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Reports from the Centre for Human Palaeoecology, University of York

Report **2009/02**

Technical Report: Fish remains from the Drogheda Boat, Ireland

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8 June 2009

THE UNIVERSITY of York

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Summary

The fish remains recovered from a 16th century Irish shipwreck were analysed and found to consist entirely of Atlantic herring, Clupea harengus*. All material was sieved to 300µ. A minimum of 513 herring were present in the samples studied, making it likely many thousands of herring had been the original cargo. Element patterning indicated the herring were butchered to remove elements from the appendicular region, most likely along with some of the guts; the herring were therefore probably picked in salt and barrelled for long-term preservation. The herring found were mostly between 20 and 30cm total length, probably reflecting exploitation of autumn-spawning populations around the Isle of Man and the east coast of Ireland. Historical sources indicate that substantial trade in preserved herring was undertaken between the eastern Irish ports and English ports, including Bristol. The herring were recovered from a total of 14 barrels, and thus might have comprised one 'last', a commonly traded commercial unit of about 10,000 to 14,000 herring.*

KEYWORDS: HERRING, PRESERVED FISH TRADE, SHIPWRECK, ZOOARCHAEOLOGY, 16TH CENTURY

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> Harland, JF (2009). Technical Report: Fish remains from the Drogheda Boat, Ireland. *Reports from the Centre for Human Palaeoecology, University of York* **2009/02**, 32pp.

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Fish remains from the Drogheda Boat, Ireland

Introduction

This report details the analysis of 15,152 identified fish remains from the Drogheda Boat shipwreck, from the port of Drogheda on the east coast of Ireland. All were derived from sieved samples and all were identified as the Atlantic herring, *Clupea harengus*. Over 19,000 other fish remains were examined but were not identified to element, although all were likely also from herring. The Drogheda Boat was a small clinker-built vessel of about 9m in length and 3m in width, and it contained a cargo of 14 barrels when it sunk. It was discovered in the River Boyne about 2km east of Drogheda, and based on preliminary dendrochronology, it was built c. 1520AD (Anon. 2008). It was probably ferrying cargos between the port itself and ships that were too large to anchor directly in Drogheda. The lower portions of the barrels were well preserved, as were the contents, which were retrieved as a dark, waterlogged, organic sludge with many visible fish remains. These were comprehensively sampled, as were nearby contexts from outside the barrels for comparison.

The Drogheda Boat remains are exceptionally unusual in that they are securely dated, well preserved, and they represent the remains of preserved herrings probably being exported for trade. Most contemporary fish remains are found in domestic contexts, representing the remains of many meals over a long time span, and could represent both fresh and preserved fish. The Drogheda Boat herring provide a unique opportunity to study preservation methods from the first half of the 16th century, set within the early historical references to European herring preservation as well as the export market from Drogheda.

Fish remains from 15 separate samples were fully examined. Eleven were from inside the barrels (including barrels 2, 4, 5, 6, 8, 12, 13) and these contained the vast majority of the herring remains. The remainder were from contexts near the barrels. One sample, number 55, context/feature E8, was examined but not a single fish bone or scale was observed. Although not every sample could be included in the analysis, at least one sample per barrel was included, and barrels 4, 8, 12, 13 were all represented by two or more samples. Samples that were excluded from analysis tended to contain much smaller quantities of bone than those that were selected for identification, and in particular, they contained far fewer of the readily identifiable remains from the >4mm sieved fraction. Only three large samples were excluded from analysis on the basis that they were from barrels 4, 12 and 13, which were already represented by two or more identified samples.

The herring trade

Herring are naturally an oily fish which decay very quickly unless some attempt at preservation is made shortly after capture. The seasonal abundance of herring stocks, and their ease of capture, have made them an important resource to fishing communities for millennia. Short-term preservation methods have probably been used for just as long to allow this important food to be consumed over weeks and months, rather than immediately after capture, but it was only with new preservation techniques in the medieval period that long-term preservation became possible – and with it, the long-distance herring trade.

Archaeological evidence from some developing English urban areas indicate that herring were first being eaten in large quantities in the 8th, 9th and 10th centuries, but these were most likely locally-caught and, if preserved, this was probably only with a light cure (Serjeantson and Woolgar 2006). However, following the 'fish event horizon', the shift towards large-scale exploitation of marine species like cod and herring that occurred c. 1000AD, herring quickly became ubiquitous in most western European sites wherever fish remains were found (Barrett *et al.* 2004b; Barrett *et al.* 2004a).

Early curing methods for herring probably involved salting, either in salt crystals or in brine, air drying in extreme northern regions like Iceland, or smoking, and sometimes these procedures were associated with limited butchery to remove non-food parts of the fish (Cutting 1955; Robinson 2000). Large scale herring fisheries are known historically from a variety of Northern European countries, including most that border on the North Sea and the Baltic. By the early decades of the second millennium AD, the large-scale herring trade can be recognised archaeologically by the increasing occurrence of herring remains in domestic deposits. These herring were most likely lightly preserved using salting, probably processed in heaps on the ground, rather than in barrels, and without any butchery (Cutting 1955; Hoffmann 2005). The resulting product would keep for a few months, but no more, which would allow them to be transported relatively long distances from the fishing grounds. Archaeological remains of herring from these early centuries are characterised by the presence of cranial, appendicular and vertebral elements being present in relatively equal, natural frequencies (e.g. Harland and Jones In prep.). Butchery marks are not normally observed in these assemblages, suggesting that if any butchery had occurred, it removed only soft parts of the flesh, and not bone. Of course, herring preserved with these simple methods are virtually impossible to distinguish from herring consumed fresh, but it is possible to take into account the distance between the archaeological site and the possible fishing grounds when speculating about early herring preservation.

Historical sources are only available from the 12th century onwards, but these confirm the importance of this early herring trade (Barrett *et al.* 2004a). The Hanse, or Hanseatic League, became the major group of merchants involved in this early trade – one of their many endeavours – and much of their power originated from the wealth derived from herring. They ensured the quality and supply of herring throughout much of Europe, maintained by strict rules, regulations and monopolies regarding curing practice and product supply. The cured herring by either smoking them ('red herring') or by pickling in salt brine ('white herring'). The latter were first gutted, washed in salt water, and packed into barrels with salt. The process of gutting the herring has not apparently left any archaeological trace, implying that no bones were removed.

Improved methods of curing occurred at some point in the 14th century. Historical sources mention the Dutch were responsible for innovations in butchery, salting and barrelling, producing a product called 'kaken' (Cutting 1955). Herring were now processed immediately after being caught, even while still onboard ship, allowing new fishing grounds to be exploited for the first time (Childs 2000; Hoffmann 2005). The gills and some of the guts were removed by one simple cut to the throat and underbelly region, leaving part of the intestines as the digestive enzymes remaining in the fish played a role in preservation. The butchered fish were then immediately salted and packed head to tail in layers in barrels. Each layer was finished with additional salt and the subsequent layer was placed at a different angle. The contents were allowed to settle, and were topped up before the barrel was sealed with fish from a similar state of preservation, creating an airtight atmosphere and thus allowing long-term storage (Cutting 1955; Hoffmann 2005). Historically at least, the Dutch took responsibility for this new method and its success played a role in the rise of Dutch power and wealth in the 15th and later centuries (Cutting 1955; Hoffmann 2005). From the early 15th century, fishing vessels increased in size to allow longer journeys and greater cargo capacity for the newly cured herring.

Herring were commonly exported in units called 'lasts' during this period, a term used throughout the ensuing centuries for herring and other fish products. Each last of herring comprised between 10 and 14 barrels, each of which contained about 1000 herring, making one last contain anything between 10,000 and 14,000 herring (Cutting 1955). Historical references to fisheries weights and measures are often imprecise and vary by place and time, making it difficult to fully appreciate what is meant in any one historical document. Bristol customs accounts from the mid 16th century list barrels and lasts of white (pickled) herring from Ireland, and as one last is worth on average £3, and one barrel is worth on average 5s, the average last must have contained about 12 barrels at this time (Flavin and Jones 2008). A slightly later Irish source is consistent with this description, as it describes a last of herring as comprising about 12 barrels, with estimates of 10,000-13,000 fish per last for smoked herring and pilchards, but with more variable quantities for salted herring (Longfield 1929). The Drogheda Boat contained 14 barrels, at least 7 of which were found to contain herring remains – so it is possible that the cargo could have represented one last of herring.

An exceptional archaeological deposit of herring remains from the Danish site of Selsø-Vestby provides the earliest evidence for the 'kaken' method of herring preservation. The 12th and 13th century date of this material questions the supposed Dutch invention of this method of preservation, although there is no doubting that the Dutch later used the method to their advantage. At Selsø-Vestby, unique deposits consisting solely of herring remains were found, and furthermore, the vast majority of identified elements were from the hyoid, gill and shoulder regions, including the cleithra, supracleithra, ceratohyals, epihyals, urohyals and scapulas (Enghoff 1996; Enghoff 1999; see Figure 3 for an anatomical diagram of the fish skeleton). These were interpreted as the discarded remains of a butchery strategy very similar to that described above – the removal of the gill region and part of the gut to aid preservation. This butchery strategy has been termed the 'Skanian' method in the zooarchaeological literature, and it probably would have prolonged the storage potential of the herring from a few days or weeks to up to a year (Childs 2000; Locker 2000; Woolgar 2000). The Skanian method was probably introduced to Britain's Yorkshire coast herring fishery in the very late 14th century, while a date of about 1400 applies to its historical introduction to the continental North Sea herring fishery (Childs 2000). However, contemporary archaeological deposits have yet to reveal the Skanian element proportions (e.g. the extensive herring deposits from 14th to 16th century sites in York show that all elements were present (Harland and Jones In prep.)), suggesting that they were probably consumed in conjunction with fresh and lightly cured herring.

