot whale.

The specimen from Molenslag (WH637) was identified by ZooMS as a dolphin (including common bottlenose dolphin (*Tursiops truncatus*), white beaked dolphin (*Lagenorhynchus albirostris*), common dolphin (*Delphinus delphis*), or striped dolphin (*Stenella coeruleoalba*)). Both the cranial and caudal side of this vertebra specimens were unfused. The length of the vertebral body of this specimen is 29 mm. Based on its morphology it was identified as a lumbar or first or second caudal vertebra. Because of its unfused state the length of the vertebral body must have been longer had the epiphyses fused. Osteometric comparison with fused lumbar and caudal vertebrae of adult short-beaked common, striped, white beaked and common bottlenose dolphins, indicated the specimen

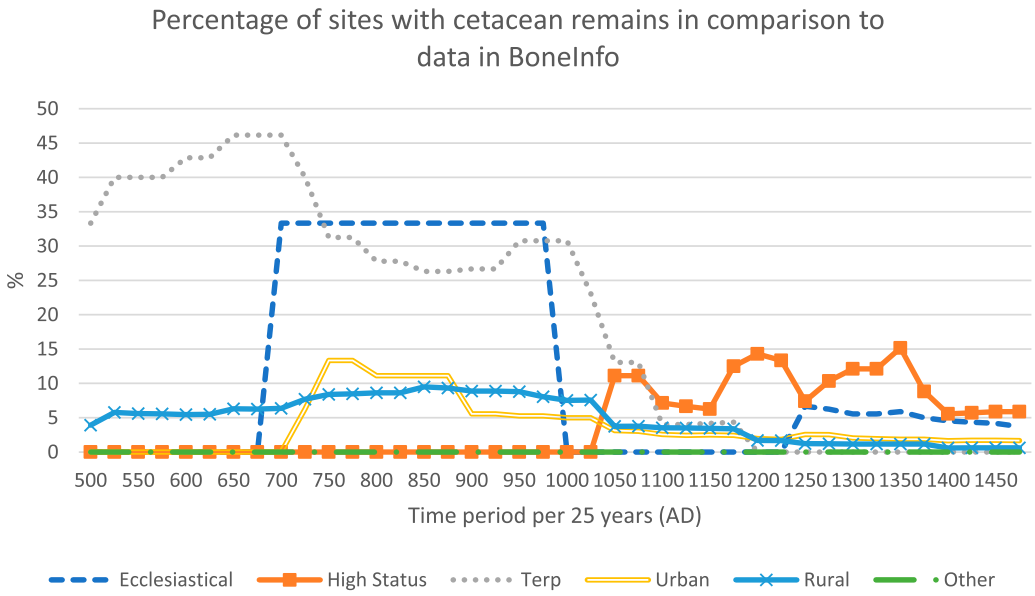

Figure 5. Percentage of sites with cetacean remains in comparison to data in BoneInfo. The peak in the data for the ecclesiastical sites from the 7th until the 10th century can be explained by the lack of identified ecclesiastical sites being identified for that period.

Figure 6. A selection of cetacean material analysed using ZooMS. 1. Worked piece of bone from Achlum, Friesland (identified as sperm whale), 2. Worked piece of bone from Tzummarum, Friesland (identified as North Atlantic right whale), 3. Vertebral body from Achlum, Friesland (identified as northern bottlenose whale), 4. Cervical vertebra from Hallum, Friesland (identified as grey whale), 5 Weaving sword from Leens, Groningen (identified as North Atlantic right whale), 6. Weaving sword from Rottum, Friesland (identified as grey whale).

