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Technical Report: The fish bone from Grand Arcade, Cambridge (site code GAD05/06)

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Summary

This report presents an analysis of the fish bones from Grand Arcade, Cambridge. This assemblage comprised sieved and hand collected bone from the 11-12th century to the 19th century, with most material from sieved 14th century deposits. Results indicated a variety of fish were exploited from freshwater and marine habitats, with a reliance on whiting and herring. The 12th century deposits had an unusually high proportion of freshwater fish, but quantities were low. Cod appeared for the first time in the 14th century, relatively late compared to many English sites. Preserved cod were likely imported from two separate sources, one in the 14th century and one in the 16th, and each was associated with different butchery patterning, element proportions and fish sizes. Eels were surprisingly absent, appearing only in the 16th century, which might indicate the relative wealth of these deposits. Large flatfishes began to be exploited in the 16th century, indicating an expansion of fishing grounds and fish species available. Some indication of the declining quality of the river systems was provided by changing freshwater fish species.

KEYWORDS: CAMBRIDGE, FISH BONES, ZOOARCHAEOLOGY, MEDIEVAL

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The fish bone from Grand Arcade, Cambridge (site code GAD05/06)

Introduction

This report details the analysis of 3697 identified fish bones from sieved features excavated at the Grand Arcade site, Cambridge. A further 93 bones were identified from hand collection. The fish bones found at this site date from the 11-12th century to the 19th century, with an emphasis on the 14th century. The fish could have been caught in the River Cam, which runs through Cambridge and joins the River Great Ouse just south of Ely, before flowing out to the North Sea at King's Lynn, or they could have been caught in the North Sea and imported fresh, lightly cured for eating within a few days, or preserved for long-term storage.

Fish bones from nine separately dated phases were recovered, ranging from the 11-12th centuries to the 19th century. Within each phase, a variety of context types were found, including pits, cess pits, wells and gravel quarries. Table 1 summarises the numbers of bones identified from each context type, by phase, in order to provide an indication of the types of conclusions that could be drawn. As can be seen, the vast majority of the identified bone from sieved contexts was found in two specialised pit features dating to the 14th century. It will therefore be possible to discuss detailed information about fish species, sizes, likely origin and possible fishing methods for these substantial features. All other phases have far fewer bones and therefore the conclusions that can be drawn from them are more simplistic. It is not worth examining variation between context types within each of these small phases, because of the very small quantities of bone involved.

Because most of the identified, sieved material is from the 14th century, it will be difficult to examine detailed changes through time. However, broad comparisons are possible from the 11-12th century to the 19th century using both the hand collected and sieved datasets. These will be used to explore basic temporal changes including fish species present, their sizes, and any changes to local (freshwater) river systems or long distance trade networks.

Hand collected fish bones are notoriously biased towards the larger elements from larger species (Wheeler and Jones 1989), but they can still reveal information about the cod family fish (some of which tend to be of substantial size), and importantly, any butchery patterning can reveal information about fish processing, preservation and fish trade. The medieval trade in cod and cod family fish is well known both historically and archaeologically (Barrett 1997; Perdikaris 1999; Enghoff 2000; Harland 2007a). Fish were caught in Northern European waters, air dried or salted, and then imported throughout Europe; the resulting product went by several names including 'stockfish', and it could be kept for several years. It can be recognised archaeologically because of the typical element patterning, butchery marks and fish sizes involved. Any evidence for the consumption of prepared cod and cod family fish at Grand Arcade will be discussed in detail. The herring trade was also well known historically from English ports on the North Sea, including Great Yarmouth and King's Lynn, and although it is more difficult to recognise and distinguish preserved herring from those consumed fresh, the historical and archaeological evidence for this trade will also be discussed.

Methods

This assemblage was recorded using the York System, an Access database utility designed for recording zooarchaeological assemblages, as well as the extensive reference material available in the Department of Archaeology, University of York. The recording protocol is fully detailed in Harland *et al.* (2003). Briefly, this entails the detailed recording of the 18 most commonly occurring and easily identified

elements, termed quantification code (QC) 1. For each of these, the element, species, approximate size, side, fragmentation, texture, weight and any modifications are recorded in detail. Fish vertebrae (QC2) are recorded in more limited fashion, with counts, element and species recorded. Some elements are unusual and particularly diagnostic, like otoliths, and are fully recorded (QC4). The final category of material (QC0), includes elements not routinely identified as well as unidentifiable material. Elements that are from very unusual species, or that are butchered, are recorded in detail even if not from the QC1 category. Data analysis involved structured database queries, as well as manipulation using Excel.

It became apparent during initial assessment that some of the larger cod were likely imported as prepared, preserved fish. When large cod and related species are preserved by air drying or salting, often most of the head elements are removed and left at the production site. Archaeologically, the imported product is often only represented by vertebrae and a few selected appendicular elements (those from the back of the head including the cleithra). Because of the lack of cranial elements, it was necessary to record fish sizes for all cod vertebrae, even though this is not usually done.

Although the minimum number of individuals (MNI) statistic is not usually calculated for small assemblages because of its many biases and distortions (Reitz and Wing 1999, O'Connor 2000), the 14th century specialised pit feature (number 3602) warrants attention. This deposit, consisting of two contexts, is a large, discrete pit containing a large quantity of fish. In order to ascertain the minimum number of fish found in it, element counts for each species were examined. Using estimated fish sizes, fragmentation patterns, and taking into account left and right siding for elements occurring in pairs, the most frequently occurring element was determined, and this was used as the MNI figure. Sometimes the first vertebra was found to be the most frequent element. This element is not usually sized (barring cod, as discussed above), so this method was only used for herrings, which were all of the same size, and for whiting, which are mostly one size.

The complete archive has been submitted to the excavators as both an Access file and as simple text files containing the same data. These are also kept on file in the Fishlab at the University of York.

Preservation

Bone condition was overall very good, with a high proportion of identifiable material, and overall good texture and completeness (Table 2). There were few modifications, and only one burnt bone was found, from the 12th century cess pit. This could indicate that burnt bone did not survive well in the burial conditions, or that very little burning of food waste took place on site; comparisons with mammal and bird bone should help resolve this pattern of rubbish disposal. Only one example of fresh breakage was observed indicating that excavation and post-excavation damage was minimal.

Evidence of crushing was very low, with only 11 specimens observed, all from >2mm sieving. These included six very large cod or cod family vertebrae from 14th century specialised pit features and two pike vertebra from the 12th century cesspit. The large size of these bones means they were unlikely to have been crushed by chewing and passage through the digestive system, so they may have been crushed during cooking or disposal. However, a further three small vertebrae may have been crushed by chewing, including an eel from a 14th century specialised pit feature, a herring from a 16th century disposal pit, and a halibut family vertebra from a 16th century disposal pit. No evidence of acid etching, caused by digestion, was noted on any of the bones. Experiments have shown that human and animal digestion of small vertebrae like those from herring and eels can produce distinctive patterning (Jones 1986), but the small quantity of chewed bone here makes it likely few of these passed through the digestive system.