Red herrings were salted and smoked, a process probably improved in Yarmouth in the 14th century, although more lightly smoked herring was probably produced in a variety of places prior to this date (Cutting 1955). They were probably lightly salted onboard ship, then upon landing, they were washed, placed in salt for a few weeks, and then speared on sticks through the gills and mouth, and smoked for a few weeks (Cutting 1955). No gutting or gill removal was used and therefore their consumption would be difficult to identify in the archaeological record. Red herrings were often seen as inferior to salted herrings, both in taste and in the duration of preservation; it is only in recent centuries, post-dating the Drogheda Boat, that smoked herring – kippers – have become so common (Cutting 1955). That said, red herring production is known historically in Ireland from at least the 17th century (Went 1977), but with no documented gutting or butchery to the product, they would not have been visible in the archaeological record.

By the late 15th century, Dutch supremacy over the herring trade was vast: they supplied most of northern Europe's preserved herring, including most of the imports to English markets (Hoffmann 2005). However, herring stocks have always been notoriously fickle, responding to subtle environmental changes as well as to fishing pressures, and several stocks were known to collapse or dramatically shift to new geographical regions in the medieval period. For example, the herring stocks in the southern North Sea region collapsed about 1360, as did those in the Skanian region of southern Sweden in the early decades of the 15th century. These were possibly linked general cooling patterns of Europe's "Little Ice Age", which would have adversely affected herring stocks from the late 14th century until the 1520s (Hoffmann 2005) – and which might have led to Ireland's herring industry becoming more important about this time.

Archaeological examples of definitively preserved herring are rare. The Selsø-Vestby example is unique in that it represents the processing waste from preserving herring using the 'kaken' or 'Skanian' method. A 16th century Dutch shipwreck provides the most obvious comparison to the Drogheda Boat: 17 barrels were found and some of the residues were sieved to 2mm (Lauwerier and Laarman 2008). Over 29,000 fish remains were then identified, most of which were herring. At least 700 fish were represented They ranged in size from 17 to 30cm total length, with an average of about 25cm, and the authors thought it likely that no grading by size was performed prior to preservation. Although most elements were present, the cleithra, urohyals, scapulae and supracleithra were either absent or represented by only a few specimens, while the ceratohyals were found in smaller than expected quantities. The few cleithra fragments present tended to be from the dorsal region and some may have been butchered. This Dutch example provides an archaeological signature for the 'kaken' or 'Skanian' method of herring preservation, and matches well to the Selsø-Vestby butchery waste. Other medieval or later examples of preserved herring are known but sample sizes tend to be much smaller (e.g. 15-16th century Dutch examples cited in Lauwerier and Laarman 2008). Herring remains from a 17th century whaling station in Spitsbergen were interpreted as herring preserved using this method

(Seeman 1986), but with less than 400 herring bones found, the results cannot be conclusive.

Historical evidence for the Irish herring trade

Historical sources relating specifically to the Irish herring trade are rare. Drogheda itself is almost never mentioned explicitly in the historical accounts, although the port was known to trade with Chester in the 14th or 15th centuries (Childs and O'Neill 1993). A 13th century reference mentions Irish fishing boats from communities on the east coast taking part in the herring fishery around the Isle of Man, and by the end of the 14th century, quantities of Irish fish were being exported to Bristol (Down 1993). However, the Irish markets were still too small at this time to interest the larger European traders like the Hanse (Childs and O'Neill 1993). Herring and other fish were "undoubtedly the most important product of sixteenth century Ireland" (Longfield 1929), but they were not necessarily fished by the Irish: historical accounts document conflicts between Spanish, French and local fishers (Longfield 1929; Down 1993). Irish fish were also caught by Irish fishers, then bought and exported by foreigners, including English merchants; however, some English boats and fishers directly exploited Irish stocks without landing any fish actually in Ireland. A fleet of 600 English boats were known to prosecute the fishery around Carlingford Lough in 1535, only about 35km north-northeast of Drogheda (Childs and O'Neill 1993). By the early 16th century, fish exported were deemed too large, and pleas were made to retain a larger portion for Irish consumption (Childs and O'Neill 1993). Drogheda was one of a number of ports exporting Irish produce, among them fish products, including herring, salmon, and the cod family, as well as wool, hides, tallow, and timber, and in return, importing salt, "all sortes of corrupt wines" and, presumably, some of better quality, as well as iron cloth, metal and luxury goods (Longfield 1929, 45; Went 1977; Moody *et al.* 1991; Childs and O'Neill 1993; Down 1993).

Irish herring were exported primarily to England, but with some quantities ultimately destined for the continent (Longfield 1929). Anglo-Irish customs reports for the 16th century provide some historical details of this trade. Herring were the staple export, along with the more valuable salmon, and various grades of fish were exported. Full, white herring were the most desired product, as they had yet to spawn and thus were full of roe; these were worth two or three times the price of white 'shotten' herring that had already spawned. Records of Cornish imports from Dungarvan, an Irish port in the southeast, indicate that in 1562 full white herring were worth £9 per last and white shotten herring about £3 (Longfield 1929). Bristol was the primary destination for much of this fish in the 15th century (Childs and O'Neill 1993), and detailed customs accounts from the 16th century provide further information on seasonality and the extent of imports from Ireland.

Detailed monthly customs accounts for 16th century Bristol are available online (Flavin and Jones 2008), and it was possible to extract values for all goods originating in Ireland and arriving in Bristol. Although it was not possible to isolate ships from Drogheda, these data are extremely useful in providing an indication of the value and seasonality of goods leaving Ireland. These data are displayed by month in Figure 1, showing the values for white (pickled) herring, red (smoked) herring, hake, salmon, other fish and other goods. The sequence through the century contains many gaps, but because the data are displayed month by month, seasonal trends are visible. White herring are the predominant export (by value) for the late autumn, winter and spring for several years. They dominated exports for December, January and February in 1525/26, while in 1541/42 they were more common slightly earlier in October and November, and secondarily in December and January. In 1542/43, 1545/46 and 1550/51, very few imports from Ireland were recorded over the winter months. During these years, herring were exported predominantly in October and November, and secondarily in January, February and March. By 1563/64, December to March was once again the predominant export season. Red herrings were exploited but in very small values, and at the same time of year as white herring. The actual quantity of fish represented in Figure 1 is more difficult to ascertain, because a variety of different units were recorded in the customs accounts. A total of 499 ¾ lasts of white herring were included in this figure, as were 8908 separately recorded barrels; assuming 12 barrels per last, this figure therefore includes just under 15,000 barrels of white herring. Very small values of white herring were also recorded under units of 'hoghead', 'hogshead', 'kilderkin', 'mease' and 'virkin'.

These customs accounts are based on several Irish herring fisheries, which have altered in importance and production throughout the 16th century. These records are not complete either, but they are still useful – they indicate both the overwhelming importance of herring to Ireland's export trade, and the late autumn to spring nature of the fisheries.

In the late 16th century the Anglo-Irish fish trade declined, probably because of the wider availability of Newfoundland fish stocks, as well as a general decline in trading (Longfield 1929). Additionally, herring stocks appear to have shifted from the Irish Sea in the early 17th century, affecting both location and international trade (Moody *et al.* 1991); this might have been in response to over-exploitation or to natural climactic fluctuations. A mid 19th century account of Drogheda describes Scottish herrings being sold in Drogheda's markets, implying no locally-produced herring were available by this time (D'Alton 1863).

Irish Sea herring biology

Irish Sea herring are known to shoal and spawn in late September for 3 to 4 weeks, predominantly now around the southern and eastern coasts of the Isle of Man, some 100km east of Drogheda (Dickey-Collas *et al.* 2001; Brophy and Danilowicz 2002). Traditional spawning grounds were also known historically in the Kilkeel region (called the Mourne spawning), about 40km north-northeast of Drogheda, and further afield in the Clyde estuary on the west coast of Scotland, about 250km to the north (Brophy and Danilowicz 2002). The Clyde herring fishery historically took place in March and April (Brophy and Danilowicz 2002).

The fish that could have been caught from Drogheda were therefore likely a mixture of autumn-spawning herring from the Isle of Man and Mourne and spring-spawning herring from the Clyde. However, even within the Irish Sea spawning grounds were known to shift historically and in the modern era, linked to environmental factors and fishing pressure (Dickey-Collas *et al.* 2001). Herring are also known to spawn in the spring in the western area of the Celtic Sea and St. George's Channel, near Dunmore and Cork (Brophy and Danilowicz 2002). Herring spawned in each of these areas are known to grow at different rates, dependent on temperature and ecosystem structure, and all are likely to have mixed in the Irish Sea area. The degree of mixing is now dependent on numerous environmental factors, as would have been the case in the past (Brophy and Danilowicz 2002). Modern studies of otoliths can distinguish between the various populations (Burke *et al.* 2008), but no otoliths were found in the Drogheda Boat material, and in any case, archaeological otoliths are often not adequately preserved for modern fisheries techniques.

