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Technical Report: The fish bone from Bon Accord, Aberdeen (site code 20215)

By

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Summary
A large assemblage of hand collected and sieved fish bone was analysed from medieval and later deposits in Aberdeen. The bulk of the material probably dated to the 13-14th centuries and 14-15th centuries, with some of 15-18th and 19-20th century date. Very large cod and ling dominated the assemblage, particularly between the 13th and 15th centuries. Many of these fish were approaching or well over 100cm total length. Some haddock of smaller size were also found, but were probably under-represented by hand collection. Increasing taxonomic diversity was found from the 15th century onwards, while at the same time the largest ling and cod were no longer recovered; this suggested a shift towards shallower or inshore fisheries. Butchery and element patterning was used to explore the possible evidence for fish trade, but it was likely the majority of the fish being consumed were eaten fresh, contrary to conclusions drawn from comparative material from medieval Aberdeen and historical sources documenting Aberdeen's role in the fish trade. Extensive butchery of the large cod and ling followed a set pattern to reduce the edible parts into smaller, manageable portions, and may have been undertaken by professionals. Numerous small knife marks did not follow set patterns and probably are evidence for food preparation and consumption at the domestic level. Surprising numbers of pathologies were found on the very big cod and ling, including evidence for joint disease, injuries and tumour type growths.

KEYWORDS: ABERDEEN, FISH BONES, ZOOARCHAEOLOGY, MEDIEVAL, BUTCHERY, FISH TRADE, PATHOLOGIES

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Introduction

This report details the analysis of 7755 fish bones and otoliths from hand collected and sieved features at Bon Accord, Aberdeen. A total of 4383 fragments were identified to species or broader taxonomic group, much of them cod and cod family. The site dated from the 13th century AD to the 20th century, with much of the identified material dating from the 13-14th century and the 14-15th century phases. This is a large and well dated urban assemblage that fills a gap in our understanding of the archaeology and history of Scottish medieval fisheries.

Following a detailed description of the fish remains from each feature, the broader discussions related to the site as a whole will be presented. This will include issues of chronology, element patterning, butchery, pathologies, and the medieval fish trade. The site will then be placed in context by a comparison with other published sites from Aberdeen, as well as a brief discussion of the historical sources relating to fishing, fish markets and the fish trade in medieval Aberdeen.

Methods

This assemblage was recorded using the York System, an Access database utility designed for recording zooarchaeological assemblages. The extensive reference collection held by the Department of Archaeology, University of York, was used for identification purposes. 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 large cod and ling found at Bon Accord might have been prepared or preserved in some way, as is commonly found in North Atlantic fish assemblages of the time (Barrett *et al.* 2008). 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). In order to explore whether or not the Bon Accord fish had been preserved, it was necessary to record fish sizes for all cod and ling vertebrae, even though this is not standard procedure.

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.

A note on recovery and collection biases

Much of the Bon Accord assemblage was recovered by hand collection, accounting for 90% of identified fish. Fish bones can be prone to recovery biases, more so than other types of bone, because the small size of many taxa consumed in Britain means that most bone is only routinely recovered by sieving (Wheeler and Jones 1989). In some cases, hand collection will

produce very few fish bones, while sieving of the same sediments could produce thousands of bones. However, the Bon Accord assemblage is unusual in this regard. The extraordinarily large ling and cod bones recovered from most phases were easily recognisable during excavation, and the good condition of the bone has enabled most body parts to be collected with minimal loss.

Comparisons between contemporary hand collected and sieved samples indicate that hand collection missed little: fish sizes are broadly similar between recovery methods, while small fish, like herring, inshore saithe, sand eels and sea scorpions appear only at trace levels in the sieved material. The smaller posterior caudal vertebrae (the tail region) are underrepresented for the large cod and ling, most likely because these are much smaller and more fragile than the huge and robust anterior vertebrae. There is a slight increase in haddock quantities recovered by sieving, rather than hand collection – indicating that this species is likely to be underrepresented in the fish assemblage as a whole. However, much of the identified, sieved material was from Phases 2, 3 and 5, whereas almost all of the identified, hand collected material came from Phases 1, 2 and 3 – so each fraction will tell a slightly different story because each relates to a different time period. These biases are discussed further where relevant.

Summary by phase and feature

A brief description is provided for each feature, with any bones of note described in full. Unless otherwise noted, all bones were derived from hand collection. 'TL' refers to total length of the fish.

Phase 1

Phase A1, Gully 005
A single cod bone from a fish of 80-100cm TL was identified.

Phase A1, Pit 026
Sieving produced 4 fish bones, 3 haddock vertebrae from fish of 15-30cm and 30-50cm TL and another vertebra from the cod family, from a small fish of 15-30cm TL. Two bones were crushed.

Phase A1, Pit 027
Two cod bones from fish of 80-100cm TL were identified. Two ling cleithra were identified, both butchered, 1 from a fish of 80-100cm TL and 1 from a fish of >100cm TL. A further 37 fragments were not identified.

Phase A1, Pit 030
This feature produced 43 identifiable bones. Twenty-one were identified as cod from a variety of vertebral and cranial elements, 6 from fish of 80-100cm TL and 15 from fish of >100cm TL. Two of these larger cod were butchered dentaries, cut or chopped near the central articulation. Twenty-one bones were identified as ling, 2 from fish of 80-100cm TL and the rest from fish of >100cm TL; again these were a mixture of vertebral and cranial elements. A ling parasphenoid was found in articulation with a basioccipital. A single saithe cranial bone was from a fish of >100cm TL. A further 35 fragments were not identified.

Phase A1, Pit 035
Three haddock bones were identified from a combination of hand collection and sieving; 2 from fish of 30-50cm TL and 1 from a fish of 50-80cm TL.

Phase A1, Spread 024
This sieved feature produced a variety of taxa, including two 30-50cm TL haddock fragments, 1 small 15-30cm TL whiting fragment, and a 50-80cm TL cod/ saithe/ pollack fragment. A further 12 bones were not identified.

Phase A1, Spread 050
This small sieved feature produced 1 haddock and 1 cod family fragment, both from fish of 30-50cm TL. One further fragment was not identified.

Phase B1, Pit 001
A single cod bone from a fish of 80-100cm TL was identified.

Phase B1, Pit 002
A single fish bone was noted but was not identified.

Phase C1, Gully 001
This feature produced 40 identified bones. Cod was represented by 16 examples, 15 of which were vertebrae. Two were from fish of 50-80cm TL, 10 from fish of 80-100cm TL and 4 from fish of >100cm TL. Two haddock bones were identified, 1 from a fish of 30-50cm TL and 1 from a fish of 50-80cm TL. A total of 22 ling cranial and vertebral elements were found, all from fish of >100cm TL; an articulating basioccipital and first vertebrae were butchered, as was an abdominal vertebra. A further 7 fragments were not identified.

Phase C1, Gully 002
Seven cod vertebrae were recovered, 4 from fish of 80-100cm TL and 3 from fish of >100cm TL. A single ling fragment from a fish of >100cm TL was also found.

Phase C1, Layer 002
Six cod cranial and vertebral fragments were identified, 3 from fish of 80-100cm TL and 3 from fish of >100cm TL. Four ling bones were identified, all from fish of >100cm TL. A further 5 fish bones were not identified.

Phase C1, Layer 051
A single cod fragment from a fish of >100cm TL was recovered.

Phase C1, Pit 001
Hand collection of fish remains produced 53 fragments. Sixteen cod were identified, 1 from a fish of 50-80cm TL, 4 from fish of 80-100cm TL and 11 from fish of >100cm TL. Seven haddock fragments were found, 6 from fish of 30-50cm TL and 1 from a fish of 50-80cm TL. Six ling fragments were identified, all from fish of >100cm TL. An additional 24 fragments were not identified.

A separate bag arrived partly sieved and labelled as a possible articulated fish, the remainder being wet sieved by the author to 1mm. This proved to be more than 1 fish. Nine cod cranial and vertebral fragments were from fish of 80-100cm TL, 3 of which were vertebrae with mild pathologies. A single ultimate vertebra was from a fish of 80-100cm TL but could only be identified as cod family. Five fragments were from ling of >100cm TL, mixed with the cod. A total of 158 fragments were not identified, many of which were tiny fragments from larger cod family fish.

Phase C1, Pit 003
Hand collection produced 50 fragments. Ten of these were cod, from both the cranium and vertebral column, and 4 were from fish of 80-100cm TL, the remainder being from fish of >100cm TL. One 80-100cm TL cod dentary was chopped at the medial articulation. A total of

9 ling elements were found, both cranial and vertebral, 7 from fish of 80-100cm TL and 2 from fish of >100cm TL. Thirty-one fish fragments were not identified.

Sieving produced 19 fragments, 1 cod of 80-100cm TL, 1 ling of >100cm TL, and 1 flounder or plaice element from a fish of 30-50cm TL. A further 16 fragments were not identified.

Phase C1, Pit 004
Two ling and 1 cod vertebrae from >100cm TL fish were identified, as was a single cod vertebra from a fish of 80-100cm TL. Two fragments were not identified. A further 7 fragments derived from sieving were also not identified.

Phase C1, Pit 008
A total of 97 fish bones were recorded. Thirty-eight were identified as cod, from both the cranium and vertebral column; 23 were from fish of 80-100cm TL and 15 from fish of >100cm TL. A single 80-100cm TL cod premaxilla was butchered at the medial articulation, while 2 cod vertebrae were also butchered, 1 from a fish of 80-100cm TL and 1 from a fish of >100cm TL. A total of 33 ling vertebrae and cranial elements were identified, all from fish of >100cm TL. A single salmon family vertebra was also recorded, as were 25 fragments that were not further identified.

Phase C1, Pit 009
This larger feature produced 169 fish fragments. A total of 66 cod fragments were identified, including a mixture of cranial and vertebral elements; 2 from fish of 50-80cm TL, 28 from fish of 80-100cm and 36 from fish of >100cm TL. One cod fragment was burnt. A single >100cm TL cod abdominal vertebra was butchered. Six haddock fragments were identified, 4 from fish of 30-50cm TL and 2 from fish of 50-80cm TL. One haddock fragment has some blue-green concretions attached. A total of 27 ling fragments were found, 1 from a fish of 80-100cm TL and the remainder from fish of >100cm TL. A small portion of articulated ling cranium included a basioccipital, parasphenoid and 4 elements not routinely identified from a fish of >100cm TL, while a separate articulated basioccipital and parasphenoid were from another ling of similar size. A single 50-80cm TL turbot fragment was also identified, while 69 fragments were not identified.

Phase C1, Pit 015
This very large multi-context feature included 1093 hand collected fish fragments, with an additional 36 recovered by sieving. Results are summarised below in Table 1. The large number of cod vertebrae contrasts to the smaller number of cranial elements, even when considering the frequent occurrence of vertebrae with a single skeleton. The same is apparent for ling. This does not appear to be a recovery bias, as the sieved material tends towards the same pattern; thus it appears this deposit contained the remains of several fish bodies with few corresponding heads. Several vertebrae were butchered.

Phase C1, Spread 002
This small, sieved feature produced a surprising diversity of fish, including a single herring vertebra, a flounder fragment from a fish of 15-30cm, 2 halibut family vertebrae, 1 sole family vertebra, and 2 plaice cranial elements, 1 each from a fish of 15-30cm and 30-50cm TL. A single haddock was from a fish of 30-50cm TL. Three cod bones were identified, 1 each from fish of 15-30cm TL, 30-50cm TL and >100cm TL. This range of taxa and the small sizes of fish found, including the 2 smaller cod, contrast strongly with the rest of the Bon Accord assemblage and probably indicate fishing in a different habitat. A further 92 fragments were not identified.

Phase C1, Spread 091
A single cod vertebra from a fish of 80-100cm TL was identified.

Phase 2

Phase A2, Gully 004
This small, sieved feature produced a haddock vertebra and a cod family vertebra, both from fish of 15-30cm TL, and, unusually, a single carp family vertebra. The latter indicates some small degree of freshwater fishing. One additional fragment could not be identified.

Phase A2, Spread 027
A single haddock vertebra from a fish of 15-30cm TL was recovered from this sieved feature.

Phase C2, Gully 004
This feature produced 29 fish fragments from hand collection. Twenty five of these were cod, from both cranial and vertebral elements, 1 from a fish of 50-80cm TL, 14 from fish of 80-100cm TL and 10 from fish of >100cm TL. One cod dentary from a fish of >100cm TL was butchered at the medial articulation. Three ling fragments were found, all from fish of >100cm TL.

A single herring vertebra and 2 haddock vertebrae from fish of 15-30cm TL were recovered from sieving, and all 3 were burnt.

Phase C2, Hollow 002
This moderately large feature produced 259 fragments of fish bone. A total of 116 cod bones were identified, 1 from a fish of 30-50cm TL, 30 from fish of 80-100cm TL and 85 from fish of >100cm TL. Although a mixture of cranial and vertebral elements were noted, 23 of these fragments were cleithra. A number of butchered cod were recorded, including 1 >100cm TL abdominal vertebra, 1 >100cm TL supracleithrum and 2 >100cm cleithra. One >100cm cod articular was pathological. Three haddock cleithra from fish of 30-50cm TL were noted. Twenty four ling elements were identified, from a mix of cranial and vertebral elements, 2 from fish of 80-100cm TL and the remainder from fish of >100cm TL. One ling 80-100cm TL cleithra and 1 >100cm TL abdominal vertebrae were butchered. A single vertebra was identified as saithe or pollack from a fish of >100cm TL. A number of flatfish were identified, including 5 plaice, 3 from fish of 30-50cm TL and 2 from fish of 50-80cm TL, 1 flounder/plaice from a fish of 50-80cm TL, 1 turbot family vertebra from a fish of 50-80cm TL, and 6 halibut family elements, 2 from fish of 30-50cm TL and the remainder not sized. A further 102 fragments were not identified.

Phase C2, Layer 003
This large, multi-context feature produced 740 fish bones from hand recovery, and a further 363 were found during sieving. Taxa, elements and sizes are summarised in Table 2; as is typical of most features, cod and ling dominate the assemblage, a few haddock were recovered, and trace quantities of a few other species were present. The relatively large size of the sieved portion make it possible to compare recovery methods. Both fractions are dominated by large cod family fish, with very little difference in total length profiles or taxonomic diversity – making it likely that few small fish were consumed at Bon Accord. A moderate number of butchered and pathological specimens were noted in this feature. Cod cleithra appear slightly over-represented compared to other elements, but both cod heads and vertebrae were being deposited together.

Phase C2, Layer 023
A single cod vertebra from a fish of 80-100cm TL was recovered from this feature.

Phase C2, Layer 050
Two cod vertebrae were identified, 1 from a fish of 80-100cm TL and the other from a fish of >100cm TL. One ling vertebra was also identified, from a fish of >100cm TL.

Phase C2, Pit 018
A total of 163 fish bones were noted from this feature. As is typical, cod were the most numerous taxa, with 73 bones identified. Two of these were from fish of 50-80cm TL, 38 from fish of 80-100cm, and the remaining 33 from fish of >100cm TL. A total of 17 ling bones were identified, 1 from a fish of 80-100cm TL and the remainder from fish of >100cm TL. Both the cod and ling were represented by cranial and vertebral elements. Two cod dentaries from fish of 80-100cm TL and 1 from a fish of >100cm TL were butchered at the medial articulation, and 1 cod vertebra from a fish of 80-100cm TL and 3 cod vertebrae from >100cm TL fish were also butchered. Six haddock fragments were identified, 4 from fish of 30-50cm TL and 2 from fish of 50-80cm TL. A single plaice from a fish of 30-50cm TL was also found. Finally, 66 bones were not identified.

Phase C2, Pit 019
This smaller feature produced 40 fish bones. Four cod vertebrae were found, 2 each from fish of 80-100cm TL and >100cm TL. Nine ling vertebrae were also recorded, all from fish of >100cm – and unusually, ling outnumbered cod in this feature. Another 3 cod were found during sieving, all from fish of 80-100cm TL. A single haddock cranial element from a fish of 30-50cm TL was found during sieving. A single unidentified fish fragment was also noted from hand collection, and 22 were found in the sieved fraction, 1 of which was burnt.

Phase C2, Pit 021
This pit produced 9 fish bones. Seven were cod, 6 of which were from fish of 80-100cm TL and 1 from a fish of >100cm TL. One cod cleithrum from a fish of 80-100cm TL was butchered. A single ling fragment was from a fish of >100cm TL and a single fragment was unidentified.

Phase C2, Pit 022
This pit produced a total of 98 fish bones, 87 derived from hand collection and the remainder from sieving. A total of 52 cod bones were identified from hand collection, equally represented by cranial and vertebral elements. One was from a small cod of 30-50cm TL, but the rest consisted of 13 80-100cm TL and 38 >100cm TL cod. A single haddock was represented by a vertebra from a fish of 50-80cm TL, while ling were represented by 14 cranial and vertebral elements from fish of >100cm TL. One pathological ling dentary was noted, and 1 ling vertebra was butchered. Two halibut family fragments were identified, 1 from a fish of 30-50cm and 1 from a fish of 50-80cm TL, while a further 18 fragments were not identified.

Sieving produced 2 herring vertebrae, 2 haddock vertebrae from fish of 15-30cm TL, 1 haddock vertebra from a fish of 30-50cm TL, and 6 unidentified fragments.

Phase C2, Pit 023
Hand collection produced a total of 13 fish bones, while an additional unidentified bone was recovered by sieving. Five cod bones were noted, 3 from fish of 80-100cm TL and 2 from fish of >100cm TL. Ling was represented by 3 specimens, all from fish of >100cm TL. Five fish fragments were not further identified. A single instance of fresh breakage was noted, which was unusual in this otherwise very well curated assemblage.

Phase C2, Pit 024
This pit produced a single butchered cod cleithrum from a fish of >100cm TL. Five ling fragments were identified, as usual all from fish of >100cm TL, and 1 cleithrum was butchered. A further 4 fragments were not identified.

Phase C2, Pit 025
This relatively large pit produced 134 fish bones. Most were cod, including 27 from fish of 80-100cm TL and 39 from fish of >100cm TL. One >100cm TL fragment could only be

identified to cod family. Three haddock cleithra from fish of 50-80cm TL were noted. Twenty four ling were identified, 1 from an unusually small fish of 50-80cm TL and the remainder from fish of >100cm TL, including 1 fragment gnawed by a carnivore. Both cod and ling were represented by cranial and vertebral elements. Butchery was fairly common, including: 4 cod 80-100cm TL cleithra, 2 cod >100cm TL cleithra, 1 cod 80-100cm TL quadrate, 1 cod 80-100cm premaxilla, 1 cod >100cm TL premaxilla, 1 ling >100cm vertebra and 1 ling >100cm TL premaxilla. Finally, 35 fragments were not identified. Sieving produced a total of 4 fragments, 1 identified as a whiting vertebra from a fish of 30-50cm TL and the remaining 3 not identified.