This is particularly apparent for the cess pit deposits, where aside from the two pike bones with evidence of crushing, there was no obvious evidence for digestion.

Results

Species

A total of 3697 fish bones were identified to species or species group from sieved deposits, and a further 93 bones were identified from the hand collected material (Table 3). Whiting and herring made up the vast majority of the fish from the sieved material, comprising 43% and 42% respectively. Other taxa from the sieved material comprised, in order, carp family, cod, eel, perch, pike, cod family, roach, perch family, ray family, rudd, dace, haddock, burbot, gurnard family and halibut family (full taxonomic names are provided in Table 8). The hand collected material was naturally biased towards the larger fish and elements, and therefore comprised a more limited range of species, including, in order, cod, sole family, halibut family, herring, ling, pike, turbot, salmon/trout, cod family and turbot family.

Although much of the material originated in 14th century deposits, it is still possible to examine broad changes through time. The earliest sieved phase dates to the 12th century and is approximately half herring, one third pike, with small quantities of eels, carp family fish and a single burbot. The one identified bone from 12th century hand collected deposits is herring. These indicate about half the fish were from marine environments (the herring) and the other half from freshwater river systems, probably caught locally and consumed fresh. Compared to other contemporary sites from England, this is a high reliance on freshwater fish and a more normal reliance on herring (Barrett *et al.* 2004a; Barrett *et al.* 2004b) – with the caveat that quantities are very small and thus possibly not representative. The absence of cod and cod family fish is unusual, as they are found in some quantity at most English sites, and would be expected to at least be present by the 14th century, even if not eaten in large quantities. This absence, together with the high reliance on freshwater fish, may indicate the inhabitants were slow to take advantage of the large variety and quantity of marine foods that became readily available following the 'fish event horizon' in the early years of the first millennium AD (Barrett *et al.* 2004a; Barrett *et al.* 2004b).

In the 14th century, cod and marine cod family fish make their first appearance, but they are still found only in small quantities, indicating continued low demand. In the sieved deposits, cod represent only 4% of all identified fish, with cod family (likely cod or whiting) only a further 1%. However, whiting were found in very large quantities, comprising 44% of all material in this phase. Some English sites have similarly high proportions of this small marine fish, including a few contemporary London sites (Serjeantson and Woolgar 2006). Herring are the second most common species, at 42%, which is typical of English sites of this date (Barrett *et al.* 2004a; Barrett *et al.* 2004b). The carp family fish represent about 7%, and eels and perch are both found at trace levels; these freshwater fish together represent about 10% of the 14th century material, which is also typical of English sites of the period.

Very few bones were found in the 13-15th, 14-15th and 15-16th century phases, and those that were found included cod and herring, neither of which were unusual at this time. By the 16th century, small hand collected and sieved data indicate some changes. Eels became common for the first time, representing about two thirds of the small sieved dataset, while herring were still frequently consumed. Other fish make their first appearance at this time, including a single specimen from the ray family, the first flatfish, from the halibut family, and a single find of haddock. The hand collected 16th century assemblage is dominated by cod, ling and cod family specimens, with a few flatfish appearing for the first time, including turbot, turbot family and halibut family specimens. These indicate exploitation of a wider range of fish, perhaps in response to demand for fresh marine fish of higher value (Serjeantson and Woolgar

2006). This increased into the 19th century phase, which is represented by a few hand collected bones. Uniquely, this phase contains several sole family remains, as well as some halibut family – indicating a preference for high value flatfish. The two bones from the 18th century include pike and the only salmon or trout at Grand Arcade (the latter being a more likely species for local capture), probably representing local freshwater fishing in what was by then a very altered river system.

The lack of eel throughout most phases is surprising, given that they tend to be common finds from many English sites (Serjeantson and Woolgar 2006). The Cambridgeshire fenland was ideal habitat for eels, and their prevalence likely gave the name to nearby Ely (Fort 2003). A 13th century merchant's poem mentions "Eels of Cambridge...Herring of Yarmouth...Cod of Grimsby" (Kowaleski 2000) – implying their importance in the city. They were likely a low status fish, commonly and cheaply available in the fens and the River Great Ouse, which is joined by the River Cam (Pinder *et al.* 1997; Lucas 1998); their absence may therefore indicate the Grand Arcade material prior to the 16th century represents wealthy – or at least, not poor – consumption patterns. A similar absence of eels was noted from 14th century deposits at Hostel Yard, Corpus Christi (Harland 2008), and again this could be interpreted as a status-related consumption pattern.

All of the freshwater fish could have been caught in the River Great Ouse system. This includes the River Cam, which flows through Cambridge and joins the Great Ouse just south of Ely (Pinder *et al.* 1997). The burbot is a freshwater cod family fish, now very probably extinct in British waters (Buczacki 2002), and along with some of the carp family fish, it is susceptible to riverine pollution (Jones 1988). Its single occurrence in the 12th century and its absence from later deposits might indicate changes to the ecology of River Cam, possibly as a response to direct exploitation of the freshwater fish as well as increased pollution and use of the river systems; a similar decline was noted at Hostel Yard, Corpus Christi (Harland 2008). The few carp family fish were predominantly found prior to the 15th century. The carps are notoriously difficult to identify to species, but it is likely most were roach and some were rudd or dace. Dace prefer faster, clear waters, while rudd live in slower water, and given that dace were found in the 14th century and rudd in the 14-15th century, this could indicate increased siltation in the River Cam, with resultant ecosystem change. Roach, the most commonly identified of the carps, is still relatively common today in the River Great Ouse system (Pinder *et al.* 1997). However, it must be noted that carp family fish could also raised in fishponds, which were maintained for high status fish consumption throughout medieval England (Aston 1988; Serjeantson and Woolgar 2006); some of the finds at Grand Arcade may have originated from these sources. These fresh water fish were often given as gifts, on a par with other more obvious luxuries, and as such were worth more as a social symbol than as a foodstuff (Dyer 1988).

The marine fish probably came from the southern North Sea region. Herring and cod may have been imported as prepared fish, with the latter possibly from the northern North Sea or Scandinavian waters and traded through a merchant centre like King's Lynn. From there, the marine fish could have reached Cambridge by water, shipped on the Great Ouse and subsequently the River Cam. Most marine fish could probably have been imported to Cambridge quickly enough to not require preservation, but herring are very quick to spoil so may have required a short-term cure (Cutting 1955). Herring migrate around the North Sea, reaching the southern region by the autumn; this would make them a seasonal resource.