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 usually recorded in detail. Fish vertebrae (QC2) are recorded in more limited fashion, with counts, element and species recorded. Some elements are unusual and/or are particularly diagnostic, like otoliths or otic bullae, and are fully recorded (QC4). The final category of material (QC0), includes elements not routinely identified as well as unidentifiable material. Data analysis involved structured database queries, as well as manipulation using Excel.

Samples arrived sieved into >4mm and 300μ to 4mm fractions, and wet from processing. These samples were slowly air-dried by the author at room temperature. The fractions were then re-sieved into >4mm, 2-4mm and 300μ-2mm. All material >2mm was fully identified, and a count was taken of the fragments that were QC0 (unidentified or unidentifiable). The material from the smallest fraction was scanned for identifiable elements, which were then fully recorded, but no attempt was made to count the QC0 elements from this fraction. The small quantity of identifiable fragments from this small fraction made it unnecessary to spend an undue amount of time on analysis, but every attempt was made to retrieve all identifiable QC1, QC2 and QC4 elements. Examples of identified and unidentified elements from each fraction are illustrated in Figure 9.

It became apparent during the initial assessment of the Drogheda Boat samples that this assemblage was exceptional and that routine recording would have to be modified. Historical and archaeological studies of preserved herring have indicated certain elements are particularly important for understanding the preservation process (Enghoff 1999; Lauwerier and Laarman 2008), making it necessary to add the epihyal and urohyal to the list of QC1 elements; as these are only of importance during the study of preserved herring, they are not routinely identified in normal assemblages. Some studies of preserved herring have included the coracoid, but as this is a small and fragile element not routinely noted even in assemblages of complete herring, it was thought unnecessary to add to the list of routinely identified elements. A simplified fish skeleton diagram is provided in Figure 3, showing approximate locations of all identified elements. Although this is based on a perch skeleton, the basic morphology is similar to that of the herring and thus the positioning of elements is comparable.

Weights and maximum linear dimension of the herring remains were not recorded, as the former is only of use when comparing between species and classes of material, while the latter is useful for understanding fragmentation patterning in normal, domestic assemblages with a variety of species. Recording of both attributes would add considerably to the analytical time but with, in this case, little return.

Because fish remains are so small, there is little point studying remains from contexts that are hand collected, and even coarse sieving will only provide certain species (Wheeler and Jones 1989). Usually, a mesh size of 2mm is preferred, as this will provide most of the identifiable elements. The material from Drogheda, sieved to 300µ, is exceptional and provides a very unusual opportunity to study the small 300µ-2mm fraction, in addition to the routinely studied 2-4mm and >4mm fractions. However, in order for the results to be comparable with other published fish assemblages, the fractions will sometimes be discussed separately, or, where relevant, in grouped form. This is made explicit throughout the text.

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 preservation was recorded using surface textures and element percent completeness, recorded for all QC1 elements. Preservation was overall very good compared to other herring remains found on more typical archaeological sites, especially when considering the small size and fragility of herring remains. Overall rates of identification were exceptionally high for sieved samples. Almost 40% of the >4mm and 2-4mm fractions combined could be identified. Bone textures were generally recorded as 'good' or 'fair' throughout most samples (Figure 2). Percent completeness was more variable, with some samples recording very high completeness scores, and others being more fragmentary (Figure 2). Within each of the four barrels with multiple samples there was a general consistency in taphonomic patterning and the percentage of bone that could be identified (Table 1), suggesting the internal barrel environment played a factor in the long-term survival of the bone. The three external samples showed the greatest degree of variation in both bone texture and percent completeness, and had some of the lowest rates of identification.

Bone modifications were extremely rare. Only three elements were noted as crushed, including one abdominal vertebra from barrel 6, sample 90, one caudal vertebra from barrel 4, sample 66, and one ceratohyal from barrel 13, sample 269. Ordinarily, herring have a high rate of crushing, as many found on typical archaeological sites have been chewed by humans or animals, but these from the Drogheda Boat were obviously not consumed. No burning was noted, again in keeping with the type of assemblage. A total of 127 bone fragments were found concreted with other material, including vegetation and shell fragments. A variety of elements and unidentifiable fragments were represented by these concretions. Most were from barrel 8 (50 fragments) and barrel 5 (49 fragments), with the remainder from barrels 4, 6, 12 and 13.

The assemblage contained a high number of fused bones, comprising at least 244 separate elements, many of which were either sequences of vertebrae, or bones from the cranium including the basioccipital and the otic bullae. Most were found in barrel

13 (210 fragments, some illustrated in Figure 15), with some others found in barrels 4, 6, 8 and 12. Their predominance in one barrel suggests they are the result of taphonomic patterning and the particular burial environment found within the barrels, rather than pathological changes to the bone.

Results

Element patterning

Elements counts and percentages are provided in Table 2 for all >2mm fractions, and in Table 3 for the smaller 300µ-2mm fraction (for reference, Figure 3 shows the basic location of each of these elements within the fish skeleton). These tables provide a basic quantification of all elements found by sample and barrel. For most samples with sufficient quantities, most parts of the skeleton are well represented: the vertebrae account for between half and three quarters of all identified bone, while the cranial elements, particularly those from around the mouth and front of the head, account for much of the remainder. However, the appendicular elements are conspicuous by their absence: the cleithra, scapula and urohyal are all represented by only a few specimens.

Element fragmentation and the number of occurrences in the body account for some of the variation in the raw counts and percentages, thus obscuring real patterning. Table 4 displays the minimum number of elements per sample, taking into account the number of times an element appears in an individual body, as well as fragmentation. When recording cranial and appendicular elements, a series of diagnostic zones is recorded which provides an indication of fragmentation, and the quantity of each recorded zone is taken into account when calculating the minimum number of elements (see Harland *et al.* 2003 for details). For vertebrae, the quantity of recorded elements is divided by the number of bones that occur in the body, thus making the minimum number of elements statistic directly comparable to cranial element statistics. The results are shown graphically in Figure 4.

The first vertebrae is the most commonly occurring element in eight of the samples. This is a small and extremely robust element, which probably accounts for its excellent survival rates. It is also readily identifiable, being large and distinctive, and it less likely to fragment than other vertebrae, which could account for the high quantities observed here. It is the most common element in all three of the external samples, which accords well with its robust survival given the variable taphonomy of these samples.

The otic bulla (the eyeball) is the most commonly occurring element in five of the samples. This is a large, robust and readily identifiable element that rarely fragments. It is particularly common in barrels 12 and 13, suggesting something in the environment of these two barrels favoured its survival. In the three external samples, it is much less frequently found, but the small sample sizes and variable taphonomy of these samples make them more difficult to interpret. Otic bullae are less common in both barrel 4 samples, but overall, cranial and appendicular elements are not very common in this barrel compared to vertebrae.

Other elements are more variable. In the two barrel 4 samples, the vertebrae greatly outnumber other elements. This could result from the slightly poorer percent completeness scores for these two samples, but texture was no different. An alternative explanation is that the fish represented a single layer from the bottom of the barrel, and this layer had been packed head-to-tail – which we know from historical sources was probably the case – and that the heads were more subject to taphonomic attrition than the bodies.

Cranial elements that are robust and easily recognisable are naturally recorded in greater numbers, as would be expected. This accounts for the high quantities of dentaries and maxillae. The frequencies of most other cranial elements are a natural result of taphonomic patterning. However, as already suggested above, the appendicular elements are unusually absent. The scapulae, urohyals and cleithra are the three least frequently occurring elements overall, while the supracleithra were found in larger quantities but were still the fourth least frequently occurring element overall. The scapula is a tiny and extraordinarily fragile element and thus would not be expected to be found in any quantity, but the cleithra, supracleithra urohyals are all moderately robust and readily recognisable. Their absence is therefore related to butchery and preservation strategies, discussed further below. There is some suggestion that, historically at least, the ceratohyal and epihyal are associated with this butchery strategy. Both are readily recognisable elements, but they are only moderately robust. At Drogheda, both were found in relatively low to average quantities. Some may therefore have been removed during butchery, but many remained with the preserved product.

Minimum numbers of herring
The samples examined originally contained at least 513 herring, and most likely many, many more were originally present. Three methods were used to determine this statistic, using the raw minimum numbers of elements detailed in Table 4 for cranial and appendicular elements (QC1), for otic bullae (QC4) and for vertebrae (QC2). The results are displayed by element type and sample in Table 5. The minimum numbers of herring recorded varied from only at least 3 in sample 279, barrel 2, to at least 91 in sample 95, barrel 8, and these results are approximately linked to sample sizes, as would be expected. If it were possible to determine estimated barrel volumes, it might be possible to compare sample volumes with the estimated minimum numbers of herring and therefore derive an approximation of the original numbers per barrel. It would not be unreasonable to suggest that the barrels may have comprised one 'last' of herring, or between 10,000 and 14,000 herring in total.