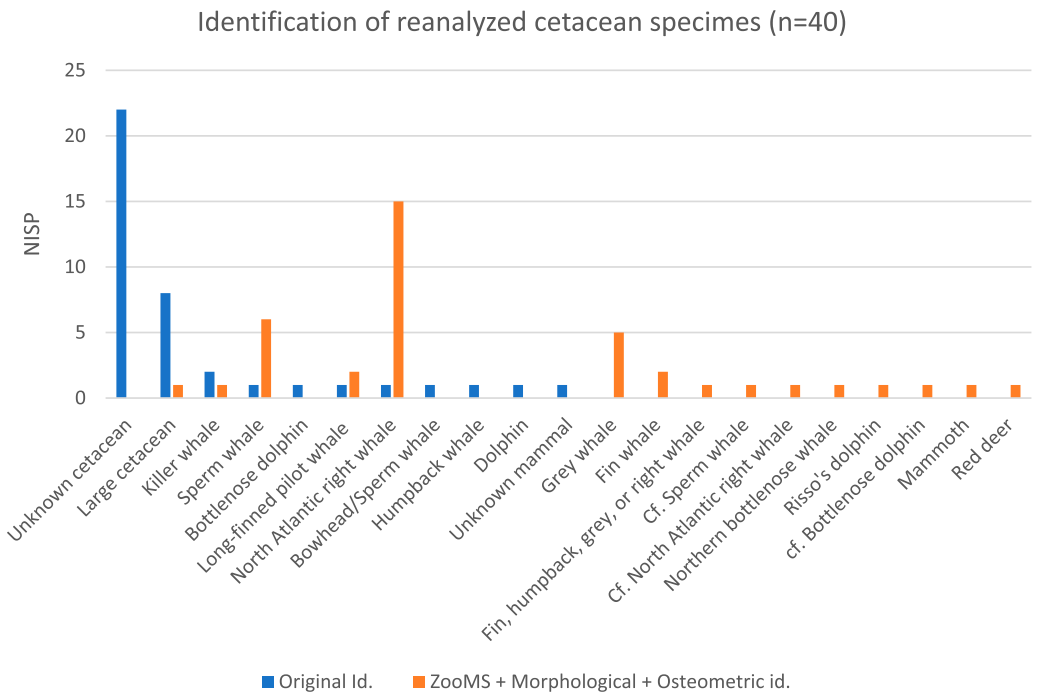

Figure 7. Identification of the cetacean material analysed as part of this study, through the combination of ZooMS, morphological analysis and osteometric analysis (n = 40).

was larger than the first two species and would also have been larger than the third species had the epiphyses already fused. This indicates that the specimen most likely was a common bottlenose dolphin (Figure 10). Though intraspecies variation (e.g. differences between the different sexes and populations) are known to occur for various of the dolphin species, the size of this specimen and the identification of the specimen as one of the later lumbar or one of the first caudal vertebrae, makes the identification as common bottlenose dolphin the most likely.

Specimen 159–35 from Achlum (WH610) was identified as a beaked whale through ZooMS. Morphological and osteometric analysis at the Smithsonian indicated the specimen was one of the last thoracic vertebrae of a northern bottlenose whale (*Hyperoodon ampullatus*). Additionally, specimen 1513–1 (WH623) from Santpoort (Brederode), a lumbar vertebra, was identified by ZooMS as killer whale, white-sided dolphin (*Lagenorhynchus acutus*), or harbour porpoise, but based on the size of the specimen, it could only be a killer whale.

Comparison to modern stranding data

Comparison between the identified zooarchaeological material for the Medieval period and modern stranding data from the Netherlands for the period of 1969–2018 as recorded by Walvisstrandingen (2019) was undertaken to examine to what extent species distributions have changed from the Medieval period until today (Table 2). This analysis was conducted acknowledging that modern stranding data should be treated with caution as modern strandings are often the result of anthropogenic factors such as ship strikes or the swallowing of plastic (Walvisstrandingen 2019).

There are a number of species which were identified in the archaeological record that are absent in modern stranding data, these species include the North Atlantic right whale, grey whale, and killer whale. The North Atlantic right whale is close to extinction and today is rarely sighted on the European side of the North Atlantic, while the Atlantic population of the grey whale is completely extirpated (Shirihai and Jarrett 2006). The killer whale has not stranded in the Netherlands for the past 50 years, though a sick individual was rescued from Dutch waters in 2010 (Walvisstrandingen 2019).

Eight species are identified both in the archaeological record and known through modern strandings, including the harbour porpoise, white beaked dolphin, sperm whale, and common bottlenose dolphin. Finally, eight species are only represented in modern strandings and have not been recorded in the Medieval archaeological record. This difference might be the results of the relatively small sample size of Medieval zooarchaeological cetacean material and an even smaller number of these which have been identified to species level. Nevertheless, in general, these eight species are absent within the archaeological record tend to strand less commonly than those species for which there is both modern strandings and archaeological data.