Fish sizes

All of the cranial elements were sized during identification, as were the cod vertebrae, thus providing an indication of changes in size through time (Table 4). Cod and cod family fish tend to be of large size if imported as preserved fish. Cod from the 14th century sieved deposits – the earliest with any quantity of cod – tended to be from fish of 50-80cm total length, with a significant minority from fish of 80-100cm total length. These were of suitable size for preservation, but the few finds of cod less than 50cm total length were likely brought to Cambridge freshly caught. The hand collected cod from the 16th century

tend to be bigger, most being from fish of 80cm total length and greater. The hand collected assemblage is naturally biased towards bigger fish, but the absence of the larger cod from the 14th century sieved material suggests this size increase through time is a real pattern. This implies exploitation of different fishing grounds in each phase, probably linked to different sources of prepared, imported cod (see element and butchery patterning below).

About three quarters of the 14th century whiting were in the 30-50cm total length category, although very few extended beyond 40cm. The remaining quarter were 15-30cm total length, with most being between 25 and 30cm. These sizes could have been caught from relatively shallow, inshore waters. The 14th century herring were all in the 15-30cm total length category, a normal size for these fish.

Some of the carp family fish were sizable, between 30 and 50cm total length, including one specimen identified as roach, while several more were between 15 and 30cm total length. The very small sizes of the perch and some of the carps (less than 15cm total length) suggest they were unlikely to have been deliberate catches. Instead, they may have been inadvertent catches, or baitfish used to catch larger species, like pike. Roach and herring were both mentioned as good baitfish in a 15th century account of freshwater fishing (Berners 1496). These small fish also may have been the stomach contents of larger fish, like pike. The pike were mostly small between 15 and 30cm total length, with one 14th century specimen between 30 and 50cm total length.

The few hand collected finds of flatfish suggest that by the 16th century – when they first appear at Grand Arcade – some very sizable turbot were being consumed, at 50-80cm total length, as well as some smaller turbot family fish (15-30cm total length) and some large halibut family fish (30-50cm total length).

Element distribution

Most of the fish being consumed at Grand Arcade were deposited in their entirety (Table 5). However, the patterning for the larger cod suggests only certain parts of the fish were arriving on site. The two phases with big quantities of cod, the 14th century sieved material and the 16th century hand collected dataset, are summarised graphically in Figure 1. In 14th century contexts, 80-100cm total length cod elements are almost entirely vertebrae, and there is an over-abundance of 50-80cm total length vertebrae. These must have been arriving without heads. The cleithra, the pair of elements from the back of the head often left in preserved cod, are found in expected proportions with other cranial elements in the 14th century – suggesting that only the larger vertebrae were arriving as prepared fish, and that the smaller heads, with the cleithra, were from fish consumed fresh and deposited whole. In contrast, the pattern is very different in the 16th century. Then, cleithra are abundant without corresponding quantities of other cranial elements. The cleithrum is one of 19 elements routinely identified, so if cleithra were arriving with their corresponding cranial elements, they should be found in much smaller proportions. This would suggest that prepared cod of greater than 100cm total length were arriving ready preserved in the 16th century. The lack of similar sized vertebrae is unusual, but could reflect differential rubbish disposal; the preserved flesh may have been served on the bone, while the cleithra may have been removed during food preparation. The smaller, more caudal vertebrae probably would not be recovered from hand collection, even from these large fish, which could also explain their absence.

All parts of the herring were recovered from the substantial 14th century sieved deposits, but some curious element proportions were observed. At sites like York, where thousands of herring were found, equal counts of abdominal and caudal vertebrae were recorded. This would be expected, given that known curing methods either leave all bones intact, staving off decay for a short time, or remove only selected elements from the gill region for longer term preservation (Enghoff 1999; Childs 2000a). However, a substantial quantity of abdominal vertebrae are ‘missing’ from the 14th century deposits. This is unlikely to be taphonomic, given the good quality of bone found throughout Grand Arcade, and nor is it a recovery bias, because abdominal vertebrae should be recovered by 2mm sieving. The reverse pattern was

observed in a small 16th century deposit from Hostel Yard, Corpus Christi (Harland 2008). There, a number of caudal vertebrae were 'missing'. Both patterns might result from differential cooking and consumption of herring bodies compared to tails. Regardless, these herring were probably imported with a light cure, given that all cranial elements were found. They were probably caught in the North Sea and landed at a specialised fishing port like Great Yarmouth or Cromer, before being traded to King's Lynn (Childs 2000b; Robinson 2000) and shipped up the Great Ouse river system.

All elements from the substantial 14th century whiting deposits were recovered, as expected. These fish were likely caught from shallower, inshore regions of the North Sea and brought to Cambridge fresh.

MNI

The minimum number of individuals was calculated for the large 14th century specialised pit (Table 6), taking into account element quantities, fragmentation patterning and sizing. This was found to contain at least 124 fish, of which one third were herring, one third were whiting, about one sixth were from the carp family, and a number of other fish were found in small quantities. These were mostly small, between 15 and 50cm total length, with a few larger and smaller. The use of the MNI statistic inflates the proportions of the minor species, like perch, perch family and gurnard family, making them appear as though they contributed more to the diet. However, despite the biases of MNI statistics, it is possible to say that this pit contained 3516 identified bones that were from at least 124 individual fish.

Butchery

A total of 39 butchery marks were recorded, 37 from cod and one each from whiting and ling (Table 7). These were only found on the larger fish, regardless of recovery method, making it possible to compare the hand collected and sieved material. Butchery marks can be indicative of processing fish for preservation, or of processing during cooking. When compared with element proportions and fish sizes, they are an important indicator of the fish trade, particularly of imported fish arriving as a dried or salted product. Although the study of butchery marks on cod and cod family fish is not yet fully understood, it is possible to compare the Grand Arcade material with other medieval assemblages analysed by the author, including York (Harland *et al.* in press).

Two distinct butchery patterns can be observed. In the 14th century material, butchery marks are only found on the vertebral column, including the basioccipital, the element at the back of the skull that articulates with the first vertebra (Figure 2). These butchery marks are mostly in the sagittal plane (dividing the skeleton into left and right halves), with a few in the transverse plane (dividing the skeleton into front and back). They are mostly found in cod of 70-80cm total length, with a few from fish of 80-100cm total length. These 14th century sieved cod are almost all from one specialised pit context, 33349. The two butchered caudal vertebrae are from context 33350 and are probably from a single cod tail, most of which was recovered.

In the 16th century material, the butchery marks are predominantly on cod cleithra from fish of 80-100cm or greater than 100cm total length, with a few more observed on caudal vertebrae and one on a supracleithrum, a bone from the appendicular skeleton closely associated with the cleithrum. The marks are a variety of chops and knife cuts in all three anatomical planes.