Size ranges
Sizes were recorded using two methods. Firstly, the broad size category was recorded for all cranial and appendicular QC1 elements. For every specimen from Drogheda, a size range of 15 to 30cm total length was recorded, which is not surprising given that most herring from domestic medieval and later European assemblages fall within this size range. Detailed measurements were recorded for all dentaries, quadrates and basioccipital (as defined in Harland *et al.* 2003). These could be compared to measurements taken from the twelve modern skeletal herring of known length held in the Fishlab's reference collection. Dentaries and quadrates provided the majority of the measurable elements, and thus are most useful for comparative analysis. Although there were insufficient modern herring to derive a regression equation for

each measurement, it was possible to perform a detailed visual comparison between measurements of fish of known length and the archaeological material.

Box plots are illustrated for all samples with at least five measurements, showing the minimum, maximum, mean, outliers and inter-quartile ranges for raw dentary measurements (Figure 5) and for raw quadrate measurements (Figure 7). These figures also indicate the approximate total fish lengths represented by these data, determined using the twelve modern reference skeletons, as illustrated in Figure 6 and Figure 8.

Both the dentary and quadrate measurements indicate a considerable range of fish sizes were present, ranging from about 20cm total length to over 30cm. Most, however, were within 23 to 28cm total length. Sample 95 from barrel 9 contained the smallest mean value, yet had two of the largest outliers when the quadrates were considered, but dentary measurements were average. Overall, there was very little patterning or consistency between samples from the same barrels, suggesting the contents of each barrel were not graded by size, and that a relatively wide size range was available at any one time.

Butchery and curing methods

Element patterning has clearly indicated that cleithra and urohyals are absent from the assemblage, barring a few unusual specimens, and scapulas are similarly rare. Four cleithra fragments were identified, two from sample 90, barrel 6 (Figure 11), one from external sample 277 (Figure 12), and one from sample 80, barrel 5 (Figure 10). All fragments were only represented by the dorsal zone, and both left and right specimens were recorded. Two explanations are possible: the ventral portions may have been naturally broken off, or they may have been deliberately removed. The specimen from sample 80 was probably butchered in the frontal plane to remove the lower, ventral half of the cleithrum, making it likely that the butchery process usually removed the entirety of the cleithra, but in some cases, a fragment from the dorsal region remained in the preserved fish.

A total of 35 supracleithra were recorded from a variety of samples, some of which are illustrated in Figure 16 and Figure 17. Both partial and complete specimens were found, as were both left and right examples. The supracleithra is a fragile element, but can be readily recognised even when fragmented. It is therefore difficult to assess whether its absence is natural taphonomic patterning or indicative of a real absence. As the supracleithrum is located adjacent to the dorsal, anterior edge of the cleithrum (Wheeler and Jones 1989), the evidence is equivocal: it may have occasionally been removed during butchery. Two urohyals were recorded, a complete element from external sample 281 (Figure 13), and a fragment from external sample 277 (Figure 14). No butchery marks were noted. As the urohyal is a midline appendicular element located in the region of the cleithra and scapulae, it was probably removed during the same butchery process. The virtually complete absence of scapulae is unsurprising, given that they articulate with the lower ventral portion of the cleithra – none of which were recorded.

Discussion and conclusions

The 15 Drogheda samples studied represent the remains of at least several hundred herring, packed into 7 barrels, with a further 7 barrels recovered from the wreck. These herring were preserved using a distinctive butchery technique known historically, but which has hitherto been very rare archaeologically. The fish were butchered to remove the gills and part of the guts, which also removed most of the cleithra, scapulae, urohyals and supracleithra. The few surviving cleithra fragments indicate that the butchery technique usually encompassed all of the cleithra, but occasionally the dorsal (upper) tip was left in the preserved product. The fish were then most likely packed with salt and/or brine in layers in the barrels. The resulting product would have been sealed and would remain preserved for many months, probably up to a year.

The low proportion of cranial elements and the predominance of vertebrae from both barrel 4 samples suggest that the heads may have been lost due to attrition. The fish were probably arranged in layers in the barrels, with all fish in each layer lying parallel. If only the bottom layer was preserved, and if one side was exposed to the elements, then this could account for the poor survival of heads.

The wide size range of the herring found in the Drogheda Boat, from about 23 to 28cm total length, indicates no particular grading by size was performed prior to gutting and packing. The herring could have come from a number of sources in the Irish Sea, including the prolific Isle of Man fishery, or the smaller Mourne spawning grounds just north of Drogheda. Both of these were autumn spawning and both fishing grounds would have been within easy reach of the port. If both were exploited at the same time, this could account for the wide size variation found in the remains. Later in the season, the spring spawning grounds of the Clyde would also have been available to the Drogheda fishers, while further south, spring spawning in the Celtic Sea and St. George's Channel could have provided additional stocks for exploitation. Both of these would have required considerable travel from Drogheda, but again, if a mixture of spring spawning grounds were being exploited, this could explain the size ranges found in the Drogheda Boat herring.

Given that a total of 14 barrels were found in the wreck, this cargo could have been one 'last' of herring. This was a unit used for customs and trade accounts during this period, and it consisted of about 10 to 14 barrels, each with about 1000 preserved herring inside, comprising a total of between 10,000 and 14,000 herring.

Archaeological comparisons are rare. Butchery waste from a 12th and 13th century Danish site was comprised almost entirely of the elements missing from the Drogheda samples, indicating this preservation method had been in use for a few centuries before being applied to the Irish material. A 16th century Dutch shipwreck contained barrels of herring with very similar element and butchery patterning to Drogheda, suggesting the same preservation strategy had been applied.

Fish bones benefit from finely detailed sieving, as has long been known (Wheeler and Jones 1989). The Drogheda Boat material was sieved to 300µ, which is more detailed than most fish assemblages, but this has proved beneficial. The small 300µ-2mm fraction, which would normally not be examined, was found to contain numerous vomers and maxillae fragments which would otherwise have been lost; the vomer in particular would have been under-represented by the larger fractions (contrast to the 16th century Dutch barrels of herring, only analysed at >2mm (Lauwerier and Laarman 2008)). The numerous small vertebrae found in the smallest fraction have also contributed to the estimation of the minimum number of herring found at Drogheda.

Tables and Figures

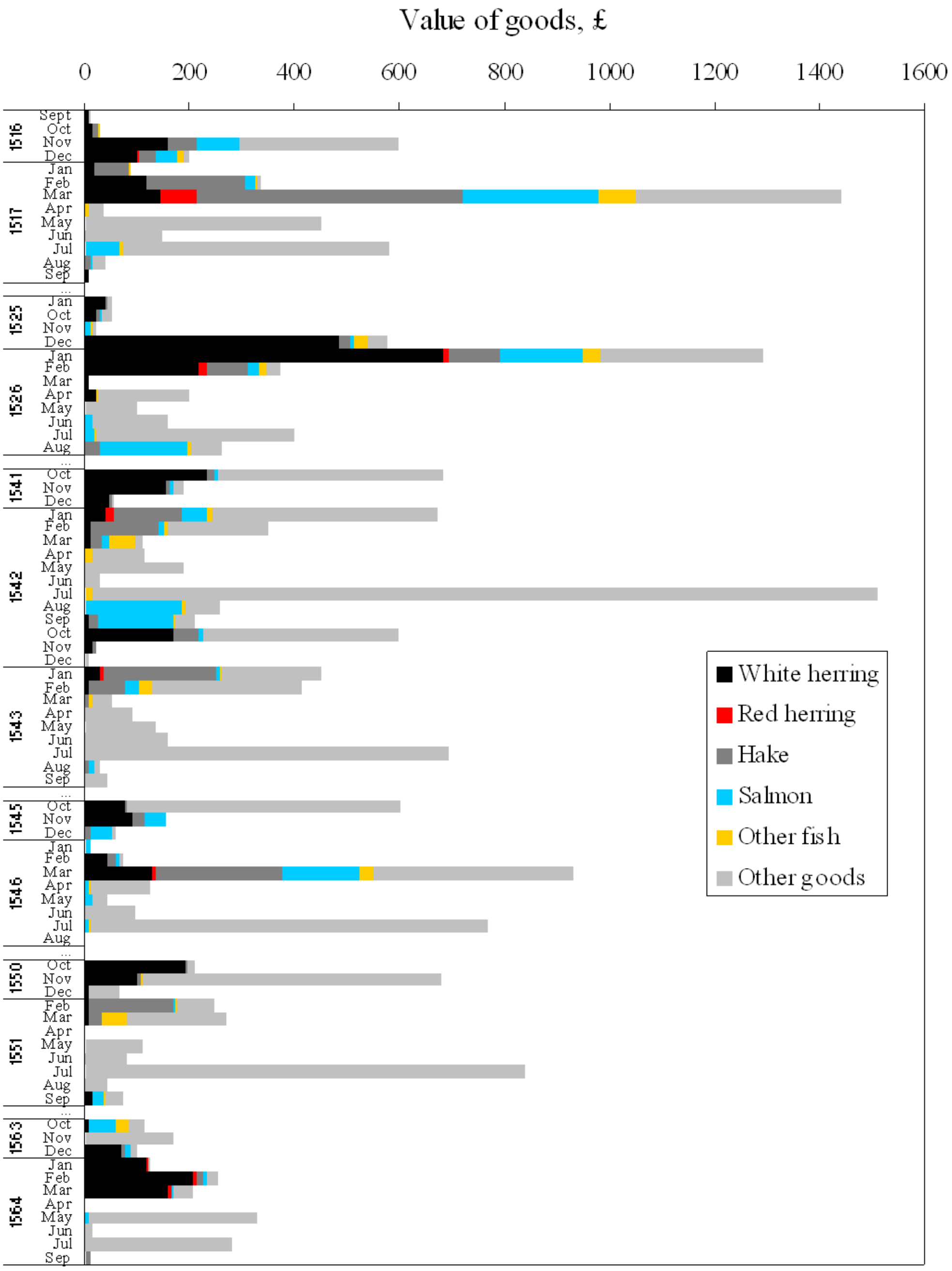
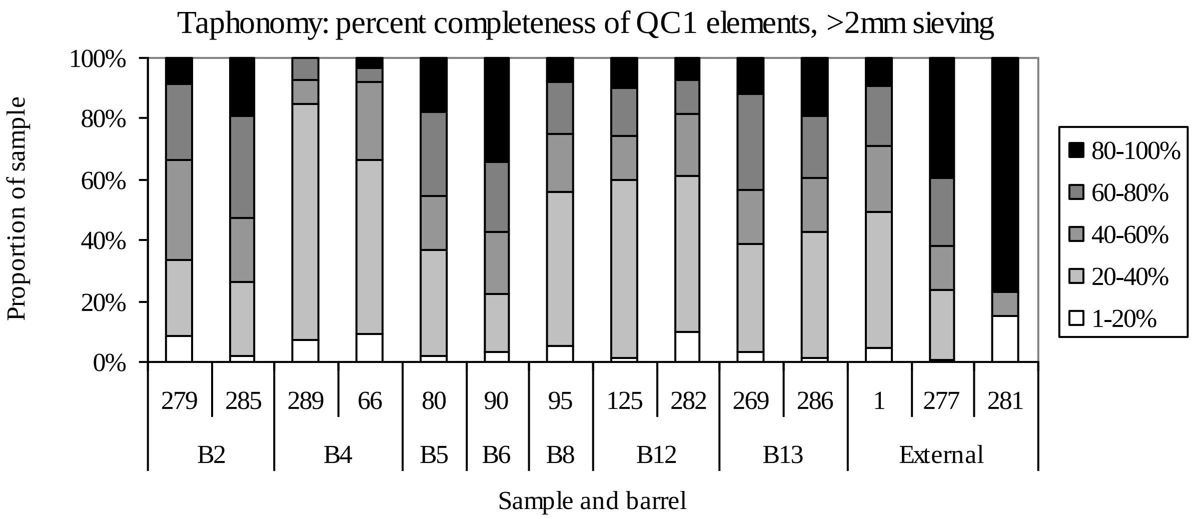