Discussion

This study set out to examine whether archaeological data supported the pattern of cetacean exploitation

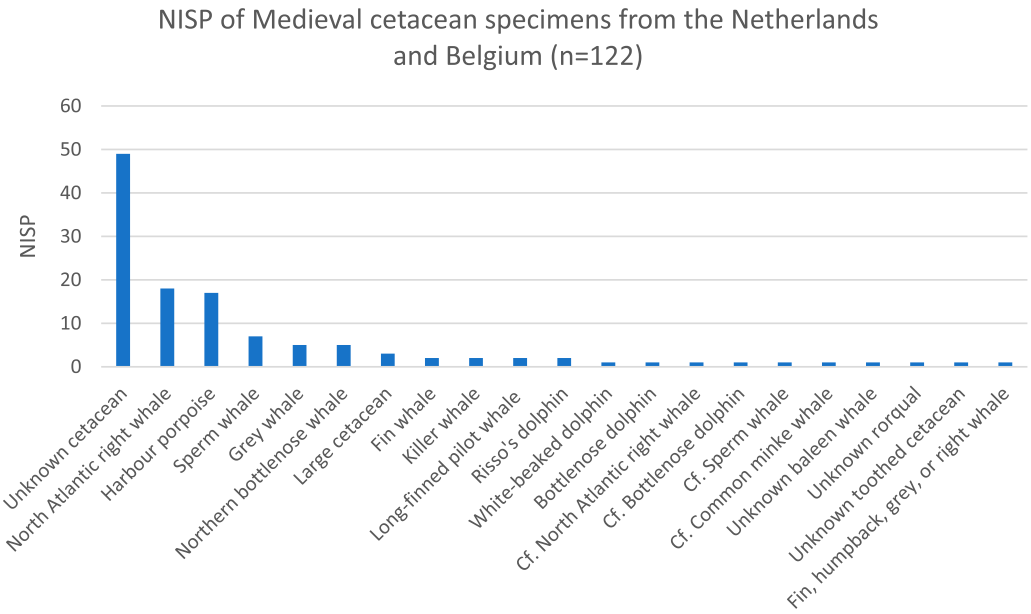

Figure 8. All Medieval (AD 400-1600) zooarchaeological cetacean specimens from the Netherlands and Belgium, including the specimens analysed as part of this study (n = 122).

recorded in historical sources. Based on historical accounts, the expectations were that cetacean exploitation would increase during the High Medieval period, and that it would be associated with the social elite. The archaeological data suggests that the exploitation of cetaceans was more frequently undertaken during the Early Medieval period and that the social elite indeed did develop a taste for cetacean meat from the High Medieval period onwards in the Netherlands and Flanders. While the numbers of high-status sites are much lower than non-high-status sites, the combination of these sites with historical sources suggests that the elite regularly tried to obtain access to cetacean meat, though they potentially did not attempt to monopolise on the consumption as seems to have been the case for England in the same period (Gardiner 1997). The apparent high proportion of non-high-status sites with cetacean remains might be explained by the fact that these site types are simply more abundant than high-status sites, overall. One potential reason for a drop in cetacean exploitation during the High Medieval period may be the result of the social elite's attempt to control cetacean exploitation, resulting in less cetacean specimens ending up in 'rural' sites. Additionally, the decrease might also be explained by the Fish Event Horizon beginning in the 10th/11th century AD (Barrett et al. 2011). This rapid and dramatic change in the intensity of marine fishing may have resulted in a higher contribution of marine resources to the diet and thus reduced the desirability of exploiting (stranded) cetaceans in order to get access to marine resources.