Phase C2, Pit 026
This small feature produced 1 cod fragment from a fish of >100cm TL, 2 ling fragments from fish of >100cm TL, and a single unidentified fragment.

Phase C2, Pit 027
A total of 10 cod fragments were noted, 4 from fish of 80-100cm TL and 6 from fish of >100cm TL. One cod 80-100cm TL maxilla was butchered, an unusual element to display evidence of butchery. Three ling were identified, 1 from a fish of 80-100cm TL and the remaining 2 from fish of >100cm TL. One saithe vertebra from a fish of 80-100cm TL was found, and a single fragment was not identified.

Phase C2, Pit 029
Hand collection produced 5 fish fragments, 1 each from cod of 80-100cm TL and >100cm TL. Two ling fragments were both from fish of >100cm TL, 1 of which was butchered, and a haddock fragment was from a fish of 30-50cm TL. Sieving produced 1 tiny vertebra that could only be identified as a <15cm TL cod family fish, as well as 2 haddock elements, 1 each from fish of 15-30cm TL and 50-80cm TL. Five additional fragments were not identified.

Phase C2, Pit 031
Hand collection produced 4 cod fragments and 10 ling identifications, all from fish of >100cm TL and all cranial elements. One ling parasphenoid was butchered. One further fragment was not identified. Sieving produced a single gurnard family vertebra from a fish of 15-30cm TL, as well as 1 burnt fragment and 9 further fragments that were not identified.

Phase C2, Pit 032
This pit produced 139 fish bone fragments. A total of 34 were cod, including 1 from a fish of 50-80cm TL, 5 from fish of 80-100cm TL and 28 from fish of >100cm TL. Two of the >100cm TL cod cranial elements were pathological. A total of 29 ling were identified, all from fish of >100cm TL. Both cod and ling included cranial and vertebral elements. A single haddock cleithrum from a fish of 50-80cm TL was noted, as was a single saithe cleithrum from a fish of 80-100cm TL. One 80-100cm TL vertebra could only be identified as saithe or pollack. A further 70 fragments were not identified, and finally, sieving produced 3 unidentified fish bones.

Phase C2, Pit 033
This pit produced 32 fish bones. Ten were identified as cod, 1 from a fish of 50-80cm TL, 7 from fish of 80-100cm TL and 2 from fish of >100cm TL; 1 of the latter was butchered. Four ling were identified, all from fish of >100cm TL. One 80-100cm TL vertebra could only be identified as cod family because of pathological modifications. A further 17 fragments were not identified.

Phase C2, Pit 034
This larger feature produced 418 fish bones. As is usual for Bon Accord, cod were the most numerous, followed by ling. A total of 149 cod were identified, 50 from fish of 80-100cm TL and 99 from fish of >100cm. One fragment was freshly broken.

Ling totalled 78, 1 from a fish of 80-100cm TL and the remainder from fish of >100cm TL. This included two almost complete, articulated ling crania, both from fish of >100cm TL. One contained several pathological lesions and bone modifications (see Pathologies below), which could explain why this remained in articulation, but the other skull was harder to explain; the author has never seen such pristine, large and articulated specimens produced from an excavation before. Not only does it mean that fish heads were being discarded whole, but that preservation was exceptional and disturbance minimal (and post-excavation processing was very gentle).

Both vertebrae and cranial elements were noted for cod and ling. Two cod >100cm TL dentaries, 2 80-100cm TL dentaries and 1 >100cm TL premaxilla were butchered at the medial articulation, as was 1 ling >100cm TL dentary. One 80-100cm TL and 1 >100cm TL cod cleithra were butchered, as were 5 cod >100cm TL vertebrae and 1 cod 80-100cm TL vertebra. In addition to the pathological ling skull noted above, 2 further ling pathological cranial elements were found, both from fish of >100cm TL. Two cod maxillae were pathologically modified, 1 from a fish of 80-100cm and 1 from a fish of >100cm TL, as was 1 dentary from a cod of >100cm TL. Four haddock cleithra were identified, 1 from a fish of 30-50cm TL that was gnawed by a carnivore and butchered, and 3 from fish of 50-80cm TL. A single saithe vertebra from a fish of 80-100cm TL was identified. A halibut quadrate was probably from a fish of similar size, but as this was an order of magnitude greater than any in the reference collection, this was only an estimate. A total of 156 fish fragments were not identified.

Sieving produced a few rare taxa, including a single ray family dermal denticle and an unidentified gurnard family cranial fragment. Three cod were also found during sieving, 1 from a small fish of only 15-30cm TL but the other 2 from fish of >100cm TL. Two haddock fragments were identified, 1 each from a fish of 15-30cm TL and 30-50cm TL. A further 22 fish bones were not identified.

Phase C2, Pit 036
This small assemblage included 2 >100cm TL cod fragments, 1 haddock from a fish of 30-50cm TL, and 1 ling from a fish of >100cm TL. A further 3 fragments were not identified.

Phase C2, Pit 037
A total of 14 cod elements were identified, 13 from fish of 80-100cm TL and 1 from a fish of >100cm TL. Two cod >100cm TL vertebrae were butchered and could be articulated together, joining the butchery marks – a rare occurrence. Two fragments were not identified from hand collection, while sieving produced a single haddock vertebra from a fish of 30-50cm TL.

Phase C2, Pit 038
A total of 7 fish bones were produced from this pit. Five were identified as cod, 4 from fish of 80-100cm TL and 1 from a fish of >100cm TL. A further 2 fragments were not identified.

Phase C2, Pit 099
A total of 64 fish bones were noted from this feature. As is usual in this assemblage, cod and ling were most common. Twelve cod bones were identified, 1 from a fish of 30-50cm TL that was also butchered, 6 from fish of 80-100cm TL and 9 from fish of >100cm TL. Eleven ling bones were found, 1 from a fish of 80-100cm TL and the remainder from fish of >100cm TL. One >100cm TL cod vertebra and 1 >100cm ling cleithrum were butchered. A single saithe cranial element from a fish of 80-100cm TL was also found, as were 3 halibut family fish, 1 from a fish of 30-50cm TL and the other 2 not sized. Finally, 32 fragments were not identified.

Phase C2, Spread 010
This small, sieved feature included 1 salmon and trout family vertebra, an unusual find at Bon Accord – and possible evidence of fishing in nearby river systems rather than marine environments. Otherwise, this feature included 2 80-100cm TL cod vertebrae and 10 fragments that were not identified.

Phase C2, Spread 041
A single cod fragment was identified from a fish of >100cm TL.

Phase C2, Spread 043
This spread contained a total of 333 fish bones. Ling were most common in this feature, with 110 fragments identified, 1 from a smaller fish of 50-80cm TL and the rest from fish of >100cm TL. Cod was the next most frequent taxa, with 86 fragments identified. Twenty four of these were from fish of 80-100cm TL and the rest were from fish of >100cm TL. A few butchered elements were found, including 6 >100cm TL ling vertebrae, 3 cod >100cm TL vertebrae, 2 cod >100cm TL dentaries, a cod >100cm TL basioccipital and 2 cod supracleithra, 1 each from a fish of 80-100cm TL and >100cm TL. Both cod and ling were represented by cranial and vertebral elements, but cod cleithra appeared slightly more frequent than other elements; 1 from a fish of >100cm was also butchered. A single branchiostegal fragment from the cod family was butchered. Haddock was represented by a single fragment from a fish of 30-50cm TL, while a single flounder or plaice fragment from a fish of 30-50cm TL was also found. An additional 134 fragments were not identified.

Phase C2, Spread 044
A few fish bones were identified, including 2 ling fragments from fish of >100cm TL, 1 cod from a fish of 80-100cm TL, and 1 cod family vertebra from a fish of >100cm TL. A further 4 fragments could not be identified.

Phase C2, Spread 145
A single ling vertebra from a fish of >100cm TL was identified.

Phase C2, Spread 154
Two cod vertebrae were identified, 1 each from a fish of 80-100cm TL and >100cm TL. A further vertebra was identified from a ling of 80-100cm TL.

Phase C2, Surface 001
A single cod cranial element from a fish of 80-100cm TL was found.

Phase C2, Stakes 002
This feature produced 24 fish bones. Eight of these were an articulating sequence of ling vertebrae, butchered with chop and cut marks. These were from a fish of >100cm TL. Two cod dentaries were also butchered, both from a fish of 80-100cm TL; 1 of these was also pathological. An additional 4 cod bones were found, 3 from fish of 80-100cm TL and 1 from a fish of 50-80cm TL. A single haddock bone from a fish of 50-80cm TL was recovered, and 9 further fragments were not identified. A fragment was freshly broken.

Phase 3
Phase A3, Layer 033
A single ling vertebra from a fish of >100cm TL was found by hand collection. Sieving produced 7 whiting vertebrae from fish of 15-30cm TL, all of which were burnt.

Phase A3, Spread 022
Sieving produced a single burnt haddock vertebra, from a fish of 15-30cm TL, and 1 further fragment that was not identified.

Phase C3, Hearth 001
Four fragments were recovered by sieving, none of which was identified.

Phase C3, Layer 005
This feature produced a total of 501 fish bones. Only 10 were found by hand collection, 4 cod and 6 ling, all from fish of >100cm TL. One cod dentary was butchered at the medial articulation. The rest were derived from sieving. Unusually for Bon Accord, haddock was the most common taxa, with 73 fragments identified. Two were from fish of 15-30cm TL, 70 from fish of 30-50cm TL, and 1, an otolith, was not sized. Both cranial and vertebral elements were identified. Four cod fragments were found, 1 from a fish of 30-50cm TL, 2 from fish of 80-100cm TL and 1 from a fish of >100cm TL. One vertebra was identified as ling, from a fish of >100cm TL, and a further vertebra could only be identified as cod family, from a fish of 15-30cm TL. Finally, 412 were not identified.

Phase C3, Pit 041
Five ling and 3 cod fragments were identified, all from fish of >100cm TL. A further 9 fragments were not identified.

Phase C3, Pit 042
A total of 24 fish fragments were found. Ten cod elements were identified, 6 from fish of 80-100cm TL and 4 from fish of >100cm TL. One cod vertebra from a fish of 80-100cm TL was pathological. Three ling were identified, 1 from a fish of 80-100cm TL and 2 from fish of >100cm TL. A single flounder or place element was found from a fish of 30-50cm TL. A further 10 fragments were not identified.

Phase C3, Pit 047
A total of 175 fish bones were found in this phase. A total of 106 were cod, 4 from fish of 50-80cm TL, 43 from fish of 80-100cm and 59 from fish of >100cm TL. Most cod fragments were vertebrae, rather than cranial elements. Four vertebrae from a fish of >100cm TL were pathological and were found fused together. One cod premaxilla and 1 cod vertebrae, both from fish of >100cm TL, were butchered. Another cod vertebra was covered in concretions. A total of 49 ling elements were found, all from fish of >100cm TL and again, almost all were vertebrae. Five saithe were also found, 3 from fish of 50-80cm TL and 2 from fish of 80-100cm TL. A further 15 fragments were not identified.

Phase C3, Pit 048
A total of 151 fish bones were identified, almost all derived from hand collection. Cod was the most common taxa, as usual, with 52 specimens identified. One of these was a fish of 30-50cm TL, 16 were from fish of 80-100cm TL, and 35 were from fish of >100cm TL. Two cod cranial elements from fish of 80-100cm TL was butchered. Ling were the next most common, with 46 fragments identified, 2 from fish of 80-100cm TL and the rest from fish of >100cm TL. Butchery included 2 >100cm TL elements, including a cleithrum. Both cranial and vertebral elements were represented for cod and ling. Two haddock cleithra were identified, 1 each from a fish of 30-50cm TL and 50-80cm TL, and 1 articular could only be identified as cod family, from a fish of 80-100cm TL. A single halibut family fish of 30-50cm TL was also found. Sieving produced a further 4 fragments, 1 identified as a small sea scorpion family fish and the remainder not identified.

Phase 4

Phase A4, Layer 015
A total of 5 fish bones were identified from sieved and hand collected contexts, 1 from a haddock of 50-80cm TL and 1 from a cod of >100cm TL; the remainder were not identified.

Phase A4, Layer 016
A single ray family dermal denticle was recovered from this feature.

Phase A4, Spread 009
A single cod fragment from a fish of 80-100cm TL was recovered from this sieved feature.

Phase A4, Spread 013
A single haddock fragment from a fish of 15-30cm TL was identified from this sieved feature.

Phase A4, Well 001
A single cod cleithrum from a fish of >100cm TL was recovered by hand collection, while sieving produced 7 fragments. These included 4 sand eel family vertebrae, a single charred cod family bone from a fish of 15-30cm TL, a haddock element from a fish of 15-30cm TL, and a whiting element from a fish of 15-30cm TL.

Phase C4, Hearth 002
This small, sieved feature produced 2 fragments from fish of 15-30cm TL, 1 from a whiting and 1 only identified as cod family. Both were charred.

Phase C4, Layer 008
A single cod fragment from a fish of 80-100cm TL was identified from this feature.

Phase C4, Layer 020
A total of 10 fragments were noted from this feature. These included 4 cod fragments, 2 each from fish of 80-100cm TL and >100cm TL. A single haddock fragment was from a fish of 50-80cm TL, and a single ling fragment was from a fish of >100cm TL. A further 4 fragments were not identified.

Phase C4, Layer 072
A total of 12 fragments were found in this sieved feature. One was identified as a flatfish, and 1 as a 15-30cm TL poor cod, and the remainder were not further identified.

Phase C4, Layer 075
This feature produced a moderate quantity of fish remains, with a total of 67 fragments identified. These included 42 identified as ling, all from fish of >100cm TL. A total of 24 cod fragments were identified, 16 from fish of 80-100cm TL and 8 from fish of >100cm TL. Two 80-100cm TL cod vertebrae were fused together. Ling and cod were both represented by cranial and vertebral elements. A single vertebra could only be identified as saithe or pollack, from a fish of 80-100cm TL. A further 8 fragments were not further identified.

Phase C4, Pit 056
A single burnt fragment was identified as belonging to the cod family, from a fish of 15-30cm TL. This feature was sieved.

Phase C4, Pit 066
A single haddock element was identified from this sieved feature, from a fish of 30-50cm TL. Five fragments were not further identified.

Phase C4, Posthole 003
This larger feature included 201 fish bone fragments derived from hand collection. A total of 55 fragments were identified as cod, 17 from fish of 80-100cm TL and 38 from fish of >100cm TL. A total of 50 fragments were identified from >100cm TL ling. A number of butchered cod and ling were noted. These included 2 cod vertebrae, 2 dentaries and a premaxilla, all from fish of >100cm TL, and a single articular from a cod of 80-100cm TL. Three ling were butchered, 2 cleithra and 1 vertebra. Single identifications of a 30-50cm TL flatfish and a 80-100cm TL pollack were also made.

A total of 24 fragments were recorded from sieving in this feature, 8 of which could be identified. These included 6 cod bones, 1 from a fish of 80-100cm TL and the rest from fish of >100cm TL. One >100cm TL cod vertebra was butchered. Single identifications of ray family and gurnard family fragments were also recorded from the sieved fraction.

Phase 5

Phase A5, Layer 007
A single cod vertebra from a fish of >100cm TL was recovered from this feature.

Phase A5, Layer 008
This small feature produced 3 cod vertebrae, 2 from fish of 80-100cm TL and 1 from a fish of >100cm TL. Three ling vertebrae were also recovered, all from fish of >100cm TL. One further fragment was not identified.

Phase C5, Gully 013
This small, sieved feature included 6 haddock vertebrae, 4 from fish of 15-30cm TL and 2 from fish of 30-50cm TL, as well as a single cod vertebra from a fish of 80-100cm TL. Two flatfish vertebrae were also recorded, as were 5 fragments that were not identified.

Phase C5, Gully 014
This small, sieved feature included a single haddock fragment from a fish of 30-50cm TL, as well as 1 fragment not further identified.

Phase C5, Layer 009
A single cod fragment from a fish of 80-100cm TL was identified, and 1 fragment was unidentified.

Phase C5, Pit 069
This feature produced 158 fish bones, 73 of which were identified, predominantly from hand collected deposits. A wide range of taxa was noted. Haddock were the most frequently found, with 16 fragments derived from hand collection (4 from fish of 30-50cm TL and 12 from fish of 50-80cm TL) and a further 3 from sieving (2 from fish of 15-30cm TL and 1 from a fish of 30-50cm TL). Cod were the second most common taxa, with 17 fragments noted, 2 from fish of 50-80cm TL and 15 from fish of 80-100cm TL. Two 80-100cm cod fragments were butchered, 1 vertebra and 1 maxilla. Saithe were unusually common here, with 12 examples noted, 10 from fish of 50-80cm TL and 2 from fish of 80-100cm TL. Fourteen bones could only be identified as cod, saithe or pollack, 1 from a fish of 80-100cm TL derived from sieving and covered with concretions, and the rest from fish of 50-80cm TL derived from hand collection. A further 4 fragments were only identified as saithe or pollack, all from fish of 50-80cm TL, and 2 fragments were only identified as cod family, 1 each from a fish of 50-80cm TL and 30-50cm TL. One fragment was identified as gurnard family, from a fish of 30-50cm TL. Single finds of ray family and a 15-30cm TL whiting fragment were also found in the sieved fraction. This feature was unusual in that no ling bones were identified.

Phase C6, Layer 011
A total of 12 fish bone fragments were identified. Six were from cod of 80-100cm TL and 2 were from cod of >100cm TL. Ling was represented by 4 fragments, all from fish of >100cm TL.

Phase C6, Layer 028
A single burnt haddock vertebra from a fish of 30-50cm TL was recovered from this sieved feature.

Phase C6, Pit 077
A single burnt vertebra was recovered from this sieved feature. This could only be identified as belonging to a fish of 15-30cm TL from the cod family.

Phase C6, Pit 078
This feature produced almost 500 fragments, all but 1 derived from sieving. These represented a surprisingly diverse range of taxa. Haddock were the most frequently identified species, with 38 fragments identified. Sizes included 27 15-30cm TL fragments and 11 30-50cm TL fragments. One 15-30cm TL haddock vertebra was butchered (unusual because most butchered fragments in this assemblage were from much bigger fish); 2 15-30cm TL vertebrae were burnt. Three herring fragments were recorded, as was a single fragment from the herring family. Torsk was represented by three fragments, all from fish of 50-100cm TL. Three whiting fragments were recorded, 1 from a fish of 15-30cm TL and 1 from a fish of 30-50cm TL. Three fragments could only be identified as cod family, including 1 each from a fish of <15cm TL (burnt), 15-30cm TL (crushed) and 30-50cm TL. Two salmon family fragments were identified. Single instances of the dogfish families, flatfish and the gurnard family were also noted. Two cod fragments from fish of >100cm TL were found, 1 from sieving and 1 from the hand collected fraction. Two burnt fragments could not be further identified, and a further 424 were not identified.