Figure 1: 16th century customs accounts for Irish imports to Bristol, showing the monthly values for fish and other imported goods

Barrel or Context	Sample	>4mm						2-4mm						%id from >2mm	300u-2mm	
		QC1	QC2	QC4	Total id	QC0	%id	QC1	QC2	QC4	Total id	QC0	%id		QC1	QC2
B2	279	6	3	0	9	24	27%	18	43	4	65	662	9%	10%	2	12
	285	75	4	22	101	202	33%	80	276	10	366	1055	26%	27%	5	225
B4	66	15	4	8	27	24	53%	50	1171	1	1222	342	78%	77%	4	353
	289	2	0	1	3	9	25%	25	898	1	924	286	76%	76%	16	503
B5	80	72	45	30	147	206	42%	94	1363	25	1482	3244	31%	32%	5	200
B6	90	163	61	34	258	163	61%	141	841	0	982	758	56%	57%	8	64
B8	95	119	53	121	293	273	52%	259	3043	60	3362	4182	45%	45%	16	1042
B12	125	8	4	49	61	65	48%	54	64	31	149	604	20%	24%	2	58
	282	23	3	27	53	88	38%	47	87	30	164	1338	11%	13%	1	35
B13	269	104	40	71	215	183	54%	121	1054	60	1235	1515	45%	46%	5	139
	286	25	8	47	80	93	46%	38	300	17	355	532	40%	41%	2	35
F6	1	66	0	3	69	93	43%	100	99	0	199	1231	14%	17%	0	23
B W of C105	277	80	5	2	87	63	58%	110	301	0	411	1431	22%	25%	13	18
W of 105	281	5	0	0	5	25	17%	8	33	0	41	389	10%	10%	1	0
Totals		763	230	415	1408	1511	48%	1145	9573	239	10957	17569	38%	39%	80	2707

Table 1: Summary of bone quantities by barrel, sample, sieve size and element type (QC1 refers to cranial and appendicular elements, QC2 to the vertebral column, QC4 to unusual elements, and QC0 to unidentifiable or not routinely identified elements)



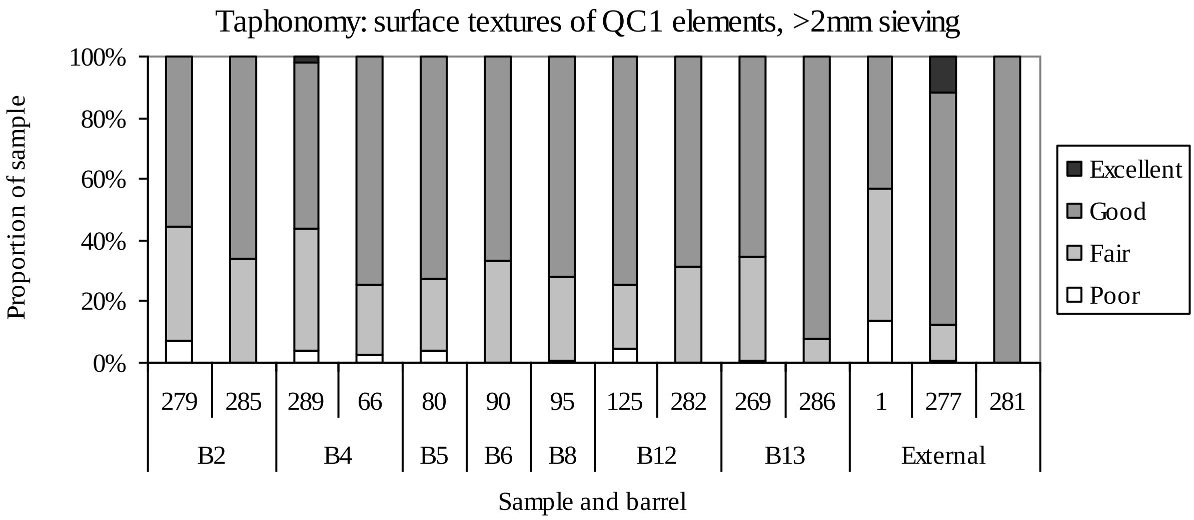
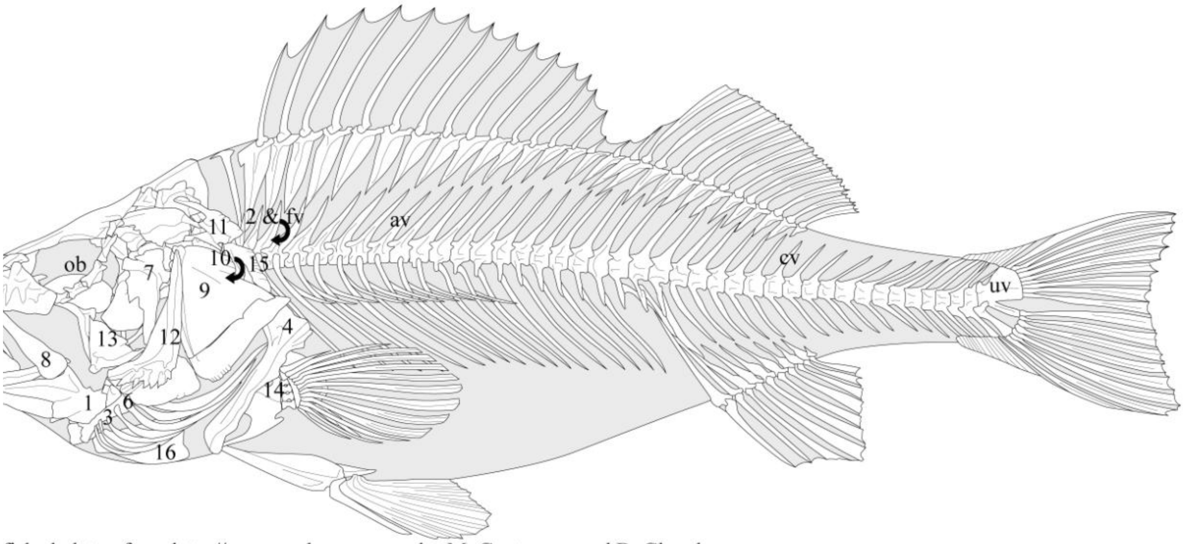


Figure 2: Taphonomic patterning



fish skeleton from http://www.archeozoo.org, by M. Coutureau and B. Clavel

Figure 3: Diagram of a fish skeleton with approximate locations of major elements: 1 – articular; 2 – basioccipital; 3 – ceratohyal; 4 – cleithrum; 5 – dentary; 6 – epihyal; 7 – hyomandibular; 8 – maxilla; 9 – opercular; 10 – parasphenoid; 11 – posttemporal; 12 – preopercular; 13 – quadrate; 14 – scapula; 15 – supracleithrum; 16 – urohyal; 17 – vomer; ob – otic bulla; fv – first vertebra; av – abdominal vertebrae; cv – caudal vertebrae; uv – ultimate vertebra