Fragmentary cetacean remains are notoriously difficult to taxonomically identify based on anatomical characteristics alone (Szabo 2008; Mulville 2002; Speller et al. 2016; Evans et al. 2016). This study combines both molecular (ZooMS) identifications with morphological and osteometric analyses to gain a more accurate view of the range of species exploited in the Medieval period. In this study, ZooMS identifications overturned previous identifications based on morphological analysis alone and identified non-cetacean species among the assemblage. Nevertheless, morphological analysis continued to provide key information concerning the exploitation of cetaceans, particularly in determining the exploited skeletal elements. The ORCA-Manual (van den Hurk, unpublished) utilising osteometric data, has the potential to further optimise the identification of zooarchaeological cetacean material, especially for dolphins and other odontocetes.

The results of this study also clearly demonstrate that several species dominate the archaeological assemblages. As observed through the meta-analysis of cetacean material in archaeological sites, North Atlantic right whale is the best represented species, with 18 specimens. Although ZooMS cannot differentiate bowhead (*Balaena mysticetus*) and right whales, current and past distribution data suggests that specimens identified as either bowhead or right whale via ZooMS represent the latter species (Foote et al. 2013). Further genomic analysis of these specimens could provide more precise taxonomic identifications. Right whales may have been caught through active whaling, as it is a migratory species that often moves close to the coast. Furthermore, right whales are slow swimmers with a maximum speed of 15 km/hr (Jefferson, Webber, and Pitman 2008, 28–30) and tend to float after being killed, therefore making them the 'right' whale to hunt. The high number of right