These two patterns, separated in time and space, probably illustrate two different types of imported, prepared cod family fish. In the 14th century, it has already been noted that cod element proportions suggested many larger fish were arriving without head elements (Figure 1), likely because they had been left at the producer site when the fish were dried or salted. The 14th century fish were chopped in the sagittal plane, possibly to divide the anterior portion of the fish into two halves which could then be dried separately. The tail appears not to have been sagittally split. A few vertebrae showed evidence of multiple chop marks, indicating they were chopped from posterior to anterior (from the tail to the head).

Many of the chop marks were slightly slanted, probably meaning the fish were chopped with a series of deep cutting chops to roughly separate the two sides, without overt accuracy. Most of the chops were either to the left or right of the exact midline, and both the larger vertebral bodies and the small wedges of bone removed from them were recovered, although none could be refitted. The heads, including the cleithra, were disposed of elsewhere. Both halves of prepared fish were imported, indicating no preference for left or right sides. Chops in the transverse plane separated the preserved fish halves into sections, and may have been done during the preservation process, or when being prepared into a meal. The two fine knife marks observed on the cod tail from context 33350 are difficult to interpret and might have been caused when removing the meat from the bones.

Similar sagittal chop marks have been observed on cod from contemporary phases at Coppergate, York (Harland *et al.* in press), as well as from 13th and 14th century deposits at Berwick-upon-Tweed (Harland 2007b); they are likely present at other sites but are as yet unrecognised. At both comparative sites, these chops also tended to be found on the anterior vertebrae, although they were from cod of 80cm total length and greater, which is slightly larger than those from Grand Arcade.

In the 16th century, it has already been observed that cod cleithra from fish of greater than 100cm total length are found in much larger quantities than expected, given the quantity of other head elements (Figure 1). These were therefore probably imported as preserved fish, and it is several of these cleithra that have been butchered. Most were found in pit 34875, which contained 16 cod cleithra and one cod vertebra. This deposit probably represents kitchen waste, the cleithra being removed from preserved cod flesh during the cooking process. The lack of vertebrae in this deposit is surprising, since preserved cod often had the vertebrae left intact, but the cooked fish may have been left on the bone and thus disposed of elsewhere. A variety of chop and knife marks were found on the cleithra, with little regularity. This pattern is commonly found on preserved cod, and parallels are known from contemporary Hostel Yard, Corpus Christi deposits (Harland 2008), from earlier deposits in York (Harland *et al.* in press) and from a variety of earlier sites from the North Atlantic region (Barrett 1997). These are sometimes accompanied by butchery to the supracleithrum, as observed from a 16th century well at Grand Arcade. These 16th century butchery marks were probably caused during removal of the rest of the head, at the production site, or during food preparation. Sometimes the dorsal or ventral cleithra tips have been removed, possibly to aid transport or storage because they can protrude from the preserved product (Harland 2006). One example from the 16th century Grand Arcade pit is particularly diagnostic because during the butchery process the bone was twisted, which could only have occurred when fresh. This probably means this particular butchery was made during head removal and preparation for drying or salting at the producer site.

The fine knife marks observed on a cod caudal vertebra were probably caused during filleting or when removing the flesh from the bones. Two other caudal vertebrae are more difficult to interpret. They both have small knife marks in approximately the transverse plane, on both left and right, likely done with a blunt knife that twisted into the bone, yet they are from different contexts (32050 and 30599). They could have been caused by similar processes during cooking or eating, and it would be interesting to see if any other finds linked these two contexts.

Two butchered dentaries were found, one large cod from 19th century deposits, and one small whiting from the 14th century. These were both butchered just adjacent to the midline articulation, possibly to aid hook removal. This distinctive method of butchery is found at a number of Northern European sites, including medieval and later deposits from York, and is often accompanied by butchery of the premaxilla, which together with the dentary, forms the outermost elements of the mouth.

Samples have been taken from the cod butchered cleithra and vertebrae for $\delta^{15}N$ and $\delta^{13}C$ stable isotopic testing, which should determine if these cod were imported as a preserved foodstuff, and if so, where they

were likely caught; this is part of the ongoing Medieval Origins of Commercial Sea Fishing Project (Barrett *et al.* 2008).

Summary and conclusions

The fish from Grand Arcade are a diverse range of freshwater and marine species, some of which were likely caught in local river systems, some in the southern North Sea, and some of which were imported as preserved fish, likely from Northern European regions. Cod and marine cod family fish were present only from the 14th century, and then only at low levels, which is surprising given comparative material. Freshwater fish made up about half of all fish from the small 12th century deposit, decreasing to about 10% by the 14th century. This indicates a greater reliance on freshwater fish, and corresponding low levels of cod consumption, compared to many other English sites. However, the large sieved deposits from the 14th century indicate a reliance on herring and whiting, both probably caught in local North Sea waters. The herring were probably lightly cured, and were thus a seasonal resource focussing on the autumn and early winter.

In the 16th century, eels became common for the first time, as do the flatfishes, the latter suggesting that there was an expansion in fishing grounds exploited compared to earlier phases. The absence of eels from earlier deposits, despite evidence of their ubiquity, may indicate the relative wealth of the inhabitants. Even in the 16th century, when eels were found in quantity for the first time, contemporary deposits of large, expensive flatfish indicate the continuing probable wealth associated with the Grand Arcade deposits.

Much of the cod was likely imported as prepared, preserved fish. Different sources were used in the 14th and 16th centuries, each with distinctive sizes and butchery strategies. Stable isotopic testing currently being undertaken should indicate the various geographic origins of each preserved product, which will in turn have important trade and exchange connotations for each time period.

The freshwater species were probably caught with hook and line, or with fish traps or nets, and some of the smallest fish may have been bait or stomach contents of the larger ones like pike. The marine fish were probably caught by long lining (particularly the cod and marine cod family fish) or by netting or with hook and line. Some of the freshwater species, including the cyprinids and possibly the pike, may have originated in managed fishponds. These were reserved for high status consumption and thus had status correlations, but they are difficult to distinguish from wild fish.

Finally, some indication of freshwater environmental change became apparent during this analysis, albeit based on very small quantities of fish. The carp family fish shift towards fish preferring slow moving rivers by the 16th century, and the pollution sensitive burbot was last seen in the 12th century Grand Arcade deposits, although they were found in very small quantities in 16th century deposits at Hostel Yard, Corpus Christi. Together these imply an increase in local river pollution, possibly linked to increasing urbanisation and more intensive agriculture around Cambridge, as well as the draining and management of the fen river systems.

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Bibliography

Aston, M (ed) (1988). *Medieval Fish, Fisheries and Fishponds in England*. Oxford: British Archaeological Reports British Series 182.