Element	B2				B4				B5		B6		B8		B12				B13				External					Total	
	279		285		289		66		80		90		95		125		282		269		286		1		277		281		
	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	%	NISP	NISP	%
Articular	3	4%	19	4%			1	0%	11	1%	27	2%	6	0%	1	0%	2	1%	21	1%	4	1%	24	9%	16	3%	2	137	1%
Basioccipital			9	2%			3	0%	6	0%	21	2%	21	1%	3	1%	2	1%	16	1%	7	2%	6	2%	8	2%		102	1%
Ceratohyal	1	1%	9	2%	2	0%	1	0%	3	0%	16	1%	9	0%	2	1%	9	4%	7	0%	1	0%	29	11%	21	4%	1	111	1%
Cleithrum									1	0%	2	0%		0%											1	0%		4	0%
Dentary	6	8%	20	4%	9	1%	10	1%	28	2%	41	3%	65	2%	5	2%	13	6%	37	3%	8	2%	39	15%	23	5%		304	2%
Epihyal			8	2%					2	0%	12	1%	3	0%	3	1%	5	2%	3	0%	1	0%	5	2%	25	5%	3	70	1%
Hyomandibular	1	1%	14	3%	1	0%	8	1%	4	0%	45	4%	25	1%	1	0%	3	1%	16	1%	5	1%	6	2%	3	1%		132	1%
Maxilla	4	5%	14	3%	11	1%	31	2%	32	2%	49	4%	167	5%	32	15%	20	9%	37	3%	16	4%	17	6%	13	3%	1	444	4%
Opercular	2	3%	11	2%			3	0%	18	1%	17	1%	9	0%	2	1%	1	0%	16	1%	3	1%	10	4%	4	1%		96	1%
Parasphenoid	4	5%	12	3%	1	0%	2	0%	15	1%	22	2%	26	1%	4	2%	4	2%	18	1%	6	1%	2	1%	3	1%		119	1%
Posttemporal			9	2%			1	0%	11	1%	13	1%	3	0%	1	0%	3	1%	13	1%	2	0%	2	1%	14	3%		72	1%
Preopercular			7	1%					7	0%	10	1%	10	0%			1	0%	11	1%	1	0%	5	2%	2	0%		54	0%
Quadrate	1	1%	15	3%	2	0%	5	0%	13	1%	22	2%	28	1%	4	2%	4	2%	18	1%	4	1%	18	7%	30	6%	2	166	1%
Scapula																							1	0%				1	0%
Supracleithrum	1	1%	1	0%					11	1%	5	0%			3	1%	1	0%	6	0%	1	0%	1	0%	5	1%		35	0%
Urohyal																								0%	1	0%	1	2	0%
Vomer	1	1%	7	1%	1	0%			4	0%	2	0%	6	0%	1	0%	2	1%	6	0%	4	1%	1	0%	21	4%	3	59	0%
First Vertebra			27	6%	38	4%	26	2%	33	2%	42	3%	77	2%	12	6%	9	4%	42	3%	14	3%	16	6%	40	8%	10	386	3%
Abdominal Vertebra	4	5%	131	28%	445	48%	429	34%	608	37%	390	31%	1178	32%	33	16%	39	18%	612	42%	181	42%	41	15%	181	36%	22	4294	35%
Caudal Vertebra	42	57%	118	25%	415	45%	716	57%	733	45%	462	37%	1836	50%	23	11%	40	18%	433	30%	112	26%	40	15%	72	14%		5042	41%
Ultimate Vertebra			4	1%		0%	4	0%	34	2%	8	1%	5	0%			2	1%	7	0%	1	0%	2	1%	13	3%	1	81	1%
Otic Bulla	4	5%	32	7%	2	0%	9	1%	55	3%	34	3%	181	5%	80	38%	57	26%	131	9%	64	15%	3	1%	2	0%		654	5%
Total identified	74	100%	467	100%	927	100%	1249	100%	1629	100%	1240	100%	3655	100%	210	100%	217	100%	1450	100%	435	100%	268	100%	498	100%	46	12365	100%

Table 2: Identified element counts and percentages by barrel and sample for >4mm and 2-4mm fractions combined

Element	B2		B4		B5	B6	B8	B12		B13		External			Total
	279	285	289	66	80	90	95	125	282	269	286	1	277	281	
Articular			1												1
Dentary			1				1								2
Maxilla			8	3	4	2	11	2		4	1		3		38
Parasphenoid						1							1		2
Quadrate			1										1		2
Supracleithrum							1								1
Vomer	2	5	5	1	1	5	3		1	1	1		8	1	34
First Vertebra			4	4	8	1	4					3			24
Abdominal Vertebra	6	150	329	224	114	43	669	42	21	121	26	17	15		1777
Caudal Vertebra	6	74	169	124	78	19	361	16	14	18	9	3	2		893
Ultimate Vertebra		1	1	1		1	8						1		13
Total	14	230	519	357	205	72	1058	60	36	144	37	23	31	1	2787

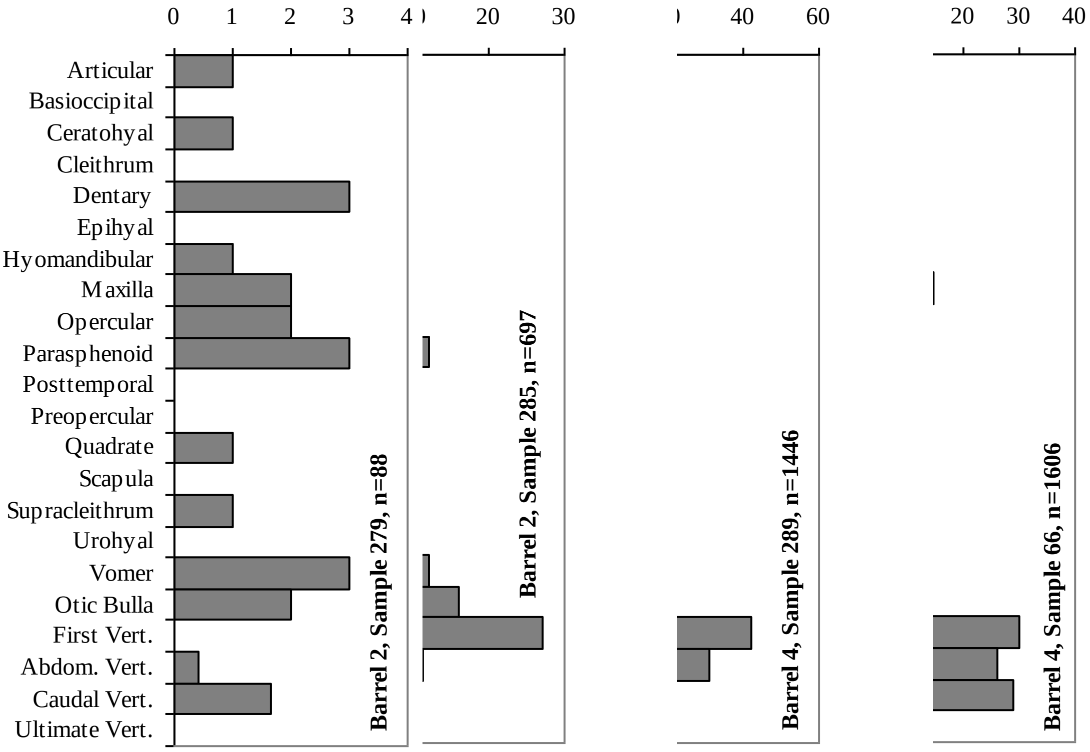
Table 3: Identified element counts and percentages by barrel and sample for 300µ-2mm fraction