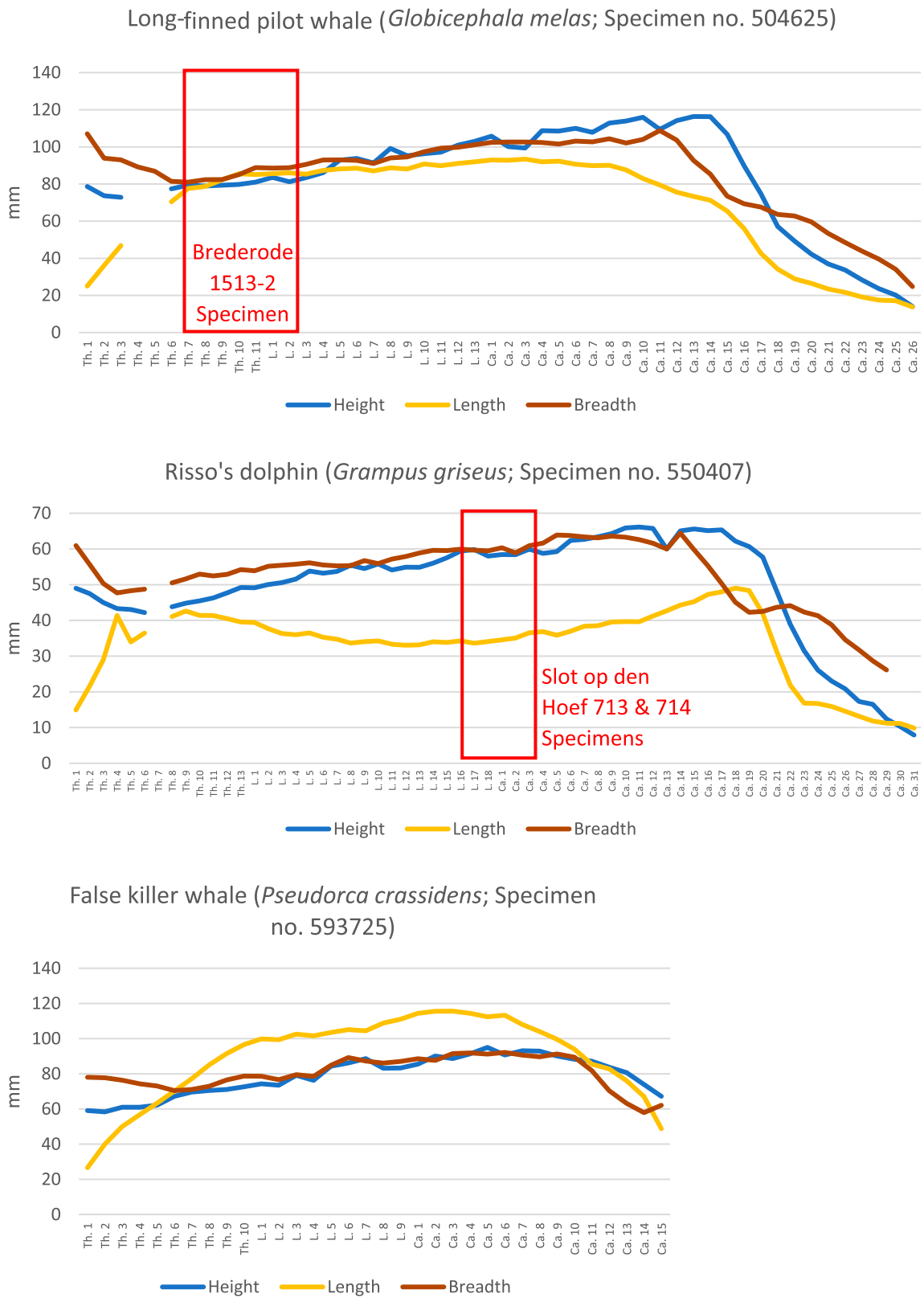

Figure 9. Height, length, and breadth of the vertebral bodies of the thoracic (Th.), lumbar (L.), and caudal (Ca.) of the long-finned pilot whale (specimen 504625), Risso's dolphin (specimen 550407), and false killer whale (specimen 593725), all part of the Smithsonian Institution, in comparison to zooarchaeological remains of Brederode (1513-2; WH621) and Slot op den Hoef (713 and 714; WH618); for vertebral dimensions of archaeological specimens see Table 1. The ratio between the height, length, and breadth of the vertebral bodies suggest that specimen 1513–2 from Brederode belonged to a long-finned pilot whale, while specimens 713 and 714 from Slot op den Hoef belonged to a Risso's dolphin.

whale specimens does indeed suggest that this species was actively hunted, though natural strandings probably occurred more frequently prior to its eastern North Atlantic depletion as well, making it possible that some these remains also derived from Medieval stranding events.