Phase C6, Pit 080
This feature produced 48 fish bone fragments, all derived from sieving. Haddock was the most commonly identified taxa, with 16 fragments noted, 9 from fish of 15-30cm TL and 7 from fish of 30-50cm TL. Five whiting fragments were found, 4 from fish of 15-30cm TL and 1 from a fish of 30-50cm TL. Four fragments could only be identified as cod family, 3 from fish of 15-30cm TL and 1 from a fish of 30-50cm TL. Single finds from a herring, a 80-100cm TL cod and a 30-50cm TL cod, saithe or pollack were also noted. Finally, 20 fragments were not further identified, 2 of which were burnt. Unusually for this assemblage, cod and ling were not frequent finds.

Phase C6, Spread 099
This small feature produced 9 fish bone fragments, all identified as cod. Two were from fish of 50-80cm TL, 5 were from fish of 80-100cm TL and 2 were from fish of >100cm TL. Unusually, all fragments were abdominal vertebrae.

Phase 6
Phase A6, Layer 009
A total of 24 fish bone fragments were noted, but none was identified.

Phase A6, Structure 016
A single fish bone was identified as haddock, from a fish of 30-50cm TL. This was from a sieved deposit.

Phase C7, Layer 012
Two cod fragments were identified from this small feature, 1 from a fish of 80-100cm TL and the other from a fish of >100cm TL. Three further fragments were not identified.

Phase C7, Pit 089
Two cod vertebrae were recorded, both from fish of 80-100cm TL.

Phase C7, Pit 100
A single cod bone was identified, from a fish of >100cm TL.

Phase C7, Spread 045
A total of 14 fish bone fragments were recorded from this feature. Four were identified as haddock, all from fish of 15-30cm TL. A single whiting fragment from a similarly sized fish was recorded. Three fragments could only be identified as cod family, again all from fish of 15-30cm TL. All identified fragments were vertebrae. Six fragments were not further identified.

Phase C7, Spread 071
A total of 4 fragments were identified, all cod. Two were from fish of 80-100cm and 2 from fish of >100cm TL.

Phase C7, Structure 008
A total of 5 fish bone fragments were noted. Two were cod of >100cm TL, 1 was a ling of >100cm TL, and 2 were not further identified.

Phase C7, Structure 011
A total of 43 fragments were noted, all derived from sieving. Eight haddock fragments were recorded, all from fish of 30-50cm TL. Two >100cm TL cod fragments were identified, as was a single fragment from a cod of 30-50cm TL. A total of 32 fragments were not further identified.

Phase C7, Structure 012
This feature produced a total of 8 fish bone fragments. Four were identified as cod, 1 from a fish of 80-100cm TL and 3 from fish of >100cm TL. A single ling fragment was from a fish of 80-100cm TL, and a single haddock fragment was from a fish of 30-50cm TL. Two fragments were not further identified.

Phase C7, Well 002
A total of 15 fish bone fragments were noted. A single haddock fragment from a fish of 15-30cm was identified from hand collection, and 6 fragments from this fraction were not further identified. Sieving produced 3 haddock bones and 1 cod family fragment, all from fish of 15-30cm TL, as well as 4 fragments that were not further identified.

Phase 1 or 2
Phase C1 or C2, Layer 014
This feature produced 3 ling fragments, all from fish of >100cm TL, and 2 cod fragments, 1 from a fish of 80-100cm TL and 1 that was burnt, from a fish of 50-80cm TL.

Phase 1 or later
Phase C1 (or later), Pit 005
A total of 16 fish bone fragments were recorded. Six cod fragments were identified, 1 from a fish of 50-80cm TL, 4 from fish of 80-100cm TL, and 1 from a fish of >100cm TL. Ling was represented by 2 fragments, 1 each from a fish of 80-100cm TL and >100cm TL. Finally, a single haddock bone was from a fish of 30-50cm TL, and 7 fragments were not further identified. All fragments were from the vertebral or appendicular areas of the skeleton.

Phase C1 (or later), Pit 006
A total of 130 fish bones were recorded. Cod was the most common taxa, with 32 fragments noted; 14 of these were from fish of 80-100cm TL and the remainder from fish of >100cm TL (1 of which was a complete, well preserved otolith). One cleithrum from a cod of 80-100cm TL was butchered. A total of 29 fragments were identified as ling, all from fish of >100cm TL; 2 of these were butchered. A range of element types was recorded for cod and ling. Finally, 9 haddock fragments were identified, all from fish of 50-80cm TL, and 60 fragments were not further identified.

Phase C1 (or later), Pit 007
This feature produced 48 fish bone fragments, most of which were derived from hand collection. Ling was the most common taxa, with 14 specimens recovered by hand collection, all from fish of >100cm TL; 1 dentary was pathological. A total of 7 cod fragments were found, 1 from a fish of 50-80cm TL, 5 from fish of 80-100cm TL, and 1 from a fish of >100cm TL. Single identifications were made of haddock (from a fish of 30-50cm TL) and salmon family, while 12 fragments were not identified. Sieving produced 2 >100cm TL ling fragments, as well as 11 fragments that were not further identified. One fragment was freshly broken.

Phase C1 (or later), Pit 016
This feature produced 2 fish bones, both found during sieving. One was identified as haddock, from a fish of 15-30cm TL, and the other could only be identified as cod family, from a tiny fish of <15cm TL. The latter was most likely stomach contents from a much larger fish, as it would have had little food value.

Phase 2 or 3
Phase A2 or A3, Spread 019
A total of 12 bones were recovered by sieving. Two were identified as haddock, both from fish of 30-50cm TL, 1 was identified as a fragment of a cod of 50-80cm TL, and 9 were not further identified.

Phase A2 or A3, Spread 023
Sieving produced a total of 10 fish bones. Haddock was the most common taxa, with 3 fragments identified, 1 from a fish of 15-30cm TL and 2 from fish of 30-50cm TL. A single whiting fragment was identified from a fish of 30-50cm TL, and a burnt flatfish family fragment was also noted. An additional 5 fragments were not identified.

Phase C2 or C3, Layer 019
This feature produced a total of 52 fish bones. Cod was the most common taxa, with 31 fragments noted, 16 from fish of 80-100cm TL and 15 from fish of >100cm TL. Two of the >100cm TL abdominal vertebrae were butchered. Ling was represented by 12 fragments, all from fish of >100cm TL. A single bone was only identified as saithe or pollack, of 80-100cm TL. A further 8 fragments were not identified.

Phase 2 to 4
Phase A2 to A4, Spread 034
This feature produced a small assortment of 13 fish bones, all recovered by sieving. Four were identified as haddock, all from fish of 30-50cm TL, and 1 was identified as whiting, from a fish of 15-30cm TL. The remaining 8 fragments were not identified.

Phase C2 to C4, Spread 006
Two fish vertebrae were identified, 1 cod and 1 ling, both from fish of >100cm TL.

Phase 3 or 4
Phase A3 or A4, Spread 017
A single ling bone was identified, from a fish of >100cm TL.

Phase C3 or C4, Layer 017
Three fish bones were identified, 2 cod from fish of 80-100cm TL, and 1 ling, from a fish of >100cm TL.

Phase 4 or 5

Phase C4 or C5, Spread 068
A single burnt fish bone was recovered by sieving. This was identified as haddock, from a fish of 30-50cm TL.

Phase C4 to C6, Layer 036
A single cod bone was identified, from a fish of >100cm TL.

Phase C4 to C6, Layer 041
A total of 31 fish bones were recovered. Cod was the most common taxa, with 15 fragments noted; 10 were from fish of 80-100cm TL and 5 were from fish of >100cm TL. Ling was represented by 5 specimens, 1 from a fish of 80-100cm TL and the remainder from fish of >100cm TL. An additional 11 fragments were not identified.

Phase C4 to C6, Spread 085
Three cod bones were identified, 1 from a fish of 80-100cm TL and 2 from fish of >100cm TL. An additional 6 fragments were not identified.

Phase 4 or later

Phase C4 or later, Pit 063
A total of 10 fish bones were identified. Ling was represented by 4 fragments, all from fish of >100cm TL; cod was represented by 3 fragments, all from fish of 80-100cm TL, and a single haddock was represented by a fish of 50-80cm TL. An additional 2 fragments were not identified.

Other

A few contexts were classed as unstratified, modern or disturbed, termed 'other' in summary tables. These represent a very small portion of the assemblage and include fish typical of the overall pattern found at Bon Accord.

Modern and/or disturbed contexts account for 274 of these bones, most derived from hand collection. Cod was the most common taxa, accounting for almost all of the 249 identified specimens, with a few finds identified as haddock, ling, whiting and cod family. Unstratified contexts account for an additional 22 fragments, all hand collected. Again, cod was the most common taxa, with a few ling and haddock identified. Three cod bones were identified from a context that was probably labelled incorrectly, as the context number does not match any in the records.

The size ranges represented are consistent with the recovery methods and the rest of the assemblage. Nine cod bones were butchered, and again all were consistent with butchery seen in the rest of the assemblage, suggesting that this material was probably not of modern date.

Taphonomy

The fish assemblage from Bon Accord was well preserved, with few alterations. Basic taphonomic information was recorded for all QC1 and QC4 elements, while any fragments with other, more unusual taphonomic alterations were noted (Table 5 for hand collected fish; Table 6 for sieved). Overall, almost three quarters of the assemblage scored a 'good' texture, with much of the remainder scored as 'fair'. Fragmentation was more variable; many incomplete fragments were recovered, with only about a third of the assemblage being 80-100% complete. Some variation reflected changing taphonomic patterning through time. In Phase 1, hand collected fragments tended to be better preserved and more complete than in later phases. In turn, Phase 3 was less well preserved than Phases 1 or 2, in terms of bone

texture, but little difference in fragmentation was noted between Phases 2 and 3. However, these differences are not considerable, and are likely to have had a minimal impact of the analysis of the assemblage. The small nature of the sieved assemblage made it difficult to judge temporal variation, but results are broadly consistent with the hand collected material.

Other taphonomic alterations were recorded when noted. Burnt fish bones were the most common of these, with 74 examples found. Sieving was much more likely to identify burnt fragments of fish bone, as these naturally tend to be highly fragmented and small; 70 burnt fragments were found by sieving alone, representing 3.3% of the sieved fraction. Over half of the burnt fragments could not be identified, but those that were tended to be the minor species, including haddock, whiting, flatfish and herring – rather than the cod or ling that formed the majority of the fish consumed at Bon Accord. This could suggest different cooking practices for the smaller, infrequently consumed species. Burnt fragments were both calcined (burnt white) and charred.

Carnivore gnawing was present throughout most phases, but at a very low level. A few crushed fish bones were also noted; these may have been chewed by either humans or animals. This low incidence suggests little scavenger activity around the material. The numerous articulating elements and the 2 complete and partial ling crania confirm that this material was not badly disturbed after deposition. This material is also unlikely to have been from cess pits. The large size of the fish bones makes them highly unlikely to have passed through digestive systems of humans or animals, and this can be confirmed by the low incidence of chewed bones.

A few examples of coloured staining were observed, including blue-green and red-brown colours, probably just reflecting close proximity to metal objects. Concretions were also noted on a few fish bones in several of the phases. An extreme example of this is illustrated below in Figure 1, showing a large, amorphous concretion built up around 2 cod vertebrae. The cause of these is unknown, but probably relates to the burial matrix.

Fresh breakage was minimal, with only 6 examples recorded for the entire assemblage, indicating excellent excavation, processing and curation. Half of these examples were found in a small, final batch of fish bones sent separately by post, and which may have been more roughly treated than the rest of the assemblage.

Results

Each feature was attributed to an area-dependent phase during initial post-excavation analysis, as listed above in the summary by phase and feature section. These individual phases (e.g. A1, A2) have then been grouped into major site-wide phasing (e.g. Phase 1), which has been used throughout this results section in order to explore temporal patterning at Bon Accord. Phasing concordance is provided in Table 3, along with approximate dating for each phase. The discussion that follows draws upon the 6 main phases, as their chronology is better understood. The minor features that span multiple phases are only discussed if relevant. Only 2 of these minor phases contained significant quantities of identified bone: ‘Phase 1 or later’ produced 106 identified bone fragments, and ‘other’ features produced 271 identified fragments. As neither of these minor phases could be dated at all, they have therefore been left out of the general discussion unless individual specimens warrant description.

Taxonomic diversity

The assemblage from Bon Accord was taxonomically diverse, with 27 different species or species groups recorded. However, the vast majority of the remains were from the cod family,

including cod, ling and haddock, with trace quantities of a variety of other fish, including flatfishes, dogfish and rays, herring, salmon and trout family fish and gurnards.

The hand collected assemblage comprised almost 4000 identified bones, and was dominated by cod (69%), ling (26%), haddock (2%) and saithe (1%) (Table 7). A range of other taxa was present, but each accounted for less than 1% of the identified fragments. These included, in rank order and including fragments that could only be identified to broad taxonomic grouping: the halibut family, cod/saithe/pollack, cod family, saithe/pollack, plaice, flounder/plaice, ray family, salmon and trout family, pollack, gurnard family, turbot family, turbot and halibut.

The sieved fraction produced a total of 428 bones that could be identified. Again much of these were from the cod family, but with more of an emphasis on the smaller fish. Haddock was the most common species (48%), followed by cod (20%), ling (8%), whiting (6%) and cod family (6%). Other taxa accounted for less than 15% of the sieved fraction. These included, in rank order: Atlantic herring, halibut family, gurnard family, sand eel family, ray family, salmon and trout family, torsk, cod/saithe/pollack, plaice, dogfish families, herring family, carp family, saithe, pollack, poor cod, sea scorpion family, flounder, flounder/plaice and sole family.

Variation between the main phases is summarised in Table 9, for both recovery methods. Looking only at hand collection, there is a shift from a primary focus on cod in Phase 1, towards increasing numbers of ling in Phases 2, 3 and 4. During this time cod decreased from 85% of the identified assemblage in Phase 1, to 59% in Phases 2 and 3, to 46% in Phase 4. Ling increased from only 13% in Phase 1, to 36-37% in Phases 2 and 3, to 50% in Phase 4. Other cod family fish were of little importance until Phase 5, when haddock and saithe increased from trace levels to 17% and 13% respectively – making a significant contribution to the diet for the first time. Ling was much reduced by Phase 5, representing only 7%.

Turning to the sieved fraction, quantities are smaller so conclusions must be more generalised. However, it is apparent that cod decreased in importance through time, from about half of all identified fish in Phase 1, to 42% in Phase 2, 5% in Phase 3 to 3% in Phase 5. At the same time, haddock increased from less than a fifth in Phase 1, 19% in Phase 2, 84% in Phase 3 to 63% in Phase 5. Ling were present in quantity in Phases 1 and 2, but only a single identification was made in Phase 3, and none was found in later phases. Whiting were found at low levels throughout the sieved fraction, increasing to 8% in Phase 3 and 9% in Phase 5. Herring represented 7% of the identified fish in Phase 2, and 4% in Phase 5, but was clearly not a major component of the diet here.

A range of flatfishes were found by both hand collection and sieving. These tended to be more common in Phases 1 and 2, but overall, few were found. These are difficult to identify to species because of similar morphology, but the majority were halibut family, probably flounder or plaice.

Many of the fish that could only be identified as cod family were small, mostly from fish of less than 30cm total length, and many from fish of less than 15cm total length. These have little value as food, but instead can be common stomach contents of the larger fish, including cod and ling. The sand eels and herrings may also fall into this category. However, although occasional stomach contents may be represented in this assemblage, there is not enough material to suggest fish were routinely being gutted and the guts discarded at Bon Accord.

While most of the fish found at Bon Accord were fished from the sea, a few finds point towards the possibility of freshwater fishing. A few salmon or trout were found in Phases 1, 2 and 5. These may indicate fishing on the Dee or Don rivers, both of which flow into the sea at Aberdeen. However, salmon and trout are anadromous species, and thus could have been

caught at sea. The single carp family identification in Phase 2 is difficult to explain, but roach – one of the hardier members of this exclusively freshwater family – was likely present in southern Scotland before the present day and thus this example could represent a northern outlier (Wheeler 1977; Froese and Pauly 2010). Estuaries may have been fished, as they can be a source of some flatfish (including flounder and dab) as well as trout, but these species can also be caught in saltwater (Froese and Pauly 2010).

Fish sizes

All QC1 cranial elements were sized during recording, using reference comparanda to record broad ordinal categories. These results are summarised in Table 12 for the hand collected fraction, and Table 13 for the smaller sieved fraction. These broad size categories capture general trends through time and space. Metrical analysis of certain taxa and elements allows a more detailed examination of statistically reconstructed total lengths, but these are based on much smaller datasets and thus provide less of an overall picture.

The Bon Accord assemblage is dominated by very large fish, predominantly cod and ling of at least 80cm in length. Overall, almost half of the hand collected cod recovered were sized between 80-100cm total length, and half were over 100cm total length. Even considering that this assemblage is slightly biased by the large quantity of hand collected material, a similar pattern can be observed in the sieved fraction: there, almost 60% of all cod were between 80-100cm total length, and a third of all cod were larger than 100cm total length. Over time, the proportion of very large cod of over 100cm total length increased between Phase 1 to Phase 3, rising from 45% in Phase 1 to 60% in Phase 3. The final three phases were smaller in quantity, but Phase 4 appeared to continue the trend towards capture of very large cod of over 100cm total length. However, in Phase 5, about three quarters of all cod were between 80-100cm total length, with only a few larger or smaller cod fished. The smaller sieved fraction mirrored the hand collected size categories, but with a few smaller cod present in most phases; these smaller individuals ranged from 15-30cm to 50-80cm total lengths, and probably represented occasional use of different fishing grounds.

Modern reference collections seldom contain very large fish of known length, because they are so rare today – making it difficult to fully appreciate the large sizes of the Bon Accord cod and ling. Some of the cod bones were estimated as representing individuals about 150cm long, based only on experience of cod identification. Most of the Bon Accord ling were substantially larger than any found in the reference collection, despite examining several modern individuals of c.80-100cm total length. Using regression equations determined by measuring modern fish of known length, it is possible to explore the cod sizes in detail. Using the two most frequently measured elements, the premaxilla (M3) and the dentary (M1), size histograms were generated and displayed in Figure 2 (measurements defined in Harland *et al.* 2003; regression formulas follow Jones 1991). Using this method, it is apparent most cod were between 80 and 140cm total length, with a peak between 100-120cm total length. The small quantities measured make it difficult to explore temporal changes, but there does appear to be a slight increase in sizes through the first three phases.