Barrett, J, C Johnstone, J F Harland, W Van Neer, A Ervynck, D Makowiecki, D Heinrich, A K Hufthammer, I Enghoff, C Amundsen, J Christiansen, A K G Jones, A Locker, S Hamilton-Dyer, L Jonsson, L Lougas, C Roberts and M Richards (2008). 'Detecting the medieval cod trade: a new method and first results', *Journal of Archaeological Science* 35, 850-861.

Barrett, J H (1997). 'Fish trade in Norse Orkney and Caithness: A zooarchaeological approach', *Antiquity* 71, 616-638.

Barrett, J H, A M Locker and C M Roberts (2004a). ''Dark Age Economics' revisited: the English fish bone evidence AD 600-1600', *Antiquity* 78 (301), 618–636.

Barrett, J H, A M Locker and C M Roberts (2004b). 'The origins of intensive marine fishing in medieval Europe: The English evidence', *Proceedings of the Royal Society of London B* 271, 2417-2421.

Berners, J (1496). *A treatyse of fysshnge wyth an Angle*: Renascence Editions, http://darkwing.uoregon.edu/%7Erbear/berners/berners.html.

Buczacki, S (2002). *Fauna Britannica*. London: Hamlyn.

Childs, W (2000a). 'The Internal and International Fish Trades of Medieval England and Wales: Control, conflict and international trade' in D. Starkey, C. Reid and N. Ashcroft (eds), *England's Sea Fisheries: The Commercial Sea Fisheries of England and Wales since 1300*, 32-35. London: Chatham Publishing.

Childs, W (2000b). 'Fishing and Fisheries in the Middle Ages: The Eastern Fisheries' in D. Starkey, C. Reid and N. Ashcroft (eds), *England's Sea Fisheries: The Commercial Sea Fisheries of England and Wales since 1300*, 19-23. London: Chatham Publishing.

Cutting, C L (1955). *Fish Saving: a History of Fish Processing from Ancient to Modern Times*. London: Leonard Hill.

Dyer, C (1988). 'The Consumption of Fresh-water Fish in Medieval England' in M. Aston (ed) *Medieval Fish, Fisheries and Fishponds in England*. Oxford: British Archaeological Reports British Series 182.

Enghoff, I B (1999). 'Fishing in the Baltic region from the 5th century BC to the 16th century AD: Evidence from fish bones', *Archaeofauna* 8, 41-85.

Enghoff, I B (2000). 'Fishing in the southern North Sea region from the 1st to the 16th century AD: Evidence from fish bones', *Archaeofauna* 9, 59-132.

Fort, T (2003). *The Book of Eels: On the Trail of the Thin-heads*: Harper Collins.

Harland, J F (2006) 'Zooarchaeology in the Viking Age to Medieval Northern Isles, Scotland: An investigation of spatial and temporal patterning', Unpublished PhD thesis, University of York.

Harland, J F (2007a). 'Status and space in the 'Fish Event Horizon': Initial Results from Quoygrew and Earl's Bu, Viking Age and Medieval sites in Orkney, Scotland' in H. Hüster Plogmann (ed) *The Role of*

Fish in Ancient Time: Proceedings of the 13th Meeting of the ICAZ Fish Remains Working Group in October 4th-9th, Basel/Augst 2005, 63-68. Rahden: Verlag Marie Leidorf GmbH.

Harland, J F (2007b) 'Technical Report: The fish bone from Berwick Workspace, Berwick-upon-Tweed (site code BTW06)', Reports from the Centre for Human Palaeoecology, University of York 2007/05.

Harland, J F (2008) 'Technical Report: The fish bone from Hostel Yard, Corpus Christi, Cambridge (site code HYC04)', Reports from the Centre for Human Palaeoecology, University of York 2008/4.

Harland, J F, J Barrett, J Carrott, K Dobney and D Jaques (2003). 'The York System: An integrated zooarchaeological database for research and teaching', *Internet Archaeology* 13.

Harland, J F, C J Johnstone and A K G Jones (in press). 'A case study from the Medieval Origins of Commercial Sea Fishing Project: Zooarchaeological results from York' in P. Béarez, S. Grouard and B. Clavel (eds), *Archéologie du poisson. 30 ans d'archéo-ichtyologie au CNRS. Hommage aux travaux de Jean Desse et de Nathalie Desse-Berset.* Antibes

Jones, A K G (1986). 'Fish bone survival in the digestive systems of the pig, dog and man: some experiments' in D. C. Brinkhuizen and A. T. Clason (eds), *Fish and archaeology: Studies in osteometry, taphonomy, seasonality and fishing methods*, 53-61. Oxford: BAR, International Series 294.

Jones, A K G (1988). 'Provisional remarks on fish remains from archaeological deposits at York' in P. Murphy and C. French (eds), *The Exploitation of Wetlands*, 113-127. Oxford: British Archaeological Reports British Series 186.

Kowaleski, M (2000). 'The expansion of the south-western fisheries in late medieval England', *Economic History Review* LIII, 429-454.

Lucas, G (1998). 'A Medieval Fishery on Whittlesea Mere, Cambridgeshire', *Medieval Archaeology* 42, 19-44.

O'Connor, T P (2000). *The Archaeology of Animal Bones*. Stroud: Sutton.

Perdikaris, S (1999). 'From chiefly provisioning to commercial fishery: Long-term economic change in Arctic Norway', *World Archaeology* 30 (3), 388-402.

Pinder, L C V, A F H Marker, R H K Mann, J A B Bass and G H Copp (1997). 'The River Great Ouse, a highly eutrophic, slow-flowing, regulated, lowland river in Eastern England', *Regulated Rivers: Research and Management* 13, 203-219.

Reitz, E J and E S Wing (1999). *Zooarchaeology*. Cambridge: Cambridge University Press.

Robinson, R (2000). 'The Common North Atlantic Pool' in D. Starkey, C. Reid and N. Ashcroft (eds), *England's Sea Fisheries: The Commercial Sea Fisheries of England and Wales since 1300*, 9-17. London: Chatham Publishing.

Serjeantson, D and C Woolgar (2006). 'Fish consumption in Medieval England' in C. Woolgar, D. Serjeantson and T. Waldron (eds), *Food in Medieval England: Diet and Nutrition*, 102-130. Oxford: Oxford University Press.

Wheeler, A and A K G Jones (1989). *Fishes*. Cambridge: Cambridge University Press.