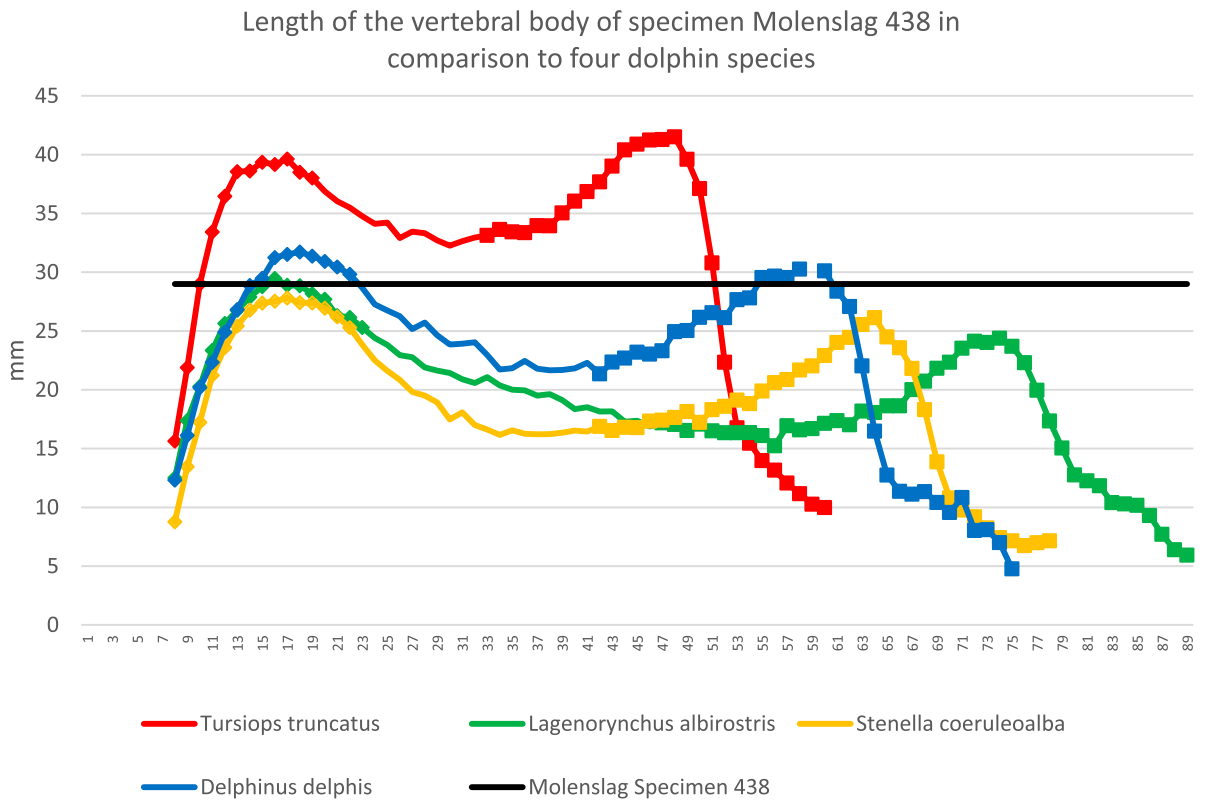

Figure 10. Length of the vertebral body of the vertebral column of the common bottlenose dolphin (specimen 593772), white-beaked dolphin (specimen 267573), striped dolphin (specimen 504350), and the common dolphin (specimen 571620), part of the Smithsonian Institution, in comparison to the zooarchaeological specimen of Molenslag (438; WH637; see osteometric data in Table 1). The X-axis denotes the number of the vertebra within the vertebral column, starting at the atlas. The line segments with diamonds indicate the thoracic section, those without any markers the lumbar section, and the segments with squares indicate the caudal section of the vertebral column.

The harbour porpoise is the second-best represented species in the archaeological material. Today, this species is abundant in the North Sea (one of its most important habitats) with an estimated population of around 250,000 individuals in 2016 and the best represented species in modern stranding data (Walvisstrandingen 2019). The historical sources also suggest that it was a widely exploited cetacean species for the Netherlands, which the zooarchaeological data supports.

The sperm whale is also relatively strongly represented in the archaeological assemblage (n = a minimum of 7 specimens). This species frequently strands along the shores of the southern North Sea. Albertus Magnus (1193–1280) saw the locals of Friesland butchering a sperm whale, piercing the animals eye resulting in the spermaceti flowing out of the hole. The locals filled eleven large flagons with it and also stripped the blubber from the animal (Szabo 2008, 92; Foote 2017). One interesting finding is a partial sperm whale skeleton displaying multiple chop- and cutmarks found on the beach in Walraversijde, Belgium dating to the Late Medieval period. This young individual probably stranded along the coast and was subsequently butchered on the beach (Van Neer and Ervynck 1993, 87). Several attributes of the sperm whale, including its size and pelagic lifestyle make it unlikely as a candidate for active hunting (Watwood et al. 2008). Similar to the sperm whale, the fin whale (represented in the archaeological record by two specimens), is not presumed to have been actively hunted, as it is a fast, stream-lined swimmer, and one of the largest species on earth.

Grey whale remains are frequently recovered from paleontological contexts in the North Sea (Alter et al.

Table 1. Measurements performed on (partially) complete vertebral remains. Measurements undertaken include the maximum height, length and breadth of the vertebral bodies (in mm).

Site	Specimen number	Height	Length	Breadth	ZooMS, morphological, and osteometric identification	Original identification
Slot op den Hoef	713 (WH618)	63,92	37,08	69,43	Risso's dolphin	Common bottlenose dolphin
Slot op den Hoef	714 (WH618)	62,65	38,61	69,8	Risso's dolphin	Common bottlenose dolphin
Brederode	1513–2 (WH621)	92,8 3	104,32	106,16	Long-finned pilot whale	Killer whale
Brederode	1513–1 (WH623)	122,6	-	137,65	Killer whale	Killer whale
Molenslag	438 (WH637)	53	42	29	Common bottlenose dolphin	Dolphin
Achlum	149–35 (WH610)	218,9	184,74	170,85	Northern bottlenose whale	Sperm whale

Table 2. Strandings data for the Netherlands from 1969–2018 compared with the zooarchaeological cetacean material dating to AD 400–1600 from both the Netherlands and Belgium. Numbers in '()' are cf. identifications.