The ling found at Bon Accord were exceptionally large. Almost all were at least 100cm total length, regardless of recovery method. Based on experience alone, these probably ranged up to 150cm total length, and occasionally longer, but reference comparanda were insufficient to investigate size variation in any greater detail. Today ling are known to reach 200cm total length, though more commonly they reach sizes of about 100cm total length (Froese and Pauly 2010).

Fish lengths can be determined relatively easily, but it can be more useful to get an estimate of weight in order to assess food value – but the is only a loose correlation between fish lengths and weights. That said, even by rounding to the nearest kilogram, it is possible to estimate weights for some of these fish. A modern cod of about 90cm total length would have

a gutted weight of about 7kg (Yoneda and Wright 2004, 239, 241). Extrapolating from the same study, a cod of about 100cm could have a gutted weight of about 10kg, a cod of 110cm about 13kg gutted weight, and a cod of 120cm about 17kg gutted weight. The large ling found at Bon Accord would likely have been even heavier still. A similar study of ling indicated that a fish of 140cm total length would weight about 16.5kg; allowing for gutting would still produce a substantial weight of food (Jennings *et al.* 2001, Table 3). Ling can sometimes reach lengths of 200cm, with an ungutted weight in the region of 45kg (Froese and Pauly 2010). These substantial weights indicate that cod and ling provided the vast majority of food in Phases 1, 2, 3 and 4, with other taxa only contributing a small amount of variety in the diet.

Haddock are naturally smaller than cod or ling, and the sizes found at Bon Accord were accordingly smaller, with just under half of the hand recovered haddock of 30-50cm total length and the other half of about 50-80cm total length. The sieved fraction presents a different picture. About a third of the sieved haddock were 15-30cm total length and two thirds 30-50cm total length, with few haddock of larger size recovered by sieving. These differences are difficult to reconcile: hand collection is obviously biased towards recovery of larger fish, but equally, the sieved samples contain none of the larger fish that would be expected. Closer investigation indicates C3 Layer 005 is responsible for much of this difference. Sieved deposits from this layer account for almost all the Phase 3 haddock, almost all from fish of 30-50cm total length. Leaving aside this unusual feature, the differences between recovery methods are less noticeable: to summarise, a range of haddock sizes were exploited, including quantities of smaller fish of less than 50cm total length, suggesting a different fishing strategies and consumption patterns than observed for cod and ling.

Some sizes ranges were available for the minor species. Saithe of 50-80cm total length and 80-100cm total length was found in moderate quantities in the hand collected assemblage, along with a few larger individuals. Sizes tended to be larger in the earlier phases: Phase 1 and 2 contained saithe of at least 80cm total length. By phase 5, saithe tended to be smaller, with most between 50 and 80cm total length. No saithe could be sized from the sieved fraction, suggesting there was no emphasis on catching smaller saithe; the plentiful inshore fishery for small saithe was therefore unlikely to have been a target for the Bon Accord markets.

A few whiting were found and sized in the sieved fraction; all were less than 50cm total length. Whiting are naturally smaller than cod, ling or haddock (Froese and Pauly 2010), and may have been missed during hand collection. The smaller ones of less than 30cm total length were predominately found in Phase 3 and Phase 5, and were likely caught in shallow, inshore waters (Froese and Pauly 2010).

Two pollack from the hand collected fraction could be sized, indicating 1 individual was 50-80cm total length, and the other 80-100cm total length. These are compatible with cod sizes, and may have been bycatch (incidental catch when targeting a specific species).

Sizes were recorded for a few other specimens. Most identified as cod family were small, tending to be less than 30cm total length, and thus could be stomach contents from the much larger cod family fish. A single flounder bone from Phase 1 was from a fish of 15-30cm total length, while a flounder or plaice from the same phase was sized at 30-50cm total length. Two gurnard family specimens were both sized at 15-30cm total length (a typical length for gurnards (Froese and Pauly 2010)), 1 each from Phase 2 and Phase 5. The 3 torsk fragments from Phase 5 were from a fish of 50-80cm total length, and all were most likely from the same individual.

Element representation and fish preservation

A select subset of elements was identified in full, comprising 18 elements from the cranial and appendicular (shoulder) region (QC1 elements), all vertebrae (QC2 elements), and unusual elements like otoliths and dermal denticles (termed QC4). Counts for cod, ling and haddock are provided for the major phases in Table 11. Counts for the minor taxa are provided in Table 14 for completeness, but are not discussed further as few conclusions could be drawn from the small quantities identified.

The hand collected assemblages for cod and ling are dominated by vertebrae. This is to be expected, because the vertebrae are plentiful, large, robust and easily identifiable elements. One cod contains between 46 and 56 vertebrae, while a single ling contains between 60 and 66 vertebrae (Barrett 1997 and personal experience of reference material), accounting for their frequency of identification compared to cranial and appendicular elements. Hand collection will miss the smaller and more fragile elements, including the last few small caudal vertebrae and the scapula and infrapharyngeal. Otoliths can often be missing, because of their small size, their calcium-carbonate composition, and because they are sometimes misidentified as shell. Despite these biases, it is possible to detect some general trends through time.

Phase 1 contains a high proportion of cod vertebrae, compared with cranial and appendicular elements. Cod vertebrae represent 89% of all hand collected cod in Phase 1, compared to an average of 69%. This is unlikely to simply reflect a recovery bias, because cod vertebrae represent 76% of the sieved, identified cod in Phase 1 as well. Nor is this a reflection of poor recovery compared to later phases, because Phase 1 cranial and appendicular elements tended to be better preserved than in later phases. In Phase 2, cod vertebrae no longer appear over-represented. However, cleithra do appear in greater than expected quantities, with 101 found by hand collection. The cleithrum is a very large appendicular element found at the back of the head, at the 'shoulder' of the fish. Despite its size, it is fragile and fragments easily, and thus would not be expected in high quantities compared to robust elements like the articular, dentary or premaxilla. The ling in Phase 2 may also contain slightly elevated numbers of cleithra.

Although many of the fish taxa found at Bon Accord were likely deposited in their entirety, as seen by the wide variety of head and body elements, it appears that some cod and ling body parts may be over- or under-represented. When cod and related species, including ling and haddock, are preserved by air drying or by a combination of salting and drying, the head and some of the anterior vertebrae are removed and discarded at the production site. The remaining elements are exported with the preserved flesh and end up discarded during cooking or consumption. These include the cleithra and associated elements from the appendicular region, as well as the more posterior vertebrae (Barrett 1997; Harland 2006). When no other head elements are found, aside from the appendicular region, and the remains are from large fish, it is most likely these remains were once preserved, imported fish. This can be confirmed by distinctive butchery patterning, as discussed in more detail below.

In order to investigate element proportions in greater detail, it is necessary to take into account the number of each element in the body. Element fragmentation must also be considered, because a single element can fracture into several recognisable parts and could thus be recorded multiple times. During recording, a diagnostic zone system is applied, following a predefined system of zones. Each zone is only recorded if greater than half of it is present; a zone cannot therefore be recorded more than once. Results are presented in Figure 3, showing the minimum number of elements (MNE) statistic, calculated for each element. These are displayed for Phases 1 and 2, as they contained sufficient quantities of fish, and they are divided by size group.

Phase 1 is indeed dominated by cod vertebrae. At a rough estimate, for every 1 cod head present, there are the remains of at least 6 cod bodies. This holds true for both cod of >100cm

total length and cod of 80-100cm total length. Ling heads and bodies were found in more equal proportions. If this phase contained the bodies of fish that had been imported as a prepared product, then a correspondingly high proportion of appendicular elements would be expected, but is *not* observed. These cod are therefore unlikely to represent imported, prepared fish. However, butchery patterning will explore this option in greater detail below.

Detailed investigation of features within Phase 1 indicates C1, Pit 015 is responsible for the unusual proportions of cod. Contexts 11351, 11354, 11357, 11398 and 11399 all contained a much higher proportion of vertebrae than usual. The small proportion of sieved bones from this feature shared the element patterning, indicating this a real depositional pattern, not one determined by selective hand collection. Pit 015 was of unusual depth, which "suggests that it was not a simple refuse pit", and may have provided drainage functioning ('Phasing Notes' document). It is possible that fish vertebrae were selectively chosen to aid drainage, like the placement of coarse gravel in a modern French drain. Or, this accumulation of vertebrae could be the result of cooking processes removing the vertebrae from fresh or prepared fish, and disposing of them differently. However, the other contents of the pit need investigating before this hypothesis can be explored further.

Phase 2 cod and ling appear to have approximately equal proportions of heads and bodies. Cleithra counts were high for this phase, but once fragmentation has been taken into account, we can see that appendicular elements are found in proportion with cranial elements. These remains likely represent fish eaten when fresh – not preserved – and disposed of in their entirety at Bon Accord.

The MNE figures provide some indication of the quantities of cod and ling found at Bon Accord. In Phase 1, there were at least c.30 cod of over 100cm total length, another c.30 of 80-100cm total length, plus at least c.9 ling. In Phase 2, there were at least c.22 cod of over 100cm total length, c.15 of 80-100cm total length, and c.20 ling. These quantities represent a minimum, and must be used cautiously. Using the rough weight estimates as a very conservative guide to the potential minimum food value, Phase 1 includes at least 600kg of gutted cod and at least 135kg of gutted ling. In Phase 2, at least 390kg of gutted cod and at least 300kg of gutted ling were present. These calculations represent the minimum weight present in these 2 phases, and it is highly likely the weight of fish was actually much higher.

Butchery

A total of 185 fish bones were butchered, mostly cod and ling and mostly from the early phases. All but 8 were from the hand collected material, so in the following discussion, no distinction will be made between recovery methods. Fish can be butchered to aid long-term preservation and storage, and/or they can be butchered during food preparation and consumption. The large size of most of the Bon Accord fish makes them very unlikely to have been cooked whole – butchery must have been necessary to divide the fish into manageable portions, regardless of whether they were preserved or freshly caught. Each process can leave a different type of butchery signature, so detailed descriptions of butchery type and location were made during recording. Descriptions refer to the various anatomical planes: 'sagittal' divides the body of the fish into left and right portions, 'transverse' divides the body into front and back portions, and 'frontal' divides the body into upper and lower portions. 'Anterior' refers to the front of the fish, 'posterior' the tail, 'ventral' the belly and 'dorsal' the back. 'Chop' marks are coarse, deep and broad, often dividing the bone in two, while in contrast, 'knife' and 'cut' marks are narrow and shallow. Most butchery marks were quickly sketched on paper, and additionally, several butchery marks were photographed as descriptions are not always straightforward.

A total of 131 cod bones were butchered, including cranial, appendicular and vertebral elements and representing 5% of all cod bones. Phase 4 has the highest proportion of butchery, with 11% of all cod bones containing some type of butchery mark. Three distinctive

groups of butchered elements can be observed. Firstly, the vertebrae were the most commonly targeted elements, which is perhaps unsurprising as they are plentiful and are surrounded by the most edible parts of the fish. However, the elements around the mouth were often butchered at the medial articulation, including the dentary (lower jaw) and the premaxilla and maxilla (both found in the region of the upper jaw). Finally, a third group of butchered elements can be distinguished. These comprise the appendicular elements, particularly the commonly-occurring cleithra, which is typically associated with fish processed for long-term preservation.

Vertebral butchery was the most common type of butchery mark for both cod and ling, representing just under half of all butchered cod and about 65% of butchered ling. These can be categorised into two broad types: chops or cuts to divide the bone into left and right sides along the sagittal plane, and chops or cuts that divide the bone into front and back in the transverse plane. There were a total of 58 examples of sagittal butchery, 30 of transverse, with some other examples in the frontal plane, with butchery marks in several planes, or that could not easily be classified. These tended to be found on abdominal vertebrae or occasionally the anterior caudal vertebrae, which simply reflects the predominance of these elements at Bon Accord, rather than any real patterning; the smaller posterior caudal vertebrae were underrepresented because of hand collection. Phase 1 contained 23 examples of sagittal butchery and 7 of transverse, but in Phase 2, quantities were more equal with 20 and 18 examples respectively. Remaining phases contained a few examples of each type, but numbers were insufficient to fully explore patterning.

Sagittal chop marks found on vertebrae were often angled towards the posterior of the fish, as illustrated by 6 examples from Phase 1, C1 pit 015 (Figure 4). In most cases the chop split the vertebral centrum, removing a wedge shape of the left, posterior part of the centrum. Similar examples were found in most phases, although occasionally an anterior part of the vertebra was removed. An example from Phase C2, Spread 043 (Figure 5) shows an unsuccessful chop that did not fully extent through the bone. In all cases where some degree of directionality can be observed, these butchery marks all appeared to be coming from the posterior towards the anterior. Sometimes these chops removed the left processes, but did not cut into the vertebral centra (Figure 6), and sometimes, it was possible to reconstruct small sequences of vertebrae where a chop had cut into two or more adjacent centra (Figure 7). In Phase 1, these sagittal chops were only found on cod of 80-100cm total length (and none on any ling), but in Phase 2 and later, they were almost entirely only found on larger cod and ling of at least 100cm total length – despite both phases having plenty of each size of cod. Both abdominal and caudal vertebrae displayed this butchery pattern.

Sagittal knife marks were also found on cod and ling vertebra throughout all phases. These tended to be found on the left and right processes that extend away from the vertebral centra (Figure 8 and Figure 9) or on the neural spines (Figure 10). These were more likely to be found on both the left and right side of the fish, and in cases where directionality could be established, knife marks originated on both dorsal and ventral aspects of the fish. This type of mark was observed primarily on cod and ling abdominal vertebrae of over 100cm total length.

Transverse chop marks were found on cod and ling in Phases 1 and 2, with 2 further examples noted in Phase 4. These chops sometimes removed the anterior or posterior articular facets (Figure 11), or were found on the ventral surface (Figure 12). When directionality could be established, these chops always originated on the ventral aspect. An example from Phase 4 indicates some were butchered on the left side as well (Figure 13); one similar example was observed in Phase 2. These were found on both abdominal and caudal vertebrae, but almost all were from fish of greater than 100cm total length.

Transverse knife marks were not as common, and were only observed in phases 1 and 2. These small knife marks were found on either left or right side, or on the ventral (underside)

of the vertebra (Figure 14). They were found on a variety of sizes and elements. The 'classic' indicator of preserved cod, ling or haddock is a small transverse knife mark on the side of the vertebral centrum, caused when removing the anterior vertebrae and the head prior to air drying (Barrett 1997; Harland 2006). A few poorly executed examples were noted on cod and ling abdominal vertebrae, but the only good example of this practice was found in an unstratified phase (Figure 15).

Butchery in the frontal plane was found throughout all phases, on cod and ling of a variety of sizes. They were found on both left and right sides, and most were very small knife marks not extending far into the bone. Most were found on the neural arch or processes, rather than on the vertebral centrum. An exception is illustrated in Figure 11, where a sequence of articulating ling basioccipital, first vertebra, and anterior abdominal vertebra were subject to multiple butchery marks. These were probably caused during head removal.

In addition to the articulating sequence illustrated in Figure 11, a sequence of 8 ling vertebrae were found with butchery extending across several elements. These 8 comprised abdominal and caudal vertebrae from a ling of over 100cm total length. The final caudal vertebra was chopped in the transverse plane, removing a wedge of posterior, dorsal centrum. All 8 vertebrae have a series of knife marks running along the right side in the frontal plane, on both dorsal and ventral aspects. These cut into the neural arches and anterior processes, but were mostly very shallow.

Vertebral butchery marks probably represent different stages of food preparation. At Bon Accord, the prevalence of large chop marks that cut through the bone probably indicate these very large cod and ling were reduced into manageable sections. Throughout all phases, cut and chop marks were about twice as likely to be on the left side of the fish, rather than the right. This could related to handedness of the butchers, and/or a consistent method of butchery. The repetitive nature of many of the coarser butchery marks probably reflects standard, set methods of butchery. There are some changes through time: sagittal chops were initially restricted to cod of 80-100cm total length in Phase 1, but from Phase 2 onwards, this method tended to be used for bigger cod and ling of over 100cm total length. This method would have divided the fish into left and right halves. Transverse butchery was used throughout and would have created segments like 'steaks' of cod and ling. The fine knife marks in various anatomical planes could result from removing the flesh from the bones either just prior to cooking, or during eating. These fine marks don't follow the set patterns of other butchery marks, which could imply they were done in the home setting, by people who weren't butchers. Taken in conjunction with the element patterning, there is little evidence to suggest fish had been preserved using the typical methods seen in the Northern Isles or Scandinavia. That said, there is nothing to rule out occasional consumption of prepared, dried fish – but this was not a routine occurrence.

Head removal left a distinctive pattern on the bones, as previously illustrated in Figure 11. Examples were found throughout most phases, but numbers were insufficient to determine any methods. Several ling and cod basioccipitals, first vertebrae, successive anterior abdominal vertebrae and parasphenoids were chopped in transverse, sagittal or diagonal planes. Some displayed multiple cuts – but as the bone is very thick at the junction with the head, this is not unexpected. Other cranial elements were generally not found butchered, suggesting that if heads were used, they were used whole (perhaps boiled) or discarded whole.

Elements from the mouth were commonly butchered in all phases, for both cod and ling. Cod dentaries (the pair of toothed elements making up the lower jaw) were almost exclusively butchered in approximately the sagittal plane to remove the medial, central articulation, a trend found throughout Phases 1 to 4 (Figure 16). Several of these cuts remove only a slight sliver of the central area, while others removed more of the bone. The presence of fainter parallel marks indicates that some of these chops originated inside the mouth and cut

outwards, and some have been made from ventral towards dorsal (Figure 17, Figure 18). The cod premaxillae butchery patterns matched those of the dentaries, as expected given that the premaxillae are a pair of toothed elements making up part of the upper jaw. All were butchered in approximately the sagittal plane, and most had the medial, central articulation removed (Figure 19). Again, these were butchered from posterior towards anterior – from inside the mouth towards outside (Figure 20). Two only had the lateral edge removed by sagittal chop or cut, and these were from Phases 3 and 4 – rather than Phases 1 or 2, hinting at changes through time. Both left and right dentaries were butchered, but of the 10 butchered cod and ling premaxillae, 9 were from the right side of the fish. Three maxillae (the pair of elements forming part of the hinge mechanism of the upper jaw) were also butchered at the medial articulation, probably matching the butchery pattern observed on the premaxillae and dentaries. These were observed in Phases 2, 3 and 5.

Ling butchery to the mouth matched the cod pattern, though there were fewer examples. Three dentaries were butchered, all in the sagittal plane removing a small slice of the medial articulation; all were from Phase 2. A single premaxilla was butchered in the same way, also from Phase 2.