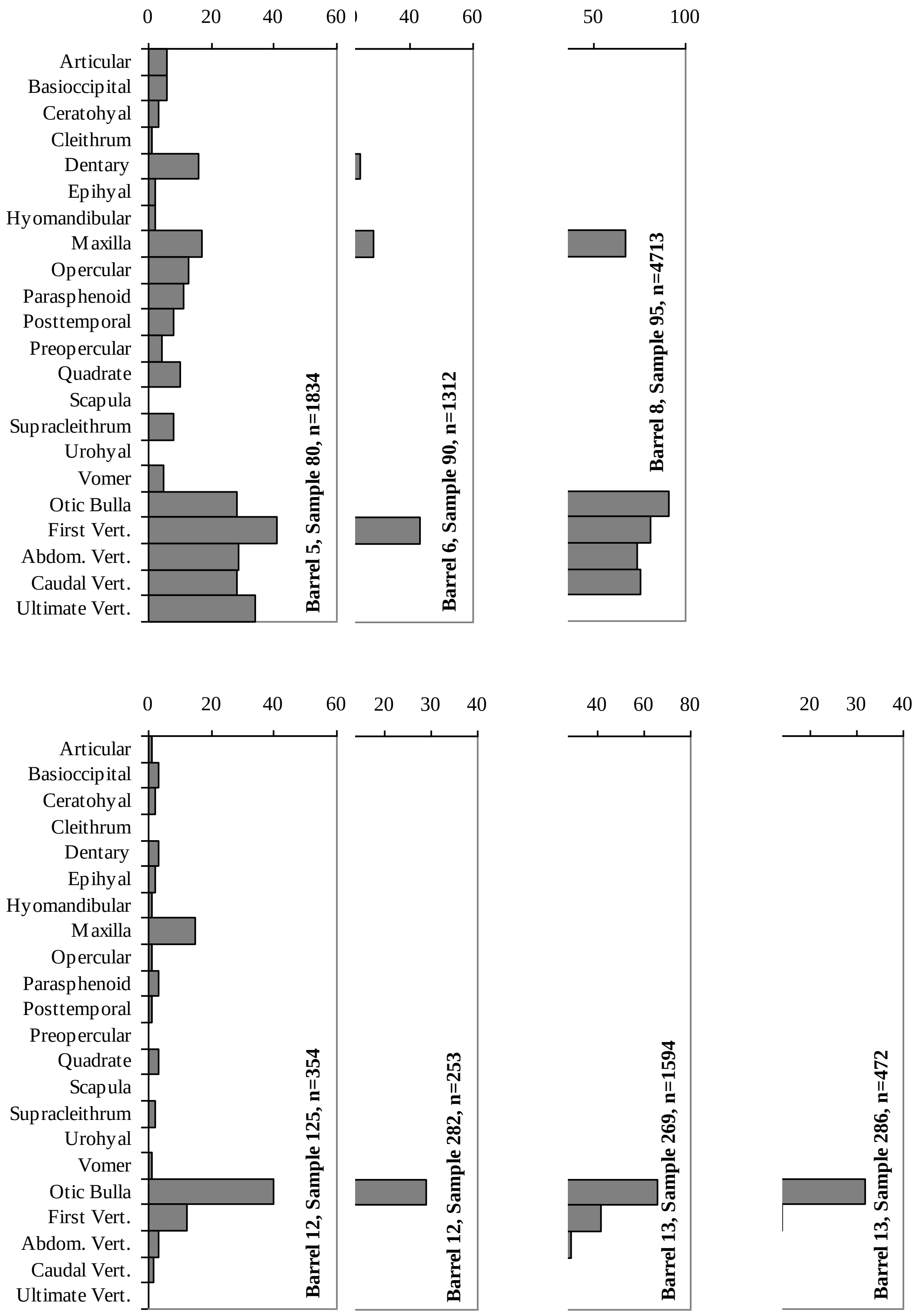
Element	B2		B4		B5	B6	B8	B12		B13		External		
	279	285	289	66	80	90	95	125	282	269	286	1	277	281
Articular	1	10	1	1	6	14	3	1	1	12	3	12	8	1
Basioccipital		9		3	6	21	21	3	2	16	7	6	8	
Ceratohyal	1	6	1	1	3	10	6	2	4	3	1	10	12	1
Cleithrum					1	2							1	
Dentary	3	11	5	4	16	24	32	3	6	16	4	16	11	
Epihyal		8			2	6	2	2	4	2	1	3	13	3
Hyomandibular	1	9	1	4	2	21	13	1	1	8	3	4	2	
Maxilla	2	6	14	15	17	28	68	15	7	14	7	7	6	1
Opercular	2	6		2	13	12	5	1	1	10	2	6	3	
Parasphenoid	3	12	1	1	11	16	17	3	3	11	3	2	4	
Posttemporal		7		1	8	8	2	1	2	7	1	2	7	
Preopercular		4			4	5	6		1	6	1	2	1	
Quadrate	1	8	2	4	10	12	16	3	2	10	2	11	19	1
Scapula												1		
Supracleithrum	1	1			8	3	1	2	1	5	1	1	3	
Urohyal													1	1
Vomer	3	12	6	1	5	7	9	1	3	7	5	1	29	4
Otic Bulla	2	16	1	5	28	17	91	40	29	66	32	2	1	
First Vertebra		27	42	30	41	43	81	12	9	42	14	19	40	10
Abdominal Vert.	1	12	31	27	29	18	74	3	3	30	9	3	8	1
Caudal Vertebra	2	7	21	29	28	17	76	2	2	16	5	2	3	
Ultimate Vertebra		5		5	34	9	13		2	7	1	2	14	1

Table 4: Minimum number of elements by barrel and sample, for all >300µ fractions combined. For QC1 cranial elements, this takes into account left or right side and element fragmentation patterns, while the value displayed for QC4 otic bullae is simply half their count, rounded up. For QC2 vertebrae, the values displayed take into account the number of each type found in one individual, rounded up, thus making them directly comparable to QC1 and QC4 element values.

Method	B2		B4		B5	B6	B8	B12		B13		External			Total
	279	285	289	66	80	90	95	125	282	269	286	1	277	281	
MNI for QC1 elements	3	12	14	15	17	28	68	15	7	16	7	16	29	4	251
MNI for otic bullae	2	16	1	5	28	17	91	40	29	66	32	2	1		330
MNI for vertebrae	2	27	42	30	41	43	81	12	9	42	14	19	40	10	412
Maximum value	3	27	42	30	41	43	91	40	29	66	32	19	40	10	513

Table 5: Minimum numbers of individuals per sample, calculated for cranial elements (QC1), otic bullae (QC4), and vertebrae (QC2).




0
20
40
60
40
60
50
100
Articular
Basioccipital
Ceratohyal
Cleithrum
Dentary
Epihyal
Hyomandibular
Maxilla
Opercular
Parasphenoid
Posttemporal
Preopercular
Quadrate
Scapula
Supracleithrum
Urohyal
Vomer
Otic Bulla
First Vert.
Abdom. Vert.
Caudal Vert.
Ultimate Vert.
Barrel 5, Sample 80, n=1834
Barrel 6, Sample 90, n=1312
Barrel 8, Sample 95, n=4713
0
20
40
60
20
30
40
40
60
80
20
30
40
Articular
Basioccipital
Ceratohyal
Cleithrum
Dentary
Epihyal
Hyomandibular
Maxilla
Opercular
Parasphenoid
Posttemporal
Preopercular
Quadrate
Scapula
Supracleithrum
Urohyal
Vomer
Otic Bulla
First Vert.
Abdom. Vert.
Caudal Vert.
Ultimate Vert.
Barrel 12, Sample 125, n=354
Barrel 12, Sample 282, n=253
Barrel 13, Sample 269, n=1594
Barrel 13, Sample 286, n=472

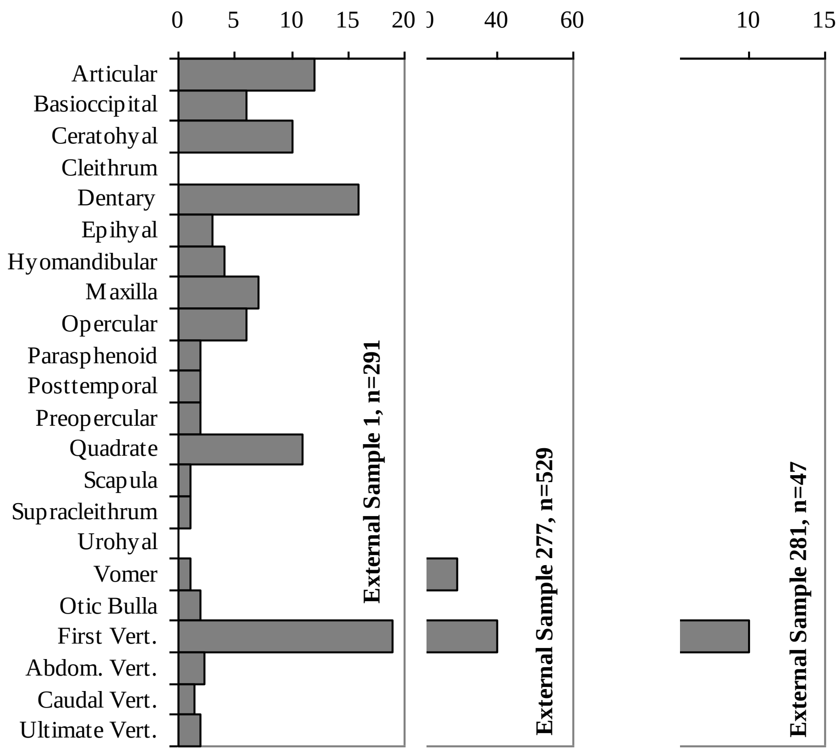


Figure 4: Minimum number of elements (MNE) by barrel, all >300µ fractions combined. For QC1 cranial elements, this takes into account left or right side and element fragmentation patterns, while the value displayed for QC4 otic bullae is simply half their count. For QC2 vertebrae, the values displayed take into account the number of each type found in one individual, thus making them directly comparable to QC1 and QC4 element values. The 'n' value refers to number of fragments used to determine the MNE statistics.