	Species	Strandings 1969–2018	Archaeological material dating to 400–1600
Both represented in modern strandings and archaeological record	Harbour porpoise	9315	17
	White beaked dolphin	202	1
	Sperm whale	28	8 (1)
	Common bottlenose dolphin	24	1 (1)
	Fin whale	14	2
	Long-finned pilot whale	14	2
	Northern Bottlenose whale	3	5
	Risso's dolphin	1	2
Represented in modern strandings – not represented in archaeological record	Common minke whale	21	0
	Sowerby's beaked whale	12	0
	White sided dolphin	11	0
	Striped dolphin	11	0
	Humpback whale	6	0
	Common dolphin	2	0
	Sei whale	3	0
	Blainville's beaked whale	1	0
Not represented in modern strandings – represented in archaeological record	Grey whale	0	4
	Killer whale	0	2
	North Atlantic right whale	0	18 (1)

2015). This study identified an additional five specimens, suggesting that this species, of which the North Atlantic population is now extirpated, was once far more abundant along the Dutch and Belgian coast. This species, like the North Atlantic right whale, is relatively slow and has similar presumed migration routes (Alter et al. 2015). Thus, grey whales may also have been actively hunted, though it remains unclear to what extent whaling led to the depletion of the North Atlantic population.

Strandings of killer whale, northern bottlenose whale, pilot whale, Risso's dolphin, and common bottlenose dolphin (the toothed cetaceans identified as part of this study besides the sperm whale), occasionally occur in the Netherlands. These species, with the exception of the bottlenose dolphin, do not frequently venture into the southern North Sea region and it is therefore likely that these species were not often actively hunted; therefore, these specimens may more likely have been acquired through scavenging of strandings (Shirihai and Jarrett 2006). Prior to the construction of the Afsluitdijk, closing off the Zuiderzee from the Wadden Sea (Walvisstrandingen 2019), there was an established population of common bottlenose dolphin in the western Wadden Sea hunting herring in the region. If this population was present in the area during the Medieval period as well, it might well have been targeted.

Conclusion

Zooarchaeological cetacean remains appear to be relatively frequently identified at high-status sites such as castles, as well as ecclesiastical sites, confirming the historical evidence that the social elite indeed did have a taste for cetacean meat. The identification of cetaceans at urban and non-elite sites, however, confirms that cetacean products were also available outside of elite and ecclesiastical contexts. The combined morphological and biomolecular identifications point to the exploitation of species that are known to strand or may have been expected to strand during the Medieval period. Fast, deep-water species, such as the sperm and fin whale, were almost certainly obtained from scavenging. The extent or intensity of more active acquisition methods of hunting for smaller, slower-moving baleen whales such as grey and right whales, and smaller odontocetes like harbour porpoise and dolphins is less clear. These species would have been within the reach of Medieval hunters and could have been obtained using pre-industrial fishing vessels and technologies. Historical sources support the notion of at least occasional active hunting, especially for Flanders and the Frisian region of the Netherlands, although the archaeological record cannot provide greater resolution into the relative frequency of hunting versus scavenging. Nevertheless, the dominance of slower, more easily acquired right whale and porpoise in the archaeological record suggests that active hunting may have been more common than inferred by historical records alone.

It should be noted that the presence of osteological remains of cetaceans on a site does not necessarily indicate that their meat was consumed but can also suggest that their osseous remains were merely used as a raw source for the production of various tools or artefacts. Moreover, the identification of cetacean remains within the archaeological record almost certainly underestimates the frequency with which cetaceans were exploited in practice. The sheer size of whales means that the majority of their skeletal remains might have been left on shore, while their meat was taken to site (Smith and Kinahan 1984). This beach-side butchery is probably what happened to the remains found in Walraversijde, Belgium (Van Neer and Ervynck 1993, 87).

The identification of zooarchaeological cetacean material still faces many challenges. It is, however,

vital to identify the remains to genus or species level in order to understand the complexities of early whaling practices. ZooMS, as well as identification guides such as the ORCA-Manual, hold the potential to unravel the early beginnings of cetacean exploitation.

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