Sagittal butchery around the midline of the mouth region is not unknown in other medieval sites with large cod and ling remains; several examples have been recorded from medieval deposits in York and continental Europe (Harland and Jones In prep.). However, they are not fully understood and are rarely discussed in print. It is possible that it is associated with hook removal, or removal of the tongue. Based on the author's experience of catching and butchering smaller modern cod and ling, these explanations are unlikely: hooks are caught in a variety of places around the mouth and face, and the tongue can be extracted through the soft flesh of the underside of the chin. There is some flesh around the mouth, cheeks and tongue that would be edible, so maybe this was being targeted. If the heads were being split along the sagittal plane, then further cranial elements should have displayed some butchery. As this was not the case, it appears that only the mouth region was of interest.

The final major area of butchery was the appendicular region, including the cleithra, supracleithra and posttemporals. Cleithra are the large pair of elements at the back of the head, and they survive well and are easily found during hand collection; in contrast, the small supracleithra is likely to be slightly under-represented at Bon Accord. These elements commonly stay in preserved fish and are deposited at consumer sites, rather than remaining with the crania at producer sites. In such contexts, the cleithra are often butchered with knife or chop marks, either from production of the preserved product, from long-distance storage and shipping, or during soaking and butchery immediately prior to consumption. At Bon Accord, there is no immediate evidence that preserved cod or ling were consumed in any quantity – given the relatively balanced element representation – but the prevalence of butchery marks to the cleithra needs exploring further. Butchered cleithra were found in Phases 1, 2 and 3, and represented 12% of all cod cleithra and 14% of all ling cleithra.

Only 2 examples were found in Phase 1. Both were ling, and both were butchered in the sagittal plane with small knife marks or removing small slivers of bone. In Phase 2, an entirely different type of butchery was observed: cleithra were most frequently butchered using a chop in the frontal plane to separate dorsal from ventral (Figure 21). In some cases, the butchery did not fully extend through the bone (Figure 22), or was at a diagonal angle. A single example from Phase 1 (or later) comprised a cod cleithrum, butchered in the frontal plane leaving only the dorsal tip. The cut did not extend fully through the bone so the separation was completed by twisting, and bending the bone when it was fresh. Smaller knife marks were also found in Phase 2, on the medial and lateral sides or on the anterior edge (Figure 23). These were again commonly in the frontal plane, but otherwise displayed little obvious patterning. Similar frontal butchery was observed on a few examples from Phase 4, while a single ling cleithra in Phase 3 was butchered in the sagittal plane. Both left and right

cleithra were found butchered. A few cod and ling supracleithra and a single posttemporal were also found butchered, all from Phase 2. These commonly displayed small knife marks (Figure 24).

Interpretation of the cleithra butchery is difficult. Small cuts to the dorsal tip on the lateral (inner) side may have been made when filleting the fish (based on person experience by the author), and the one example from Phase 1 (or later) confirms that this was probably done when fresh. Small knife marks to other regions are more difficult to interpret, but could relate to skinning or removing the cleithra from the fillet. Chops in the frontal plane are more difficult still. If the cleithra were left with the flesh – as they naturally form the leading edge of fillets – then the large size may mean that they needed to be chopped to facilitate cooking. Or, they were simply butchered along with the vertebrae to reduce these substantial fish into portions suitable for individual or household use. It is possible that a few of these cleithra may have been arriving as prepared, preserved fish (although overall, most fish were consumed fresh and deposited whole). Contemporary material from York indicate that a greater variety of butchery was observed on cleithra that were definitely associated with a long-distance trade in preserved fish.

Two haddock bones were butchered. One was a caudal vertebra from Phase 5 which was repeatedly chopped in the sagittal plane. This was from a small fish of 15-30cm total length, so it was probably being butchered to remove the tail prior to cooking. The second butchered bone was a cleithra from Phase 2, which displayed 3 knife marks in the frontal plane on the anterior edge. This was a fish of 30-50cm total length, so although much smaller than the cod and ling from this phase, it was still butchered using a similar method.

Finally, 1 butchered bone could only be identified as cod family, and was a branchiostegal ray with 2 small knife marks. There is no obvious reason for this area to be butchered, as there is little flesh associated with the lower sides of the throat region.

In summary, the very large cod and ling from Bon Accord were commonly butchered. This was most likely done to reduce these large fish into manageable portions for cooking. Chop marks indicate that the coarser butchery followed a systematic, repeatable method with some changes through time, which would suggest this primary butchery was undertaken by professionals. Finer knife marks didn't follow routine patterns, implying that they were the remains of food preparation or consumption at the domestic level. There was little evidence to indicate cod and ling had been preserved and imported (or exported) on a large scale, a conclusion that matches the element patterning evidence.

Pathologies

The Bon Accord assemblage produced a surprising number of pathological specimens (summarised in Table 17). The study of fish diseases and injuries from archaeological assemblages is not as advanced as that of the domestic mammals, making description and interpretation difficult. The presence or absence of fish pathologies doesn't reveal information about farming practices or diet and nutrition of livestock, making them less likely to be discussed in the literature, but this important aspect of fisheries history should not be ignored.

A total of 42 fish pathologies were identified at Bon Accord, as well as an almost entire articulated ling cranium with multiple instances of pathologies; counting the articulated cranium as 1, these represent 0.5% of the entire fish assemblage, or 1% of all identified fragments – a considerable proportion. In comparison, at the Viking Age and medieval site of Quoygrew in Orkney, where the author analysed over 85,000 fish bones, less than 0.03% were pathological; at Viking Age and medieval deposits in York, less than 0.02% of the 22,000 fish bones examined by the author were pathological.

The Bon Accord pathologies can be divided into two broad groups. Firstly, there are a number of instances of wear and tear related to ageing. These are arthropathies, or joint diseases, and this categories includes several splayed and fused vertebrae. Vertebrae are the most numerous of any element within an individual fish, and pathologies can extend across several vertebrae, which may account for their high frequency. Also included in this category are several cranial or appendicular elements with polished articular facets, new bone growth, or pitting, much as could be seen in an assemblage of older or hard-worked domestic mammals. The second group of pathologies are more difficult to explain and may relate to illnesses, stresses or cancerous growths. These include large lumps of amorphous bone growth on otherwise normal looking elements, or severe malformations and lesions like those found in several places on the almost complete articulated ling cranium. These tend not to be located on joints or articulations, and thus are less likely to result from wear and tear.

Typical of the first category of pathologies is the unusually large cod quadrate from Phase 2 (Figure 25). This animal was probably approaching 1.5m in length and was therefore a very old individual (Froese and Pauly 2010). The quadrate has a highly polished, grooved and worn articular facet suggesting long years of use. Similar eburnation can be found on articular facets of older domestic mammals. Other examples include a cod maxilla with wear and polishing to the medial articulation (Figure 26), and a cod maxilla with bone loss and reshaping to the medial articulation that might relate to joint disease (Figure 27). A few dentaries have pathological alterations to the medial articulation, possibly relating to joint disease (Figure 28 for ling and Figure 29 for cod; Figure 30 has similar alterations along with a possible tooth abscess). Two cod dentaries have remodelling and new bone growth on the inside of the mouth (Figure 31 and Figure 32), which could be related to healing following injury to the mouth; these are possibly even associated with escaping from fish hooks which have damaged flesh and bone. Tentatively included in this category is the ling maxilla illustrated in Figure 33, where the middle of the maxilla displays 'peeling' exposing inner layers of bone, as though injury or infection at the or in the bone has caused remodelling.

Numerous vertebrae have been distorted or remodelled, and these are included in this first category of pathologies. These range from slight splaying of the articular facets, often with associated shortening and thickening of the vertebral centrum (as illustrated in Figure 34), to several articulating, fused vertebrae that are twisted, fused, collapsed and remodelled (as illustrated in Figure 35 and Figure 36). The latter example is a sequence of about 6 vertebrae, all splayed, skewed and twisted. Two vertebrae from this sequence have fused and foreshortened, taking on the appearance of a single vertebral body.

Possibly included in this first category are large premaxillae and dentaries with what appear to be tooth abscesses (examples are illustrated in Figure 30 for cod and Figure 37 and Figure 38 for ling). In these cases, an area immediately around several tooth sockets appears to be hollowed out and remodelled, as though infection has destroyed the immediate bone and caused new growth around the site. Although the author has experience of this pathology in mammal populations, she is unaware of any other cases in fish populations.

The second category of fish pathologies comprises those with pathological growths that do not appear to be associated with joint disease or wear and tear. The growths are called 'neoplasias' or tumours, referring to unusual growths of tissue which can be benign or invasive (Leatherland and Down 2001, 60). A classic example is provided in Figure 39, a cod articular with a large, amorphous sphere of extra bone growth on the lateral side. The complete ling cranium with multiple lesions and twisted new bone growth (Figure 40) is another example, as are the cod and ling ceratohyals with new bone growth (Figure 41).

Interpretation of these pathologies is difficult because of the lack of comparative assemblages or modern veterinary literature. Fish bone does not heal as well as mammalian bone, because it is constantly kept in motion while swimming. Any injuries are therefore likely to be

apparent as badly healed or distorted bone (Roberts 2001, 127). This may explain some of the first category of injuries, particularly those displaying remodelling around the mouth region, where hook damage may have injured bone. Joint diseases tend not to be discussed with respect to changes to the skeleton. Descriptions of fused vertebrae are known in the literature, because this is one of the most common pathologies thought to affect the bone (Witten and Huysseune 2009, 331). Tumours that affect the fish skeleton are not well understood (wild or not); a recent textbook on fish pathologies describes them as "very limited in occurrence" (Roberts 2001, 162). Most of the modern literature deals with cases linked to direct or accumulating pollutants in the food chain (Mawdesley-Thomas *et al.* 1974, 15; Russell and Yonge 1974, 162). Poor diet can contribute to skeletal malformations – seen today in farmed fish (Roberts 2001, 127) – but these explanations are unlikely to be a causal factor in medieval times, when ocean ecosystems were rather better balanced than today. Distorted, shortened and twisted vertebrae can form as a result of parasitic infestation, or inbreeding, as displayed by farmed salmonids today (Roberts 2001, 127). Again, these is unlikely to be applicable to medieval archaeological material. Tooth abscesses are relatively common in mammalian material, both modern and ancient, but the author was unable to find a single example in the fish pathology literature, suggesting they are an extremely rare occurrence today. Pathologies and tumours in bone from wild populations have not been widely investigated or published, barring a few individual case studies (Mawdesley-Thomas *et al.* 1974; Leatherland and Down 2001), most of which don't fully describe the pathologies at bone level. In any case, full diagnosis of tumour type depends on investigation of the entire fish, which again is not possible with archaeological material. However, the prevalence of growths and lesions found in the single ling cranium makes it likely this fish suffered from a malignancy (Russell and Yonge 1974, 169).

The Bon Accord pathologies are found throughout the larger area and phases, including Phases 1 and 2, with a few also found in Phases, 3 and 4. There may be a correlation between the extremely large size ranges found at Bon Accord and the unusually high prevalence of pathologies. Larger fish – and thus older – are more likely to suffer joint diseases than younger fish. The second group of pathologies is more difficult to attribute to age, but larger and older fish might be more prone to lesions and cancerous growths than younger ones. The Bon Accord assemblage is mostly hand collected, which is biased towards larger individuals, but taking into account the small sieved dataset and the good preservation of material, this assemblage is still comprised of an unusually high proportion of very big, very old fish. One possible explanation is that in the 13-14th century, fishermen from Aberdeen began to fish new, previously unexploited fishing stocks. Such a population would have had numerous large, old fish at the top of the food chain, with sizes unlike anything seen today around the North Sea. Those old fish with joint diseases and tumours may have been more easily caught than healthy specimens. Further work in conjunction with fisheries biologists is necessary to fully understand these specimens.

Discussion

The fish remains from Bon Accord were dominated by the cod family fish, including cod, ling and haddock. Temporal changes in the composition of the fish assemblage can be seen, and probably reveal changes in fishing grounds and demand for taxa. In Phase 1, probably dating to the 13-14th century, cod was the dominant choice, representing 85% of all bones. Cod decreased in prominence over the next 3 phases, with ling becoming more common. By Phase 4, probably dating to the 14-15th century, ling slightly outnumber cod. A dramatic change occurred about the 15th century, because by Phase 5, of 15-18th century date, haddock and saithe have become important minor species, while ling were no longer of much importance; cod remained the fish of choice. Haddock were probably underrepresented by hand collection, so may have been of minor importance in Phase 2, increasing to become an important alternative to cod and ling in Phase 3.

The cod and ling found at Bon Accord were exceptionally large; most were between 80 and 140cm in length, with a peak between 100 and 120cm total length. Cod actually increased sequentially through time, with more and more very large cod of over 100cm found in Phases 2, 3 and 4. However, by the 15-18th century Phase 5, most cod were smaller, between 80-100cm total length, and there were very few ling. This change would suggest different fishing grounds were being exploited, perhaps in waters that were not as deep as in Phases 1 to 4.

The large size of the cod and ling suggest a consistent method of targeting specific fish at specific fishing grounds, particularly between Phases 1 and 4. Ling prefer deeper water, particularly when older and bigger, so depths of at least 100m, up to 1000m, would be expected (Froese and Pauly 2010). Fishing grounds were likely some distance from Aberdeen, in the northern portions of the North Sea or in the North Atlantic. Other fish may have been caught when targeting cod and ling, and kept for consumption; the large saithe and pollack, the dogfish and the flatfish could come into this category. The smallest fish found could easily have been stomach contents, but overall there was little evidence that fish were routinely gutted at Bon Accord.

The smaller fish like haddock and whiting, and some of the medium sized saithe, were probably caught in different ecosystems (Froese and Pauly 2010). These were probably caught in shallower, inshore waters closer to Aberdeen. These tended to be more common in Phase 5, providing more evidence of a change to fishing grounds. These fish were also found to a lesser degree in Phase 3, suggesting that some shallow or inshore waters were being exploited on a small scale in this phase, alongside the deeper offshore waters.

The large cod and ling found at Bon Accord and elsewhere in Aberdeen were most likely caught by long-lining, a method of marine fishing using a long line with multiple hooks held over the side of a boat without a rod (Fenton 1978). The actual evidence for fishing is slight: excavations at Castle Street produced a single hook of 13-14th century date that closely resembles contemporary fish hooks (Steane and Foreman 1988), but which are cautiously attributed any number of uses by the excavators. A second hook in poor condition from 43-57 Upperkirkgate is of 16-18th century date and similarly cautiously attributed any number of functions, including fishing (Cameron *et al.* 2001, 200). Historical sources mention fishing for cod using lines in association with medieval Aberdeen (Jackson 2002, 162). Fishing weights to hold down nets or lines are sometimes recovered from archaeological sites, but none are known from Aberdeen.

The small quantities of salmon family fish suggest some fishing of local river systems, most likely with hook and line or with nets. Historical evidence describes ‘stells’ being used to catch salmon in the Dee and around the natural harbour area at the coast; this was a method of net fishing using wooden stakes or boats to support the nets (Jackson 2002, 161). This was probably the case throughout all phases.

The medieval fish trade is a well recognised and documented phenomena around the North Sea region (Barrett *et al.* 2008). Preserved, dried fish can be traced from producer site to consumer using zooarchaeology and isotopic signatures. The large cod and ling from Bon Accord were analysed using element proportions, taphonomy, fish sizes and butchery to assess whether or not they had been preserved and traded. It is most likely that they arrived in Aberdeen as fresh fish, which were then consumed and deposited in their entirety. A few examples may have been preserved, but not in any quantity sufficient to alter the overall balanced deposition of element parts.

Individual features generally conformed to the overall pattern of each major phase, but a few are exceptional and can provide insights about the variation of material found at Bon Accord. Phase 1 was dominated by cod, with some ling. Although a few other taxa were recovered, much of these originated from a single feature that appeared quite different from others in this

phase: C1, Spread 002. The fish remains indicated that herring, 4 types of flatfish, haddock and cod of small, medium and large size were all consumed and deposited in this single feature. If the dating is correct, then this feature could represent the remains of high status dining, as a variety of more unusual fresh fish appear to have been consumed.

As discussed above, a few features displayed unusual element patterning. Most simply represent the natural variability seen at individual context levels, but the high proportion of vertebrae found in C1, Pit 015 is unusual. This could represent the remains of one particular stage of food preparation. Another different feature is C2, Hollow 002. This contained 23 cod cleithra fragments from a total of 116 cod remains. C2, Layer 003 also shows higher than expected numbers of cleithra. Overall, there is no indication that cleithra were over- or under-represented in the assemblage, meaning that fish were generally consumed fresh and deposited whole. However, these two features may indicate that occasionally, some imported, preserved and headless cod might have been consumed. Or, like C1, Pit 015, these may represent kitchen waste from particular stages of food preparation. Full analysis of other contents from this feature may provide insight into this curious pattern.

A thorough analysis of the butchery patterning indicates the large cod and ling were routinely chopped into segments in the 13-14th and 14-15th century phases, and occasionally later. The repetitive nature of the chops, and the occasional preference of one side of the fish, suggests this was done by professional butchers. In contrast, the many fine knife marks found on vertebrae and cleithra were a lot more varied, and were probably the result of cooking and consumption at the domestic level. Butchery to the central, midline articulation of mouth elements was occasionally undertaken following a set pattern, but the purpose of this is not known. It is, however, known from multiple, contemporary sites around the North Sea.

Cooking differences are apparent not only in the butchery patterning, but also in the types and quantities of burnt bone. The charred and calcined fish tended to be the minor species, including haddock, whiting, flatfish and herring. Most of these were much smaller than the cod and ling that were most popular. It is likely these smaller taxa were cooked near open fires, where some bone could end up burnt, whereas cod and ling were cooked in a way that made burning less likely.

Historical evidence for markets and trade in Aberdeen

Historical sources describe Aberdeen role in the fish trade in some detail, and these can be contrasted with the zooarchaeological evidence. The historical sources mention Aberdeen's importance in the trade and exchange networks of the North Sea from as early as the 12th century, when a royal charter was granted to the city. At that time, Aberdeen was known to export cloth, wool, animal skins, leather and fish, while timber, iron, manufactured goods, quality cloth and wine were imported (Jackson 2002, 159-60). Aberdeen probably traded widely with continental cities like Bruges, as well as English ports, from the 13th century to the mid 15th century, with Edinburgh gradually gaining predominance in the 16th century (Jackson 2002, 160). However, Aberdeen remained an important centre for fishing, even if it became overlooked for international trade (Jackson 2002, 160).

Aberdeen's medieval fish trade centred around salmon and herring, as well as 'whitefish', most likely cod and ling. Salmon were caught using nets in the Dee or its estuary, and were preserved by salting or barrelling in brine or dry; this preserved product was known to be exported as far as London from at least the mid 14th century (Jackson 2002, 161). Between the second half of the 15th century and the end of the 16th, Aberdeen's salmon probably represented at least 40% of the salmon being exported from Scotland, reaching markets around the North Sea, the Baltic and Iberia (Jackson 2002, 162). Few of the products of this trade were eaten and deposited at Bon Accord – either through dietary preference, or because salmon was too valuable as an export product.