Tables and figures

Table 1: Summary of dates, context types and bone quantities

Centuries	Context type	>2mm sieved bone			Hand collected bone		
		Identified	Unidentified*	Total	Identified	Unidentified	Total
11-12th	Pit				0	2	2
12th	Cess pit	25	0	25			
	Gravel quarry	11	0	11	1	13	14
14th	Pit				1	0	1
	Specialised pit	3615	978	4593			
13-15th	King's Ditch				0	4	4
14-15th	Pit				1	3	4
	Posthole				0	1	1
	Well	5	0	5			
15-16th	King's Ditch				9	1	10
	Pit	5	2	7			
16th	Animal burial				0	12	12
	Cess pit				1	0	1
	Disposal pit	36	5	41	1	0	1
	Gravel quarry				9	9	18
	Pit				28	49	77
	Well				12	17	29
18th	Cellar				2	6	8
19th	Cellar				1	1	2
	Planting pit				23	9	32
	Soakaway				4	4	8
Total		3697	985	4682	93	131	224

*unidentified bone only counted from >4mm sieving, not 2-4mm

Table 2: Taphonomy data

Percent completeness of elements, QC1

Recovery	Centuries	1-20%	20-40%	40-60%	60-80%	80-100%	Total
>2mm	12th				1		1
	14th	16	108	110	203	166	603
	14-15th					2	2
	16th					3	3
	Total	16	108	110	204	171	609
Hand collection	12th				1		1
	14th				1		1
	14-15th			1			1
	15-16th		1		1	2	4
	16th	19	8	3	7	5	42
	18th				1		1
	19th			1		3	4
	Total	19	9	5	11	10	54

Surface texture, QC1

Recovery	Centuries	Good	Fair	Poor	Total
>2mm	12th		1		1
	14th	531	72		603
	14-15th	2			2
	16th	3			3
	Total	536	73		609
Hand collection	12th		1		1
	14th			1	1
	14-15th	1			1
	15-16th	4			4
	16th	26	16		42
	18th	1			1
	19th	3	1		4
	Total	35	18	1	54

Quantities of diagnostic elements per phase

Recovery	QC	11-12th	12th	14th		13-15th	14-15th	15-16th	16th		18th	19th	Total	
>2mm	1		1	603	13%		2		3	7%			609	13%
	2		35	2989	65%		3	5	32	78%			3064	65%
	4			23	1%				1	2%			24	1%
	0			978	21%			2	5	12%			985	21%
	Total		36	4593	100%		5	7	41	100%			4682	100%
Hand collection	1		1	1			1	4	41	30%	1	4	53	24%
	2							5	9	7%	1	24	39	17%
	4								1	1%			1	0%
	0	2	13			4	4	1	87	63%	6	14	131	58%
	Total	2	14	1		4	5	10	138	100%	8	42	224	100%
Grand Total		2	50	4594		4	10	17	179		8	42	4906	

Table 3: Number of identified specimens (NISP) by species (p=present but QC0)

>2mm sieving									
Family	Taxa	12th	14th		14-15th	15-16th	16th	Total	
Rajidae	Ray Family						1	1	0%
Anguillidae	Eel	6	32	1%	2		24	64	1.7%
Clupeidae	Atlantic Herring	17	1513	42%	2	5	7	1544	41.8%
Cyprinidae	Carp Family	2	245	7%				247	6.7%
	Rudd				1			1	0%
	Roach		10	0%				10	0.3%
	Dace		1	0%				1	0%
Esocidae	Pike	10	17	0%			1	28	0.8%
Gadidae	Cod Family		23	1%				23	0.6%
	Cod		130	4%				130	3.5%
	Haddock						1	1	0%
	Whiting		1602	44%			1	1603	43.4%
	Burbot	1						1	0%
Triglidae	Gurnard Family		p					p	
Percidae	Perch Family		2	0%				2	0.1%
	Perch		40	1%				40	1.1%
Pleuronectidae	Halibut Family						1	1	0%
Total identified		36	3615	100%	5	5	36	3697	100%
Unidentified (QC0)		0	978		2	0	5	985	
Total >2mm sieved		36	4593		7	5	41	4682	

Hand collected													
Family	Taxa	11-12th	12th	14th	13-15th	14-15th	15-16th	16th		18th	19th	Total	
Clupeidae	Atlantic Herring		1								2	3	3%
Esocidae	Pike							1	2%	1		2	2%
Salmonidae	Salmon/ Trout									1		1	1%
Gadidae	Cod Family							1	2%			1	1%
	Cod			1		1	9	42	82%		7	60	65%
	Ling							3	6%			3	3%
Bothidae (Scophthalmidae)	Turbot Family							1	2%			1	1%
	Turbot							2	4%			2	2%
Pleuronectidae	Halibut Family							1	2%		6	7	8%
Soleidae	Sole Family										13	13	14%
Total identified		0	1	1	0	1	9	51	100%	2	28	93	100%
Unidentified (QC0)		2	13		4	4	1	87		6	14	131	
Total hand collected		2	14	1	4	5	10	138		8	42	224	

Table 4: Fish size summary

>2mm sieving						
Taxa	Total length	12th	14th	14-15th	16th	Total
Eel	30-50cm			1		1
Atlantic Herring	15-30cm		172			172
Carp Family	<15cm	1	17			18
	15-30cm		34			34
	30-50cm		13			13
	50-80cm		7			7
Rudd	15-30cm			1		1
Roach	<15cm		4			4
	15-30cm		5			5
	30-50cm		1			1
Dace	<15cm		1			1
Pike	15-30cm		7		1	8
	30-50cm		1			1
Cod Family	15-30cm		4			4
	30-50cm		3			3
	80-100cm		3			3
Cod	15-30cm		2			2
	30-50cm		18			18
	50-80cm		80			80
	80-100cm		30			30
Haddock	15-30cm				1	1
Whiting	15-30cm		66		1	67
	30-50cm		210			210
Burbot	15-30cm	1				1
Perch Family	<15cm		1			1
Perch	<15cm		8			8
	15-30cm		4			4

Hand collected									
Taxa	Total length	12th	14th	14-15th	15-16th	16th	18th	19th	Total
Atlantic Herring	15-30cm	1						2	3
Pike	50-80cm					1	1		2
Cod Family	>100cm					1			1
Cod	50-80cm				5			1	6
	80-100cm				1	9		5	15
	>100cm		1	1	2	33			37
Ling	>100cm					2			2
Turbot Family	15-30cm					1			1
Turbot	50-80cm					2			2
Halibut Family	30-50cm					1		1	2

Table 5: Element quantification

Taxa	Element	12th		14th		14-15th		15-16th		16th		18th	19th	Total
		>2	Hc	>2	Hc	>2	Hc	>2	Hc	>2	Hc	Hc	Hc	
Ray Family	Dermal Denticle									1				1
Eel	Basioccipital					1								1
	Abdominal Vert.	4		12						5				21
	Caudal Vert.	2		20		1				19				42
Atlantic Herring	Articular			18										18
	Basioccipital			10										10
	Ceratohyal			21										21
	Cleithrum			8									1	9
	Dentary			19									1	20
	Hyomandibular			14										14
	Maxilla		1	31										32
	Opercular			15										15
	Otic Bulla			23										23
	Parasphenoid			5										5
	Posttemporal			6										6
	Preopercular			7										7
	Quadrate			11										11
	Supracleithrum			6										6
	Vomer			2										2
	First Vert.	1		41										42
	Abdominal Vert.	8		456				3		3				470
	Ultimate Vert.			28										28
	Caudal Vert.	8		792		2		2		4				808
Carp Family	Basioccipital			7										7
	Ceratohyal			9										9
	Cleithrum			10										10
	Dentary			6										6
	Hyomandibular			9										9
	Infrapharyngeal	1		2										3
	Opercular			10										10
	Parasphenoid			1										1
	Preopercular			3										3
	Quadrate			1										1
	Scapula			13										13
	Abdominal Vert.	1		73										74
	Ultimate Vert.			6										6