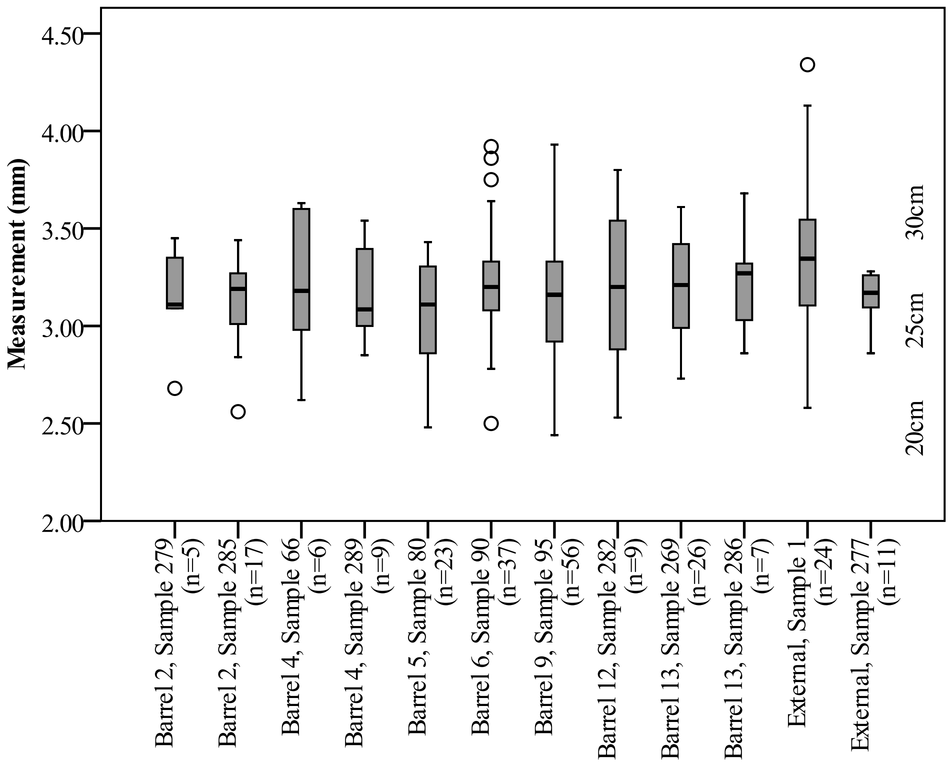


Figure 5: Dentary measurement box plots by barrel and sample, for samples with at least 5 measurements; approximate total fish length correlations are displayed on the right.

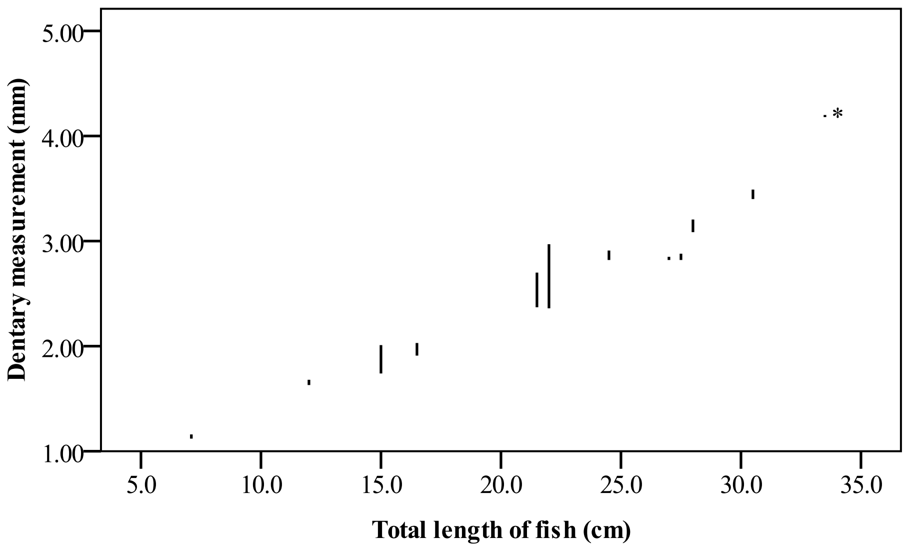


Figure 6: Dentary measurement correlation using 12 modern reference herring; vertical bars show differences between left and right elements within each specimen; * based only on the left measurement.

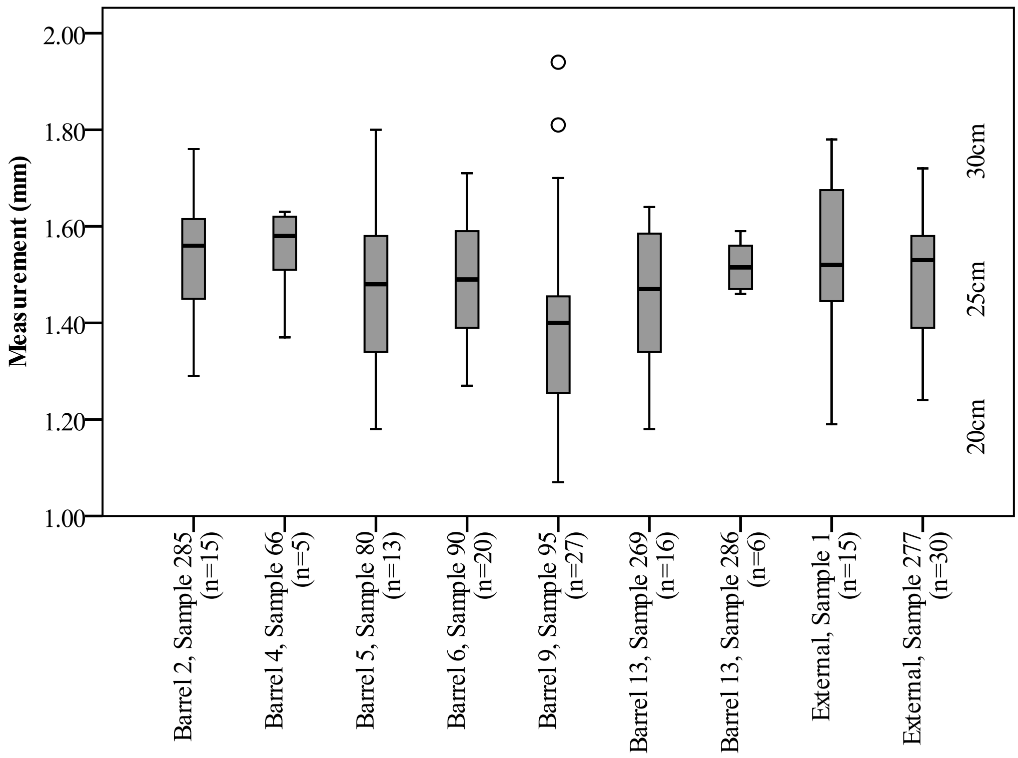


Figure 7: Quadrate measurement box plots by barrel and sample, for samples with at least 5 measurements; approximate total fish length correlations are displayed on the right.

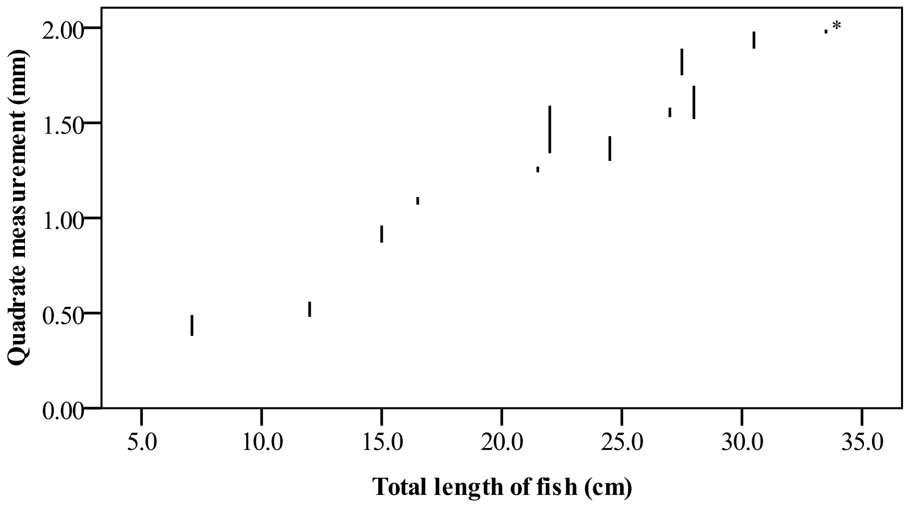


Figure 8: Quadrate measurement correlation using 12 modern reference herring; vertical bars show differences between left and right elements within each specimen; * based only on the left measurement

Figure 9: Barrel 6, sample 90, selected >4mm identified specimens (top left), selected >4mm unidentified specimens (top right), selected 2-4mm identified specimens (middle left), selected 2-4mm unidentified specimens (middle right), and barrel 4, sample 289, selected 300µ-2mm identified specimens (bottom left), and selected 300µ-2mm unidentified specimens (bottom right, residue from this fraction was unsorted hence other inclusions). Scale 5mm.

Figure 10: Possibly butchered cleithrum from barrel 5, sample 80, shown with a modern example from a fish of 27cm total length. Scale 5mm.

Figure 11: Two cleithra fragments from barrel 6, sample 90, shown with a modern example from a fish of 27cm total length. Scale 5mm.

Figure 12: Cleithrum fragment from external sample 277, shown with a modern example from a fish of 27cm total length. Scale 5mm.

Figure 13: Urohyal from external sample 281, shown with a modern example from a fish of 27cm total length. Scale 5mm.

Figure 14: Urohyal fragment from external sample 277, shown with a modern example from a fish of 27cm total length. Scale 5mm.

Figure 15: Examples of fused cranial elements and vertebrae from barrel 13, sample 269. Scale 5mm.

Figure 16: Supracleithra from barrel 12, sample 125, shown with a modern example from a fish of 27cm total length. Scale 5mm.

Figure 17: Supracleithra from barrel 13, sample 269, shown with a modern example from a fish of 27cm total length. Scale 5mm.

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