The Aberdeen cod trade was small compared to its salmon trade, but still important historically. Cod were "also popular because their size allowed the split fish to be lightly salted at sea and then dried and barrelled on land. There are signs that this was once a lucrative trade: in thirteenth-century Flanders cod was known as *aberdaan*" (Jackson 2002, 162). This trade probably declined from the 15th century, when Newfoundland cod became more widely available. Fish that were gutted and 'split' at sea, as implied here, could have been landed at Aberdeen and then barrelled for export, with few fish actually consumed in Aberdeen itself. Aberdeen's proximity to fishing grounds would mean fresh fish could have been caught and landed regularly, and these may have been preferable to inhabitants.

The herring trade was extensive, and involved many ports around the North Sea (Starkey *et al.* 2000). However, by the late 15th century, there were complaints that much of the herring stocks in Scottish waters were being fished by other countries bypassing Scotland altogether. It is likely that Aberdeen's role in the herring trade became fairly minimal, if indeed it was ever extensive, with only small quantities of fresh fish being landed (Jackson 2002, 163). The complete lack of herring bones suggest there was little demand or preference for herring at Bon Accord.

Historical evidence can also be used to interpret local consumption patterns within the city. Aberdeen provided a large population that was fairly wealthy (Jackson 2002, 162), and thus provided a demand for fresh fish. Although these tended to be more expensive than preserved fish, fresh fish were much in demand in medieval urban centres. From the 15th century onwards, small fishing towns like Findhorn, Banff and Peterhead were known to supply Aberdeen with fresh fish from inshore and deeper waters (Jackson 2002, 162). Aberdeen itself had a small fishing village called Futty, on the outskirts of town (Dennison *et al.* 2002, 16); from at least 1500 fishermen from this village fished for salmon in the local waters, as well as local inshore fisheries along the coastal regions (Jackson 2002, 162). The rise of the small fishing towns can probably be traced through the zooarchaeological record: from the 15th century, smaller, more inshore fish tended to be consumed. Some of these small inshore fisheries could be 'owned' and were subject to controls. Although its extent is not known, this system became problematic by the mid 15th century, when the city was forced to decree that no person from outside of Aberdeen should be allowed to control the inshore fisheries (Boardman 2002, 216). A century later, there were still problems over control of the inshore fisheries, when "John, sixth Lord Forbes, was involved in a long-running, occasionally violent dispute with the burgh, ostensibly over fishing rights" (White 2002, 224). Records from 1522 show half the profits from fisheries around the mouth of the Dee were paid to a particular post at King's College (Lynch and Dingwall 2002, 198), suggesting ownership and control could be lucrative.

Legislation and grievances relating to medieval markets often feature fishmongers, and Aberdeen is no exception. A weekly market was held from the 13th century onwards (Blanchard *et al.* 2002, 137), probably involving sales of fresh or preserved fish. Regulations were in place to ensure locally caught fish were not sold at Futty or other nearby villages, but were brought to the market and sold fairly, with dues payable to the city (Blanchard *et al.* 2002, 145). From the mid 15th century there are records of 'fleshers' charging set rates for cleaning and butchering larger varieties of fish, and other records described 'keling' or cod, being cleaned and butchered in the market (Blanchard *et al.* 2002, 139, 142). A record of 1482 describes fines charged for selling fish too early and making too much profit on 'breaking' fish (Blanchard *et al.* 2002, 139). This matches the butchery evidence from Bon Accord, albeit a few centuries before these documents were written: the large cod and ling show evidence of being chopped into manageable segments using set, routine methods of chopping from the 13-14th and 14-15th century phases.

Comparative assemblages

Aberdeen has a rich archaeological record, with several sites of medieval to early modern date brought to full publication. Bon Accord is located on Gallowgate, one of the principal streets leading to the centre of Aberdeen in the medieval period (Cameron and Stones 2001). Houses and buildings lined the street, with open ground behind them allowing for deposition of rubbish and midden, backing onto a loch. Immediately adjacent to Bon Accord is 45-75 Gallowgate, while within about 200m away are 30-46 and 43-57 Upperkirkgate and Gallowgate Middle School. The Kirk of St. Nicholas, St. Nicholas Triangle and 16-18 Netherkirkgate/1-15 Guestrow and Castle Street are all less than 500m away. Fish remains have been found at some of these sites, and are useful comparanda to the Bon Accord assemblage. Fish were also found during recent excavations at St Nicholas Kirk, including large cod and ling of medieval date (Stones 2008), but this site has yet to be fully published.

Excavations took place in the immediate vicinity of Bon Accord in the 1970s and early 1980s (Murray 1982). The publication included an analysis of late 12th to 14th century animal bone from 42 St Paul Street and Queen St Midden Area, but aside from the tantalising mention that "significantly, the Queen Street site was rich in fish bones" (Hodgson and Jones 1982, 232), no quantification or taxonomy listing was provided. A contemporary paper considering the zooarchaeology from medieval sites in eastern Scotland similarly ignored the fish remains, simply listing a few species that were recovered from sites in Perth (Hodgson 1983, 6).

Recent excavations provide more useful comparanda. The 45-75 Gallowgate site located adjacent to Bon Accord produced fish remains in some quantity, some of which 'hinted' towards fish processing evidence (Evans 2001, 83). Archaeological material from the Gallowgate area dates from the 12th to 14th centuries, and includes a variety of industrial processing. In the 13th and 14th centuries, middens accumulated around the edge of the loch, probably associated with the nearby buildings (Evans 2001, 105). Archaeological evidence from the middens and structures indicate this area was used for a number of industrial activities, including sand and gravel quarrying, a variety of leather working crafts, dying and textile processing, non-ferrous metal working and butchery (Evans 2001, 105-107).

Fish assemblages were recorded from 5 sites in the area (information discussed here and below extracted from Cameron and Stones 2001, particularly Hamilton-Dyer *et al.* 2001). Individual bone counts from each of these sites are of moderate size, but when combined, a total of 1329 bones were identified. These include: 45-75 Gallowgate (483 fish remains in total, mid 13th century to c.1770/80), Castle Street (184 fish remains in total, 13-20th century) , 16-18 Netherkirkgate (672 fish remains in total, 13th-15th century), 30-46 Upperkirkgate (86 fish remains in total, 12th-18th century), and Gallowgate Middle School (333 fish remains in total, late 12th-20th century). Most of these derived from hand collection, with 'some' sieving undertaken at 16-18 Netherkirkgate and 45-75 Gallowgate, although the results were presented without distinguishing recovery method.

The fish taxa recovered from these comparative sites were similar to those from Bon Accord: cod, ling and haddock were the most commonly recovered taxa, with a few examples of salmon, flatfish, saithe/pollack and turbot also recorded (comparative sites are summarised by period in Table 16). Cod and ling dominated the assemblages from the 12-13th century to the 15-18th century, with cod found in the greatest quantities. Haddock was found at low levels throughout, which appears similar to Bon Accord, given that haddock were likely under-represented by hand collection. A few saithe/pollack and a single flatfish were identified in the 12-13th century, and a few more saithe/pollack in the 13-14th century.

Fish sizes were described, but not quantified. Cod tended to be fish of 100-120cm total length, while some of the ling recovered were of 120cm total length and others were substantially bigger – very similar to the size ranges found at Bon Accord. The haddock remains represented fish of 35 to 70cm total length, again typical of Bon Accord.

The tentative evidence for fish processing in the Gallowgate area dates from the mid 13th century, and included cod, haddock and ling. Large quantities of cranial remains were found, as were several butchered bones, which were interpreted as evidence for filleting, gutting and cleaning on site. Furthermore, the authors believed that Aberdeen was "receiving cod from the Norwegian fishing grounds which were then controlled by Bergen" in the mid 13th century or earlier (Evans 2001, 107).

Detailed investigation of the data suggests that these claims are indeed very tentative. The quantities of fish bone recovered are actually very small, once each phase of each site is considered. Fish elements and skeletal representation were both discussed qualitatively, making it difficult to reconstruct the arguments for fish processing. At most sites, the vertebrae and cleithra were said to be *underrepresented* compared to cranial elements, which was interpreted as evidence for fish processing: the vertebrae and cleithra were thought to be removed with the prepared flesh, leaving the waste cranial elements here. It seems very unlikely that fish were being prepared for preservation in an urban centre, given that air drying or drying and salting typically took place in cold areas with plenty of space for hanging or laying out the fish (e.g. the Northern Isles, Norway (Perdikaris 1999)). The quantities of recorded bones for any one phase of these comparative sites is very small – the maximum recorded is 158 cod bones from a 13-14th century phase at 16-18 Netherkirkgate, followed by 108 ling bones from a phase dating to c.1250-1375 from 45-75 Gallowgate. In neither example were quantities sufficient to fully explore the interplay of taphonomy, fragmentation and element representation – the latter being of particular relevance given that a single cod can contain up to 56 vertebrae and dozens of large, robust cranial bones. The frequent mentions of butchery to the appendicular elements suggests that they were not overly absent from the archaeological record.

Butchery evidence from the comparative sites was recorded, although not quantified. Butchery was most common on the appendicular elements, including the cleithra, supracleithra and posttemporals, and was interpreted as filleting evidence. Other evidence included butchery to remove the gills, to remove deeply swallowed hooks, and to remove the tongue. A few cranial bones were 'axially' chopped. Perforated opercular bones were thought to indicate fish were threaded together and hung up on lines, which is certainly possible although no examples were found at Bon Accord. This butchery evidence appears similar overall, particularly regarding the butchered cleithra and mouth elements, but it is curious that butchered vertebrae don't appear as common at the comparative sites as at Bon Accord.

Samples from a number of sites were assessed for plant remains, and during this process, some fish remains were noted (Hall 2003). Although not investigated in any detail, they are unusual in that they include some small fish bones. These included 4 samples from a Carmelite friary, one of which was of 16-17th century date. Two were thought to contain cess material, including crushed fish bones; this perhaps suggests that small fish were being consumed, as cess material tends to include smaller fish like herring or eel. A sample from 43-57 Upperkirkgate, dating to the 15-16th century contained fish bones, some burnt, while Gallowgate Middle School produced a sample of late 12-13th century date that contained very large fish bones. However, the most remarkable evidence to emerge from sampling is the consistent lack of small fish from the early material; large cod and ling appear to have been the food of choice throughout the 12th, 13th, 14th and 15th centuries.

Conclusions

Historical sources describe medieval Aberdeen as an important hub in trade and exchange networks around the North Sea – and in particular, Aberdeen seems to have exported preserved salmon, herring and cod and ling. However, the actual zooarchaeological evidence from Bon Accord and comparative sites challenges this view. Aberdeen may have been an

important centre for fish trade, but very little of these traded products were consumed in Aberdeen itself. Salmon and herring were present in some phases, but were only represented by a few specimens. This may have been a dietary choice, or this might have been because these goods were too valuable for local consumption. Cod and ling, on the other hand, were the dominant fish consumed in quantity throughout the 13-14th and 14-15th century phases. These fish tended to be very big, with most over 80cm total length and many exceeding 100cm in length. Detailed examination of element proportions and fragmentation patterns suggests that whole fish were deposited at Bon Accord. There was no indication that fish preservation was undertaken at Aberdeen (contrary to earlier zooarchaeological studies), and nor was there evidence that only the preserved product was being consumed, although the odd preserved fish may have been eaten occasionally. These large fish were routinely butchered, probably by professionals to reduce them to smaller, manageable portions which were then consumed in the domestic setting.

Throughout, fishing by long line seems to have been particularly important, though nets may have been used in shallower waters closer to Aberdeen itself. Trends in consumption over time, with shifts in fish sizes and availability of species, most probably relate to a move towards exploitation of inshore or shallower fishing grounds around the 15th century. Prior to this, the deep and open waters of the northern North Sea or North Atlantic were the preferred fishing grounds.

A few features display elements or species that differ from the norm, and that may hint at specific patterns of consumption linked to status. Further work on these will be necessary to fully understand these differences. The pathological alterations to the very large cod and ling are difficult to understand and also warrant further work. Fish pathologies are generally very rare in zooarchaeological assemblages, but the numerous examples from Bon Accord provide examples of joint diseases, recovery from injuries and infections, as well as multiple tumours and bone growths.

Tables and Figures

Table 1: Summary of Phase C1, Pit 015

Taxa	Element	30-50cm	50-80cm	80-100cm	>100cm	Total	Notes
Hand collection							
Cod	Articular			1	2	3	
	Basioccipital			1		1	
	Ceratohyal		1	2	3	6	1 fragment with signs of recent breakage
	Dentary				1	1	
	Hyomandibular			1	1	2	
	Maxilla		1			1	
	Palatine			1	1	2	
	Parasphenoid			3		3	
	Posttemporal			1		1	
	Premaxilla			2	1	3	1 80-100cm TL with pathology
	Preopercular			1	3	4	
	Quadrate				1	1	
	First Vertebra			7	1	8	1 80-100cm TL butchered
	Abdominal Vertebra Group 1			110	105	215	1 80-100cm TL and 1 >100cm TL vertebra with light blue-green staining, 5 >100cm TL vertebrae with pathologies, 5 80-100cm TL butchered, 3 >100cm TL butchered
	Abdominal Vertebra Group 2			106	123	229	1 80-100cm TL with light blue-green staining, 1 >100cm TL with concretions, 3 80-100cm TL with pathologies, 6 >100cm TL butchered
	Abdominal Vertebra Group 3		1	212	137	350	1 80-100cm TL and 1 >100cm TL with light blue-green staining; 3 80-100cm TL and 3 >100cm TL with pathologies, 3 80-100cm TL butchered, 3 >100cm TL butchered
	Caudal Vertebra Group 1			72	39	111	7 80-100cm TL butchered
	Caudal Vertebra Group 2			1		1	
Cod total			3	521	418	942	
Saithe	Abd. Vert. Group 1			1		1	
	Abd. Vert. Group 3		2		4	6	
Saithe total			2	1	4	7	
Saithe/ Pollack	Abd. Vert. Group 1			1		1	
	Cau. Vert. Group 1			1		1	
Saithe/ Pollack total				2		2	
Ling	Basioccipital				1	1	
	Ceratohyal				1	1	
	Cleithrum				2	2	
	Dentary			1	1	2	
	Parasphenoid				1	1	
	Preopercular				1	1	
	Abd. Vert. Group 1				6	6	1 butchered
	Abd. Vert. Group 2				16	16	
	Abd. Vert. Group 3			2	10	12	
	Cau. Vert. Group 1				2	2	
Ling total				3	41	44	
Gurnard family	Unidentified	1				1	Cranial element not routinely identified
Unidentified						97	
Total hand collected						1093	

>2mm sieving						
Cod	Articular			1	1	
	Preopercular		1		1	
	Abd. Vert. Group 1		1	1	2	
	Abd. Vert. Group 2		1		1	
	Abd. Vert. Group 3	1	6		7	1 80-100cm TL butchered
	Cau. Vert. Group 1		1		1	
Cod total		1	10	2	13	
Ling	Abd. Vert. Group 2			1	1	
	Abd. Vert. Group 3			1	1	
Ling total				2	2	
Saithe	Abd. Vert. Group 3		1		1	
Unidentified					20	
Total sieved					36	

Table 2: Summary of feature C2, Layer 003

Taxa	Element	30-50cm	50-80cm	80-100cm	>100cm	Total	Notes
Hand collected							
Ray family	Dermal Denticle					1	
Cod	Articular			3	4	7	
	Ceratohyal	1		4	4	9	
	Cleithrum			7	16	23	
	Dentary			6	8	14	1 >100cm TL pathological, 1 80-100cm TL butchered, 2 >100cm TL butchered
	Hyomandibular			1	2	3	
	Maxilla			4	7	11	
	Opercular			6	3	9	
	Palatine			1	1	2	
	Parasphenoid			3	2	5	
	Posttemporal			1	3	4	1 80-100cm TL butchered
	Premaxilla			1	6	7	2 >100cm TL butchered
	Preopercular			5	1	6	
	Quadrate			2	2	4	1 >100cm TL pathological
	First Vertebra			2	2	4	
	Supracleithrum			5		5	1 butchered
	Vomer			2	4	6	
	Abdominal Vertebra Group 1		2	11	16	29	1 >100cm TL gnawed by carnivore, 1 80-100cm TL butchered
	Abdominal Vertebra Group 2			8	14	22	
	Abdominal Vertebra Group 3		2	25	27	54	2 >100cm TL butchered
	Caudal Vertebra Group 1		1	16	6	23	
	Caudal Vertebra Group 2			4	6	10	1 >100cm TL gnawed by carnivore
Cod total		1	5	117	134	257	
Cod family	Caudal Vertebra Group 2			1	2	3	1 >100cm TL pathological and gnawed by carnivore
Haddock	Cleithrum	7	6			13	1 50-80cm TL gnawed by carnivore
	Posttemporal	1	1			2	
	Preopercular	2				2	
	Abdominal Vertebra Group 3	2	1			3	
	Caudal Vertebra Group 1	1				1	

Haddock total		13	8			21	
Ling	Articular				12	12	
	Basioccipital				1	1	
	Ceratohyal			1	12	13	
	Cleithrum				8	8	2 butchered
	Dentary				10	10	2 butchered
	Hyomandibular				8	8	
	Maxilla				8	8	1 pathological
	Palatine				4	4	
	Parasphenoid			1	2	3	
	Posttemporal				2	2	
	Premaxilla				4	4	
	Preopercular				5	5	
	Quadrate				3	3	
	Supracleithrum				2	2	
	Vomer				3	3	
	First Vertebra				4	4	2 butchered
	Abdominal Vertebra Group 1			1	14	15	
	Abdominal Vertebra Group 2				53	53	3 butchered
	Abdominal Vertebra Group 3				40	40	1 butchered
	Caudal Vertebra Group 1				13	13	
	Caudal Vertebra Group 2				8	8	
Ling total				3	216	219	
Pollack	Maxilla			1		1	
Plaice	Preopercular	1				1	
Halibut family	Abdominal Vertebra	1				1	
Unidentified						236	
Total hand collected						740	
>2mm sieving							
Atlantic Herring	Abdominal Vertebra					2	
	Caudal Vertebra					2	
Atlantic Herring total						4	
Cod	Ceratohyal				1	1	
	Premaxilla			1	1	2	
	Supracleithrum			1		1	
	Abdominal Vertebra Group 1			3		3	
	Abdominal Vertebra Group 2			5	1	6	
	Abdominal Vertebra Group 3				7	7	1 pathological, 1 butchered
	Caudal Vertebra Group 1			3	2	5	1 80-100cm TL butchered
	Caudal Vertebra Group 2			9		9	
Cod total				22	12	34	
Haddock	Ceratohyal	1				1	
	Cleithrum	2				2	
	Dentary	1				1	
	Opercular	1				1	
	Scapula	1				1	
Haddock total		6				6	
Ling	Cleithrum				2	2	
	Abdominal Vertebra Group 1				1	1	
	Abdominal Vertebra Group 2				3	3	2 butchered
	Abdominal Vertebra Group 3				14	14	
	Caudal Vertebra Group 1				4	4	1 butchered
Ling total					24	24	
Unidentified						295	
Total sieved						363	