Taxa	Element	12th		14th		14-15th		15-16th		16th		18th	19th	Total
		>2	Hc	>2	Hc	>2	Hc	>2	Hc	>2	Hc	Hc	Hc	
	Caudal Vert.			95										95
Rudd	Basioccipital					1								1
Roach	Basioccipital			1										1
	Infrapharyngeal			9										9
Dace	Infrapharyngeal			1										1
Pike	Articular			2						1				3
	Ceratohyal			2										2
	Cleithrum										1			1
	Parasphenoid											1		1
	Preopercular			1										1
	Quadrate			3										3
	Abdominal Vert.	10		9										19
Salmon/ Trout	Abdominal Vert.											1		1
Cod Family	Cleithrum			2										2
	Maxilla			2										2
	Opercular			1										1
	Scapula			2										2
	Supracleithrum										1			1
	Abdominal Vert. Group 1			4										4
	Abdominal Vert. Group 2			1										1
	Caudal Vert. Group 1			3										3
	Caudal Vert. Group 2			6										6
	Caudal Vert.			2										2
Cod	Articular			1					1					2
	Basioccipital			3										3
	Ceratohyal			2							2			4
	Cleithrum			9					1		24			34
	Dentary			2									1	3
	Hyomandibular			4										4
	Opercular			3										3
	Palatine			4										4
	Parasphenoid			3										3
	Posttemporal			1			1				3			5
	Preopercular			5					2		1			8
	Quadrate			2										2

Taxa	Element	12th		14th		14-15th		15-16th		16th		18th	19th	Total
		>2	Hc	>2	Hc	>2	Hc	>2	Hc	>2	Hc	Hc	Hc	
	Scapula			2										2
	Supracleithrum				1						4			5
	Vomer			3										3
	First Vert.			3										3
	Abdominal Vert. Group 1			14					2					16
	Abdominal Vert. Group 2			13					3		1		1	18
	Abdominal Vert. Group 3			11							4		1	16
	Caudal Vert. Group 1			11							1			12
	Caudal Vert. Group 2			32							2		4	38
	Penultimate Vert.			1										1
	Ultimate Vert.			1										1
Haddock	Supracleithrum									1				1
Whiting	Articular			16										16
	Basioccipital			9										9
	Ceratohyal			17										17
	Cleithrum			55										55
	Dentary			22										22
	Hyomandibular			7										7
	Infrapharyngeal			1										1
	Maxilla			18										18
	Opercular			4										4
	Palatine			4										4
	Parasphenoid			6										6
	Posttemporal			11						1				12
	Premaxilla			25										25
	Preopercular			13										13
	Quadrate			16										16
	Scapula			23										23
	Supracleithrum			21										21
	Vomer			8										8
	First Vert.			37										37
	Abdominal Vert. Group 1			146										146
	Abdominal Vert. Group 2			194										194

Taxa	Element	12th		14th		14-15th		15-16th		16th		18th	19th	Total
		>2	Hc	>2	Hc	>2	Hc	>2	Hc	>2	Hc	Hc	Hc	
	Abdominal Vert. Group 3			395										395
	Caudal Vert. Group 1			60										60
	Caudal Vert. Group 2			494										494
Ling	Cleithrum										1			1
	Supracleithrum										1			1
	Abdominal Vert. Group 2										1			1
Burbot	Caudal Vert. Group 1	1												1
Perch Family	Basioccipital			1										1
	Caudal Vert.			1										1
Perch	Articular			2										2
	Basioccipital			1										1
	Ceratohyal			2										2
	Cleithrum			1										1
	Dentary			4										4
	Maxilla			1										1
	Premaxilla			1										1
	Abdominal Vert.			21										21
	Caudal Vert.			7										7
Turbot Family	Hyomandibular										1			1
Turbot	Hyomandibular										1			1
	Palatine										1			1
Halibut Family	1st Anal Pterygiophore										1			1
	Hyomandibular												1	1
	Abdominal Vert.												1	1
	Caudal Vert.									1			4	5
Sole Family	Abdominal Vert.												1	1
	Caudal Vert.												12	12

Table 6: MNI quantification for 14th century specialised pit feature

	<15cm	15-30cm	30-50cm	50-80cm	80-100cm	Unsized (i.e. QC2)	Total*	
Eel						1	1	1%
Atlantic Herring						41	41	33%
Carp Family	2	5	4	3			14	11%
Roach	3	2	1				6	5%
Dace						1	1	1%
Pike		2	1				3	2%
Cod Family		2	2		1		5	4%
Cod		1	3	4	2		10	8%
Whiting						37	37	30%
Gurnard Family						1	1	1%
Perch Family						1	1	1%
Perch	3	1					4	3%
Total*	8	13	11	7	3	82	124	

*These totals should be taken as approximations, given the inherent inaccuracies involved with any MNI calcuations

Table 7: Butchery summary

Element	Description	Interpretation	Total length	Recovery
Cod, 14th century				
Basioccipital	Chopped on left side, in sagittal plane, leaving a small wedge of bone	Processing for preservation	50-80cm	>2mm
First Vertebra	Chopped in sagittal plane, chop facet tending towards dorsal, chopped from posterior to anterior	Processing for preservation	70-80cm	>2mm
Abdominal Vert. Group 1	Chopped on left side, in sagittal plane, leaving only a small wedge of bone	Processing for preservation	70-80cm	>2mm
Abdominal Vert. Group 1	Chopped on right side, in sagittal plane, leaving only a small wedge of bone	Processing for preservation	70-80cm	>2mm
Abdominal Vert. Group 1	Chopped on left side, in sagittal plane, chop facet tends towards anterior	Processing for preservation	70-80cm	>2mm