Table 3: Phasing summary

Phasing from interim report		Approximate dates	Description
Phase 1	A1, B1 and C1	Probably 13-14th century	Often waterlogged, with several pits with good preservation and survival of organic material and some evidence of leather working industrial function; some pottery tentatively of 13-14th century date
Phase 2	A2, C2	Probably 13-14th century	Occupation dumps, waste disposal, drainage, industrial functions (including leather working), and clearly marked activity areas and boundaries [the phasing documentation lists B1 as also belonging to this phase, but for simplicity and until details have been resolved, B1 has been included only in Phase 1]
Phase 3	A3, C3	Probably 13-14th century	Occupation, structures and levelling episodes, as well as waste disposal and industrial function
Phase 4	A4, C4	Probably 14-15th century	Increased structural activity, boundary evidence, drainage features, occupation and dump deposits, floor deposits
Phase 5	A5, C5, C6	Probably 15-18th century (late- and post-medieval)	Occupation deposits, structures, surfaces, floors, drainage, refuse disposal
Phase 6	A6, B2, C7	19-20th century	Brick and rubble structures, drainage, cellars, floors, probably of large industrial function
Unstratified/ other			Includes a number of contexts that were unstratified, that extended across multiple phases, that were not in the phasing documentation, or that may have been wrongly recorded
Phase 1 (or later)	C1 (or later)	Probably 13th century +	
Phase 1 or 2	C1 or 2	Probably 13-14th century	
Phase 2 or 3	A2 or 3, C2 or 3	Probably 13-14th century	
Phase 2 to 4	A2 to 4, C2 to 4	Probably 13-15th century	
Phase 3 or 4	A3 or 4, C3 to 4	Probably 13-15th century	
Phase 4 or later	C4 or later	Probably 14th century +	
Phase 4 or 5	C4 or 5, C4 to 6	Probably 14-18th century	

Table 4: Summary of bone counts per phase

Phases	Hand collection			>2mm sieving			Grand total
	Identified	Total	% identified	Identified	Total	% identified	
Ph. 1	1325	1663	80%	57	363	16%	2026
Ph. 2	1587	2514	63%	103	479	22%	2993
Ph. 3	295	374	79%	88	508	17%	882
Ph. 4	184	291	63%	23	57	40%	348
Ph. 5	96	172	56%	104	567	18%	739
Ph. 6	19	56	34%	24	66	36%	122
Ph. 1 or 2	5	5	100%				5
Ph. 1 or later	102	181	56%	4	15	27%	196
Ph. 2 or 3	44	52	85%	8	22	36%	74
Ph. 2 to 4	2	2	100%	5	13	38%	15
Ph. 3 or 4	4	4	100%				4
Ph. 4 or 5	24	41	59%	1	1	100%	42
Ph. 4 or later	8	10	80%				10
Other	258	265	97%	13	34	38%	299
Total	3953	5630	70%	430	2125	20%	7755

Table 5: Taphonomic summary for all hand collected fish bone

	Ph. 1		Ph. 2		Ph. 3		Ph. 4	Ph. 5	Ph. 6	Total for all major and minor phases	
Percent completeness, recorded for QC1 and QC4 elements											
1-20%	6	3%	19	2%	2	2%		2		32	2%
20-40%	26	13%	153	19%	17	18%	13	6		243	18%
40-60%	32	16%	149	18%	14	15%	13	6	4	237	18%
60-80%	62	31%	244	30%	39	42%	13	8	2	405	30%
80-100%	75	37%	242	30%	21	23%	43	4	4	429	32%
Total	201	100%	807	100%	93	100%	82	26	10	1346	100%
Texture, recorded for QC1 and QC4 elements											
Poor	9	4%	41	5%	8	9%	8		3	90	7%
Fair	37	18%	202	25%	38	41%	11	6	1	314	23%
Good	153	76%	558	69%	47	51%	59	21	6	929	69%
Excellent	2	1%	6	1%			4			13	1%
Total	201	100%	807	100%	93	100%	82	27	10	1346	100%
Other modifications, recorded for all elements											
Carnivore gnawing	3		6		1		1			11	
Burnt, calcined	1				2					4	
Fresh breakage	2		3							6	
Blue-green staining	6									6	
Red-brown staining										2	
Concretions	2				2					4	

Table 6*: Taphonomic summary for all sieved fish bone*

	Ph. 1	Ph. 2	Ph. 3	Ph. 4	Ph. 5	Ph. 6	Total for all major and minor phases	
Percent completeness, recorded for QC1 and QC4 elements								
1-20%	1		1				2	2%
20-40%	2	3	4		5	1	16	20%
40-60%	2	1	2		2	1	8	10%
60-80%	2	8	6	1	5	2	26	32%
80-100%	6	5	5	2	11	1	30	37%
Total	13	17	18	3	23	5	82	100%
Texture, recorded for QC1 and QC4 elements								
Poor		2			2		4	5%
Fair	3				11	1	17	21%
Good	10	15	18	2	10	4	60	73%
Excellent				1			1	1%
Total	13	17	18	3	23	5	82	100%
Other modifications, recorded for all elements								
Crushed	2				1	1	4	
Burnt, calcined	2	9	26	4	8		51	
Burnt, charred	1	7	8	1	2		19	
Concretions					1		1	

Table 7: Hand collected summary by area, phase and taxa

Taxa	A1	A3	A4	A5	A6	A3 or 4	B1	C1		C2		C3		C4		C5	C6	C7	C1 (or later)	C1 or 2	C2 or 3	C2 to 4	C3 to 4	C4 or later	C4 to 6	Other	Grand total	
Ray Family			1							1	0%																2	0%
Salmon & Trout Family								1	0%										1								2	0%
Cod	24		2	4			1	1105	86%	953	59%	175	60%	84	46%	18	18	15	45	2	31	1	2	3	19	246	2748	69%
Saithe	1							7	1%	4	0%	5	2%	1	1%	12											30	1%
Haddock	1		1					15	1%	43	3%	2	1%	1	1%	16		2	11					1		1	94	2%
Ling	23	1		3		1		148	12%	579	36%	109	37%	93	51%		4	2	45	3	12	1	1	4	5	10	1044	26%
Pollack										1	0%					1											2	0%
Saithe/ Pollack								2	0%	2	0%			1	1%	4					1						10	0%
Cod/ Saithe/ Pollack																13											13	0%
Cod Family										7	0%	1	0%			2										1	11	0%
Gurnard Family								1	0%							1											2	0%
Turbot Family										1	0%																1	0%
Turbot								1	0%																		1	0%
Halibut										1	0%																1	0%
Plaice										7	0%																7	0%
Flounder/ Plaice										2	0%	1	0%														3	0%
Halibut Family										12	1%	1	0%	1	1%												14	0%
Total identified	49	1	4	7	0	1	1	1280	100%	1613	100%	294	100%	181	100%	67	22	19	102	5	44	2	3	8	24	258	3985	100%
Unidentified	72			1	24		1	260		901		79		106		75		13	79		8			2	17	7	1645	
Grand total	121	1	4	8	24	1	2	1540		2514		373		287		142	22	32	181	5	52	2	3	10	41	265	5630	

Table 8: Sieved summary by area, phase and taxa, >2mm sieving

Taxa	A1	A2	A3	A4	A6	A2 or 3	A2 to 4	C1	C2	C3	C4	C5	C6	C7	C4 or 5	C1 (or later)	Other	Grand total	
Dogfish Families													1					1	0%
Ray Family									1		1	1						3	1%
Atlantic Herring								1	7				4					12	3%
Herring Family													1					1	0%
Carp Family		1																1	0%
Salmon & Trout Family									1				2					3	1%
Cod				1		1		25	42	4	6	1	2	3				85	20%
Saithe								1										1	0%
Haddock	8	2	1	2	1	5	4	1	17	73	1	10	55	15	1	1	9	206	48%
Ling								8	24	1						2		35	8%
Pollack												1						1	0%
Poor cod											1							1	0%
Torsk													3					3	1%
Whiting	1		7	1		1	1		1		1	1	8	1			3	26	6%
Cod/ Saithe/ Pollack	1											1	1					3	1%
Cod Family	2	2		1				2	1	1	2		8	4		1	1	25	6%
Gurnard Family									2		1		1					4	1%
Sea Scorpion Family										1								1	0%
Sand Eel Family				4														4	1%
Flounder								1										1	0%
Plaice								2										2	0%
Flounder/ Plaice								1										1	0%
Halibut Family						1		2			1	2	1					7	2%
Sole Family								1										1	0%
Total identified	12	5	8	9	1	8	5	45	96	80	14	17	87	23	1	4	13	428	100%
Unidentified Fish	13	1	1	3		14	8	293	377	419	31	17	446	42		11	21	1697	
Grand total	25	6	9	12	1	22	13	338	473	499	45	34	533	65	1	15	34	2125	

Table 9: Summary for major phases by taxa, hand collected and >2mm sieved

Recovery	Hand collection																					
Date range	Probably 13-14th century						Probably 14-15th century		Probably 15-18th century		19-20th century	Probably 13-14th century						Probably 14-15th century		Probably 15-18th century		19-20th century
Taxa	Ph. 1		Ph. 2		Ph. 3		Ph. 4		Ph. 5		Ph. 6	Ph. 1	Ph. 2		Ph. 3			Ph. 4		Ph. 5		Ph. 6
Dogfish Families																				1	1%	
Ray Family			1	0%			1	1%					1	1%				1		1	1%	
Atlantic Herring												1	7	7%						4	4%	
Herring Family																				1	1%	
Carp Family													1	1%								
Salmon & Trout Family	1	0%											1	1%						2	2%	
Cod	1130	85%	953	59%	175	59%	86	46%	40	42%	15	25	42	42%	4	5%		7		3	3%	3
Saithe	8	1%	4	0%	5	2%	1	1%	12	13%		1										
Haddock	16	1%	43	3%	2	1%	2	1%	16	17%	2	9	19	19%	74	84%		3		65	63%	16
Ling	171	13%	579	36%	110	37%	93	50%	7	7%	2	8	24	24%	1	1%						
Pollack			1	0%					1	1%										1	1%	
Poor cod																		1				
Torsk																				3	3%	
Whiting												1	1	1%	7	8%		2		9	9%	1
Cod/ Saithe/ Pollack									13	14%		1								2	2%	
Saithe/ Pollack	2	0%	2	0%			1	1%	4	4%												
Cod Family			7	0%	1	0%			2	2%		4	3	3%	1	1%		3		8	8%	4
Gurnard Family	1	0%							1	1%			2	2%				1		1	1%	
Sea Scorpion Family															1	1%						
Sand Eel Family																		4				
Turbot	1	0%																				
Turbot Family			1	0%																		
Flounder												1										
Halibut			1	0%																		
Plaice			7	0%								2										
Flounder/ Plaice			2	0%	1	0%						1										
Halibut Family			12	1%	1	0%	1	1%				2						1		3	3%	
Sole Family												1										
Total identified	1330	100%	1613	100%	295	100%	185	100%	96	100%	19	57	101	100%	88	100%		23		104	100%	24
Unidentified	333		901		79		106		76		37	306	378		420			34		463		42
Grand total	1663		2514		374		291		172		56	363	479		508			57		567		66

Table 10: Summary by minor phase group and taxa, hand collected and >2mm sieved

Recovery	Hand collection								>2mm sieving				
Taxa	Ph. 1 or 2	Ph. 1 or later	Ph. 2 or 3	Ph. 2 to 4	Ph. 3 or 4	Ph. 4 or 5	Ph. 4 or later	Other	Ph. 1 or later	Ph. 2 or 3	Ph. 2 to 4	Ph. 4 or 5	Other
Salmon & Trout Family		1											
Cod	2	45	31	1	2	19	3	246		1			
Haddock		11					1	1	1	5	4	1	9
Ling	3	45	12	1	2	5	4	10	2				
Whiting										1	1		3
Saithe/ Pollack			1										
Cod Family								1	1				1
Halibut Family										1			
Total identified	5	102	44	2	4	24	8	258	4	8	5	1	13
Unidentified Fish		79	8			17	2	7	11	14	8		21
Grand total	5	181	52	2	4	41	10	265	15	22	13	1	34

Table 11: Fish element counts for major taxa

Taxa and element	Hand collected							>2mm sieving						
	Ph. 1	Ph. 2	Ph. 3	Ph. 4	Ph. 5	Ph. 6	Total all major and minor phases	Ph. 1	Ph. 2	Ph. 3	Ph. 4	Ph. 5	Ph. 6	Total all major and minor phases
Cod														
Articular	14	58	8	4	1	1	98	1		1				2
Basioccipital	1	8	2	1			14							
Ceratohyal	15	48	7	5	1		83		1					1
Dentary	12	74	11	8	2	1	118							
Hyomandibular	4	19	2	1	1		30							
Infrapharyngeal		1					1	1						1
Maxilla	10	48	4	3	3		80		1					1
Opercular	1	22		2			27							
Palatine	3	6					9							
Parasphenoid	8	24	6	3	1		44							
Premaxilla	13	28	1	1		1	52	1	2					3
Preopercular	11	38	2	7			61	1			1			2
Quadrate	3	13	1	2	1		21							
Vomer		14				1	15	2						2
Cleithrum	13	101	9	4			137							
Posttemporal	6	15	1	1	1	2	27						1	1
Scapula		1					1							
Supracleithrum	5	15				2	22		1					1
First Vertebra	10	11	1	2			24							
Abdominal Vert. Group 1	236	87	29	12	6		413	2	3	2	1			8
Abdominal Vert. Group 2	252	65	35	7	7	5	430	1	6		3			10
Abdominal Vert. Group 3	376	144	43	19	14	1	714	7	12			1	1	21
Caudal Vert. Group 1	126	80	12	4	2	1	278	2	5		2	1		11
Caudal Vert. Group 2	10	33	1				47	7	11	1		1	1	21
Otolith							1							
Cod total	1129	953	175	86	40	15	2747	25	42	4	7	3	3	85
Haddock														
Articular	2						2					1		1
Basioccipital										1		1		2
Ceratohyal	3						4		1			3		4
Dentary	1				1		2		1			3		4
Hyomandibular		1					1			1		1		2
Infrapharyngeal														
Maxilla							1			2		1		3
Opercular	1						1		2			2		4
Palatine	1						1		1	1		1		3
Parasphenoid	2				3		5			1				1
Premaxilla							1			1		1	1	3
Preopercular	1	2				1	4					1		1
Quadrate													1	1
Vomer												1	1	2
Cleithrum	4	33	2	2	2		51		2	2			1	6
Posttemporal		2					3			2		3		5
Scapula									1	1				2
Supracleithrum								1	2	2				5
First Vertebra										1			1	3
Abdominal Vert. Group 1								1	1	3		6	2	14
Abdominal Vert. Group 2								1		3	1	3		11
Abdominal Vert. Group 3	1	3				1	5	4	5	23	1	14	3	55
Caudal Vert. Group 1		2			6		9	2		9		11	2	27
Caudal Vert. Group 2					4		4		3	18	1	12	4	44
Otolith										3				3
Haddock total	16	43	2	2	16	2	94	9	19	74	3	65	16	206

Ling											
Articular	9	35	5	6			60				
Basioccipital	9	8	1	2			21				
Ceratohyal	6	38	8	6			61	1			2
Dentary	11	30	5	3			55				
Hyomandibular	1	12		2			16				
Infrapharyngeal				1			2				
Maxilla	5	17	1	3			30				
Opercular	2	2		3			7				
Palatine	1	7	2	4	2		17				
Parasphenoid	6	8	4	2			23				
Premaxilla	4	10		3			17				
Preopercular	3	15	4	4			29				
Quadrate	2	10					13				
Vomer		5	2	1			10				
Cleithrum	7	35	2	3		1	55		2		2
Posttemporal		5	1				6	1			1
Scapula		1					1				
Supracleithrum	2	4	1	1			10				
First Vertebra	1	6	1	1		1	12				
Abdominal Vert. Group 1	23	47	13	6			103		1		1
Abdominal Vert. Group 2	39	115	35	30	3		238	1	3		4
Abdominal Vert. Group 3	25	99	18	9	2		159	1	14		15
Caudal Vert. Group 1	6	32	7	2			49		4	1	6
Caudal Vert. Group 2	5	12					19	4			4
Otolith		1					1				
Ling total	167	554	110	92	7	2	1014	8	24	1	35

Table 12: Fish sizes, hand collected summary for major taxa and phases

Taxa	Size (TL)	Ph. 1		Ph. 2		Ph. 3		Ph. 4	Ph. 5	Ph. 6	Total for all major and minor phases	
Cod	30-50cm			4	0%	1	1%				5	0%
	50-80cm	8	1%	11	1%	4	2%		4		33	1%
	80-100cm	610	54%	374	39%	65	37%	36	29	6	1333	49%
	>100cm	512	45%	564	59%	105	60%	50	7	9	1377	50%
Total		1130	100%	953	100%	175	100%	86	40	15	2748	100%
Haddock	15-30cm									1	1	
	30-50cm	11		24		1			4	1	43	
	50-80cm	5		19		1		2	12		50	
Total		16		43		2		2	16	2	94	
Ling	50-80cm			2	0%						2	0%
	80-100cm	9	5%	10	2%	3	3%			1	25	2%
	>100cm	158	95%	540	98%	107	97%	93	6	1	985	97%
Total		167	100%	552	100%	110	100%	93	6	2	1012	100%
Pollack	50-80cm								1		1	
	80-100cm			1							1	
Total				1					1		2	
Saithe	50-80cm	2				3			10		15	
	80-100cm	1		4		2		1	2		10	
	>100cm	5									5	
Total		8		4		5		1	12		30	

Table 13: Fish sizes, sieved summary for major taxa and phases

Taxa	Size (TL)	Ph. 1	Ph. 2	Ph. 3	Ph. 4	Ph. 5	Ph. 6	Total for all major and minor phases	
Cod	15-30cm	1	1					2	3%
	30-50cm	1		1			1	3	4%
	50-80cm	1						2	3%
	80-100cm	14	27	2	2	2		47	59%
	>100cm	3	14	1	5	1	2	26	33%
Total		20	42	4	7	3	3	80	100%
Haddock	15-30cm	2	8	3	2	42	7	67	33%
	30-50cm	7	10	70	1	23	9	137	67%
	50-80cm		1					1	0%
Total		9	19	73	3	65	16	205	100%
Ling	>100cm	8	24	1				35	
Whiting	15-30cm	1		7	2	7	1	21	81%
	30-50cm		1			2		5	19%
Total		1	1	7	2	9	1	26	100%