Element	Description	Interpretation	Total length	Recovery
Abdominal Vert. Group 1 (x4)	Chopped on right side, in sagittal plane, chop facet tends slightly towards dorsal	Processing for preservation	70-80cm	>2mm
Abdominal Vert. Group 1	Chopped on right side, in sagittal plane, chopped from posterior to anterior, and chop facet tends slightly to dorsal	Processing for preservation	70-80cm	>2mm
Abdominal Vert. Group 1	Chopped on left side, in sagittal plane, leaving only a small wedge of bone	Processing for preservation	80-100cm	>2mm
Abdominal Vert. Group 2 (x2)	Chopped on right side, in sagittal plane	Processing for preservation	70-80cm	>2mm
Abdominal Vert. Group 2	Chopped on left side, in sagittal plane, from posterior to anterior	Processing for preservation	70-80cm	>2mm
Abdominal Vert. Group 2	Chopped on left side, in sagittal plane, and also chopped in approximately transverse plane on the left side	Processing for preservation, also possibly filleting	70-80cm	>2mm
Abdominal Vert. Group 2	Chopped on left side, in sagittal plane, from posterior to anterior, removing small wedge to posterior, chop facet tends towards anterior and three chop attempts were made	Processing for preservation	70-80cm	>2mm
Abdominal Vert. Group 2	Chopped in approximately transverse plane, removing anterior wedge of bone, and chop facet tends slightly to the right side	?Processing or filleting	70-80cm	>2mm
Abdominal Vert. Group 3	Chopped in transverse plane, removing small wedge of the posterior articular facet	?Processing or filleting	70-80cm	>2mm
Abdominal Vert. Group 3	Chopped in transverse plane, chop facet tending towards ventral	?Processing or filleting	70-80cm	>2mm
Caudal Vert. Group 1	Chopped in transverse plane, removing anterior articular surface, chop facet tends slightly to dorsal	?Processing or filleting	70-80cm	>2mm
Caudal Vert. Group 2 (x2)	Small knife mark on right side, in approximately sagittal plane, extending between two articulating vertebrae from about 18 that were likely in articulation	?	80-100cm	>2mm
Cod 16th century				
Cleithrum	Chopped in approximately frontal plane, at dorsal tip	Processing for preservation	80-100cm	Hand collected
Cleithrum	Chopped in frontal plane, on anterior edge, approximately in middle, and likely twisted immediately afterwards and when very fresh	Processing for preservation	>100cm	Hand collected
Cleithrum	Small very oblique knife marks in approximately sagittal plane, on medial side in middle	Processing for preservation	>100cm	Hand collected
Cleithrum	Chopped in frontal plane, leaving only the ventral tip	Processing for preservation	>100cm	Hand collected
Cleithrum	Chopped diagonally in the middle	Processing for	>100cm	Hand

Element	Description	Interpretation	Total length	Recovery
		preservation		collected
Cleithrum	Chopped in transverse plane at dorsal tip	Processing for preservation	>100cm	Hand collected
Cleithrum	Knife marks in approximately transverse plane, on medial side towards dorsal tip	Processing for preservation	>100cm	Hand collected
Cleithrum	Chopped in approximately frontal plane, at ventral tip	Processing for preservation	>100cm	Hand collected
Cleithrum	Small knife mark in approximately transverse plane, on dorsal tip	Processing for preservation	>100cm	Hand collected
Cleithrum	Chopped in frontal plane, at ventral tip	Processing for preservation	>100cm	Hand collected
Supracleithrum	Chopped obliquely	Processing for preservation	80-100cm	Hand collected
Caudal Vert. Group 1	Two fine knife marks on right anterior edge, in sagittal plane	?Filleting	80-100cm	Hand collection
Caudal Vert. Group 2 (x2)	Small knife marks on both sides, in approximately transverse plane, probably done with a blunt knife and when fresh, as some marks are partly twisted (two separate examples from different contexts)	?	>100cm	Hand collection
Cod 19th century				
Dentary	Chopped in approximately sagittal plane, removing medial articulation	?Hook removal	80-100cm	Hand collected
Ling 16th century				
Cleithrum	Chopped in transverse plane, towards dorsal	Processing for preservation	>100cm	Hand collection
Whiting 14th century				
Dentary	Chopped in sagittal plane, removing small sliver of articular surface	?hook removal	35-40cm	>2mm

Table 8: Summary of common and Latin names of fish mentioned in the text

Common name	Latin name
Ray Family	Rajidae
Eel	*Anguilla anguilla*
Atlantic Herring	*Clupea harengus*
Carp Family	Cyprinidae
Rudd	*Scardinius erythrophthalmus*
Roach	*Rutilus rutilus*
Dace	*Leuciscus leuciscus*
Pike	*Esox lucius*
Salmon/ Trout	Salmo
Cod Family	Gadidae
Cod	*Gadus morhua*
Haddock	*Melanogrammus aeglefinus*
Whiting	*Merlangius merlangus*
Ling	*Molva molva*
Burbot	*Lota lota*
Gurnard Family	Triglidae
Perch Family	Percidae
Perch	*Perca fluviatilis*
Turbot Family	Bothidae
Turbot	*Scophthalmus maximus*
Halibut Family	Pleuronectidae
Sole Family	Soleidae

Figure 1: Cod elements and sizes for 14th and 16th century deposits

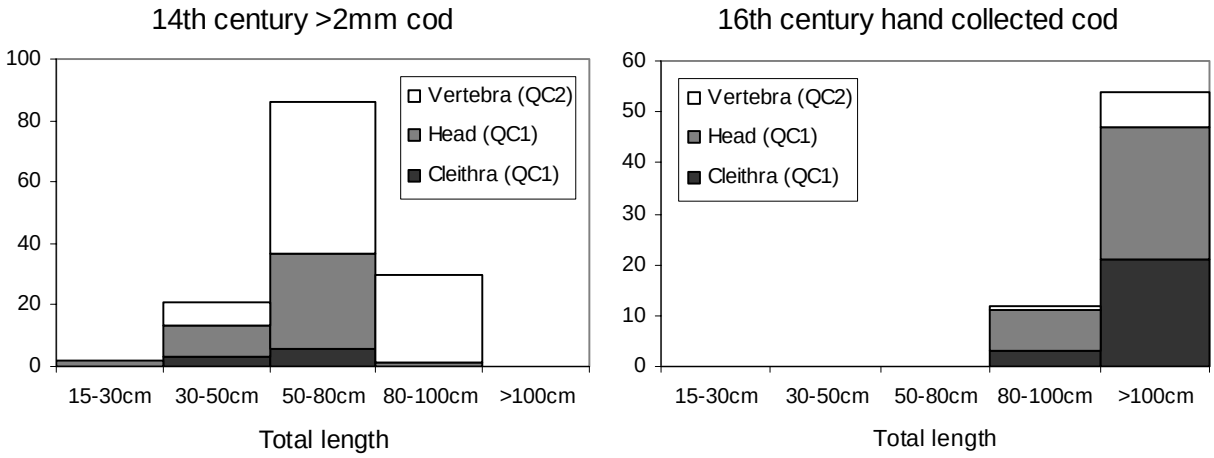

Figure 2: 14th century butchered cod vertebrae, scale is 1cm