Table 14: Element counts for minor taxa

Taxa	Element	Hand collected						>2mm sieving						
		Ph. 1	Ph. 2	Ph. 3	Ph. 4	Ph. 5	Total all major & minor phases	Ph. 1	Ph. 2	Ph. 3	Ph. 4	Ph. 5	Ph. 6	Total all major & minor phases
Dogfish Families	Vert.											1		1
Ray Family	Dermal Denticle		1		1		2		1		1	1		3
Atlantic Herring	Abdominal Vert.								3			4		7
	Caudal Vert.							1	4					5
Herring Family	First Vert.											1		1
Carp Family	Abdominal Vert.								1					1
Salmon & Trout Family	Abdominal Vert.								1			1		2
	Caudal Vert.	1					2					1		1
Saithe	Cleithrum		1				1							
	Dentary					1	1							
	Parasphenoid	1					1							
	Hyomandibular					1	1							
	Opercular					1	1							
	Palatine					1	1							
	Premaxilla					1	1							
	Vomer		1				1							
	Abdominal Vert. Group 1	1					1							
	Abdominal Vert. Group 2			1		3	4							
	Abdominal Vert. Group 3	6	2	2	1	4	15	1						1
	Caudal Vert. Group 1			2			2							
Pollack	Maxilla		1				1							
	Abdominal Vert. Group 3											1		1
	Caudal Vert. Group 1					1	1							
Poor cod	Dentary										1			1
Torsk	Caudal Vert.											3		3
Whiting	Maxilla													1
	Quadrate											1		1
	Abdominal Vert. Group 1									2				2
	Abdominal Vert. Group 3								1	1	1	4		9
	Caudal Vert. Group 1							1		3	1	4	1	12
	Caudal Vert. Group 2									1				1

Cod/ Saithe/ Pollack	Abdominal Vert. Group 3												1			1
	Caudal Vert. Group 1								1				1			2
	Caudal Vert. Group 2					13		13								
Saithe/ Pollack	Abdominal Vert. Group 1	1						1								
	Abdominal Vert. Group 2							1								
	Abdominal Vert. Group 3		1		1			2								
	Caudal Vert. Group 1	1	1					2								
	Caudal Vert. Group 2					4		4								
Cod Family	Articular			1				1								
	Branchiostegal		1					1								
	Maxilla		1					1								
	Dentary							1								
	Parasphenoid					1		1								
	Quadrate					1		1					2			2
	Scapula											1				1
	Abdominal Vert. Group 1		1					1								1
	Abdominal Vert. Group 2												1	1		2
	Abdominal Vert. Group 3		1					1	1	2			1	2		6
	Caudal Vert.								1	1			1			4
	Caudal Vert. Group 1											2				2
	Caudal Vert. Group 2		3					3	1				3	1		5
	Penultimate Vert.										1					1
	Ultimate Vert.								1							1
Gurnard Family	Parasphenoid					1		1								
	Opercular												1			1
	Unidentified	1						1		1						1
	Abdominal Vert.											1				1
	Caudal Vert.									1						1
Sea Scorpion Family	Abdominal Vert.										1					1
Sand Eel Family	Vert.											4				4
Turbot	Preopercular	1						1								
Turbot Family	Caudal Vert.		1					1								
Flounder	Premaxilla								1							1
Halibut	Quadrate		1					1								
Plaice	1st Anal Pterygiophore		3					3								
	Cleithrum		2					2								
	Quadrate								1							1
	Premaxilla								1							1
	Preopercular		2					2								
Flounder/ Plaice	1st Anal Pterygiophore			1				1	1							1
	Basioccipital		1					1								
	Preopercular		1					1								
Halibut Family	1st Anal Pterygiophore		4	1	1			6								
	Hyomandibular		1					1								
	Abdominal Vert.		2					2	2							3
	Caudal Vert.		5					5				1	3			4
Sole Family	Abdominal Vert.								1							1

Table 15: Butchery summary by taxon and element

Taxa	Element	Ph. 1	Ph. 2	Ph. 3	Ph. 4	Ph. 5	Total all major and minor phases
Cod	Articular				1		1
	Basioccipital		1				1
	Dentary	3	15	2	2		22
	Maxilla		1	1		1	3
	Premaxilla	2	5	1	1		8
	Quadrate		1				1
	Cleithrum		14		2		17
	Posttemporal		1				1
	Supracleithrum		4				4
	First Vertebra	1					1
	Abdominal Vert. Group 1	8	6	1	1		18
	Abdominal Vert. Group 2	8	3				12
	Abdominal Vert. Group 3	8	11		2	1	26
	Caudal Vert. Group 1	8	2		1		15
	Total	38	64	5	10	2	131
	% of identified cod	3.2%	6.4%	2.8%	10.8%	4.7%	4.6%
Cod Family	Branchiostegal		1				1
Haddock	Cleithrum		1				1
	Caudal Vert. Group 2					1	1
	Total		1			1	2
Ling	Basioccipital	1		1			2
	Dentary		3				3
	Parasphenoid		1				1
	Premaxilla		1				1
	Supraoccipital				1		1
	Cleithrum	2	5	1			8
	Supracleithrum		1				2
	First Vertebra	1	2		1		5
	Abdominal Vert. Group 1	2	2				4
	Abdominal Vert. Group 2		8				8
	Abdominal Vert. Group 3		15				15
	Caudal Vert. Group 1		2				2
	Total	6	40	2	2		52
	% of identified ling	3.4%	6.6%	1.8%	2.2%		4.8%

Table 16: Summary of comparative material from Castle Street, 16-18 Netherkirkgate, 30-46 Upperkirkgate, Gallowgate Middle School and 45-75 Gallowgate (Cameron and Stones 2001)

Taxa	12-13th c		13-14th c[1,2]		14-15th c[1]		15-18th c[2]		18-20th c[2]	
Cod	119	56%	282	41%	69	54%	91	50%	43	37%
Ling	42	20%	230	33%	45	35%	37	20%	28	24%
Haddock	7	3%	23	3%	3	2%	7	4%	10	9%
Gadid	40	19%	153	22%	11	9%	46	25%	31	27%
Salmon									1	1%
Flatfish									1	1%
Saithe/pollack	5	2%	3	0%					1	1%
Turbot	1	0%								
Total identified	214	100%	691	100%	128	100%	181	100%	115	100%
Not identified	99		263		34		8		25	

1. includes 'some' sieved material from 16-18 Netherkirkgate, quantity unknown
2. includes 'some' sieved material from 45-75 Gallowgate, quantity unknown

Table 17: Pathology summary

Phase and feature	Species	Element and size	Description
Phase 1			
C1, Pit 001	Cod	Caudal vertebra group 2, 80-100cm TL	Slight flattening and splaying of anterior articular surface
	Cod	Caudal vertebrae group 2, 80-100cm TL	Two vertebrae with slightly flattened articular facets
C1, Pit 015	Cod	Premaxilla, 80-100cm TL	New bone growth on tooth surface at medial articulation; possible tooth abscess (Figure 30)
	Cod	Abdominal vertebrae group 3, 80-100cm TL	Two separate vertebrae, both with a flared articular surface and a shortened and twisted vertebral body (Figure 34)
	Cod	Abdominal vertebrae group 3, >100cm TL	Two instances of paired fused vertebrae, bodies shortened and slightly flared (one illustrated in Figure 34)
	Cod	Abdominal vertebra group 1, >100cm TL	Slightly shortened and thickened vertebral body
	Cod	Abdominal vertebra group 1, >100cm TL	Shortened vertebral body, worn articular facet (Figure 34)
	Cod	Abdominal vertebrae group 2 and 3, 80-100cm TL	?Six articulating vertebrae, all skewed, twisted and shortened, with splayed articular facets (Figure 36)
Phase 2			
C2, Hollow 002	Cod	Articular, >100cm TL	Large bone growth on lateral side, consisting of dense, smooth spheres of new bone (Figure 39)
C2, Layer 003	Ling	Maxilla, >100cm TL	'Peeling' of original bone surface, exposing inner layers of bone with some new bone growth on new inner surface (Figure 33)
	Cod	Quadrate, >100cm TL, probably c. 150cm TL	Articular facet shows signs of polishing, grooving and eburnation (Figure 25)
	Cod	Abdominal vertebra group 3, >100cm TL	Slight extra bone growth around ventral edges of articular facets
	Cod family	Caudal vertebra group 2, >80cm TL	Vertebral body of squashed and shortened appearance, with large, splayed articular facets; identification to species difficult because of changed morphology
	Cod	Dentary, >100cm TL	Extra indentation adjacent to the lateral foramen
C2, Pit 022	Ling	Dentary, >100cm TL	Distortion and new bone growth around medial articulation (Figure 28)
C2, Pit 032	Cod	Dentary, >100cm TL	Distortion, pitting and new bone growth to medial articulation (Figure 29)
	Cod	Ceratohyal, >100cm TL	Distortion and new bone growth to proximal articulation (Figure 41)
C2, Pit 033	Cod family	Abdominal vertebra group 1, 80-100cm TL	Squashed vertebral body with splayed articular facets; changes to morphology make identification to species difficult
C2, Pit 034	Ling	Articulated cranium, mostly complete, >100cm TL	Several instances of extra bone growth, twisted or skewed morphology and lesions to the neurocranium; these are possibly cancerous growths (Figure 40)
	Cod	Maxilla, 80-100cm TL	Wear and eburnation to medial articulation (Figure 26)
	Cod	Maxilla, >100cm TL	Squashed appearance with bone loss and reshaping to medial articulation (Figure 27)
	Ling	Dentary, >100cm TL	Bone loss around tooth sockets with new growth and layering on lateral edge, possible tooth abscess (Figure 38)
	Cod	Dentary, >100cm TL	New bone growth and layering on medial aspect,

			near medial articulation (Figure 32)
	Ling	Ceratohyal, >100cm TL	Large lump of new bone growth with mammal-like texture and appearance
C2, Stakes 002	Cod	Dentary, 80-100cm TL	Shallow, elongated indentation just ventral to tooth row, and just posterior to the usual foramen
Phase 3			
C3, Pit 042	Cod	Abdominal vertebra group 3, 80-100cm TL	Distorted vertebral centrum with new bone growth around edges of articular facets
C3, Pit 047	Cod	Abdominal group 3 vertebrae, >100cm TL	Four fused vertebrae, vertebral bodies shortened and flared (Figure 35)
Phase 4			
C4, Layer 075	Cod	Abdominal vertebrae group 1, 80-100cm TL	Two fused vertebrae with slight remodelling to articular facets
C4, Posthole 003	Cod	Dentary, >100cm TL	Extra bone growth in layers near medial articulation, ventral to tooth row and on inside of mouth (Figure 31)
Phase 1 (or later)			
C1 (or later), Pit 007	Ling	Dentary, >100cm TL	Bone growth and remodelling on and ventral to the tooth row near the medial articulation; possible deep tooth abscess (also gnawed) (Figure 37)

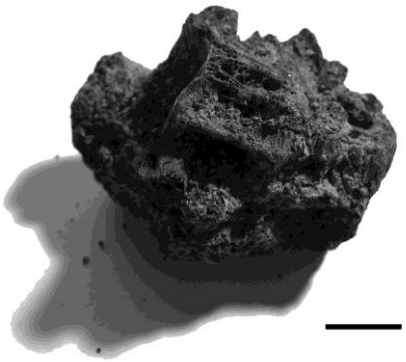


Figure 1: Example of concretions surrounding 2 cod vertebrae from C3, Pit 047 (scale 1cm)

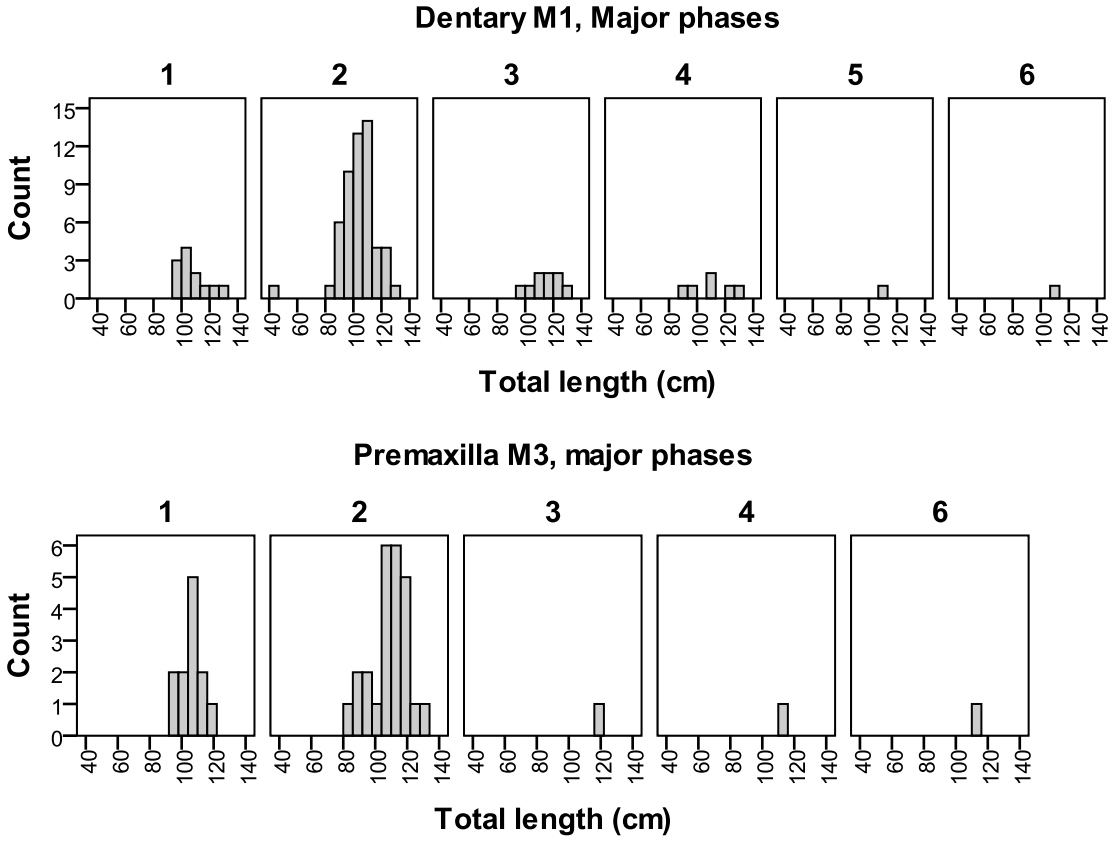
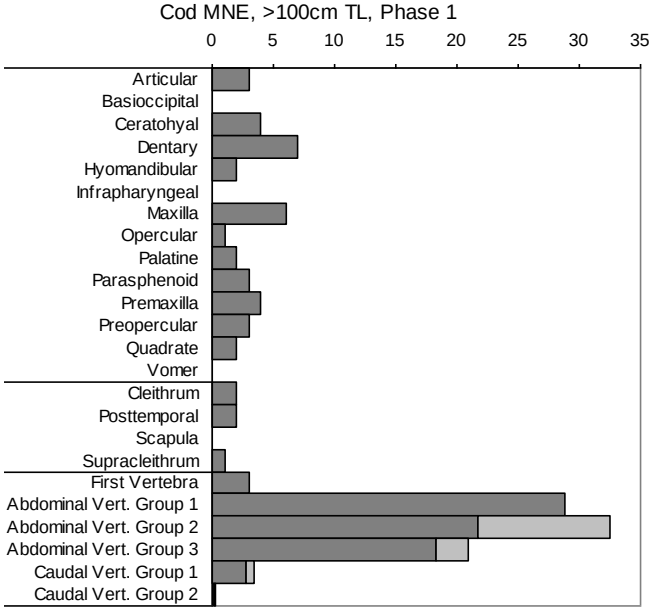
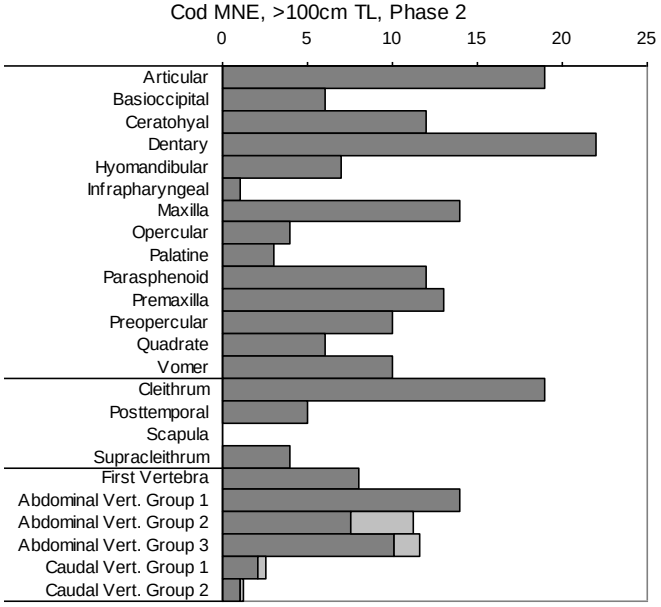
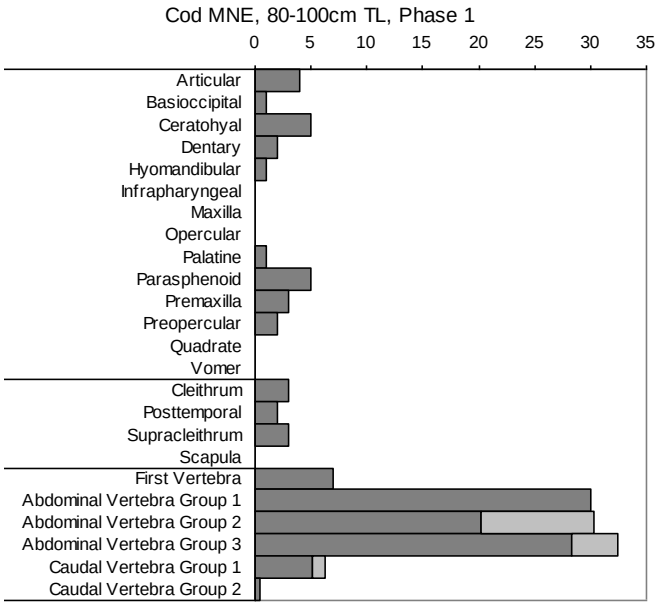
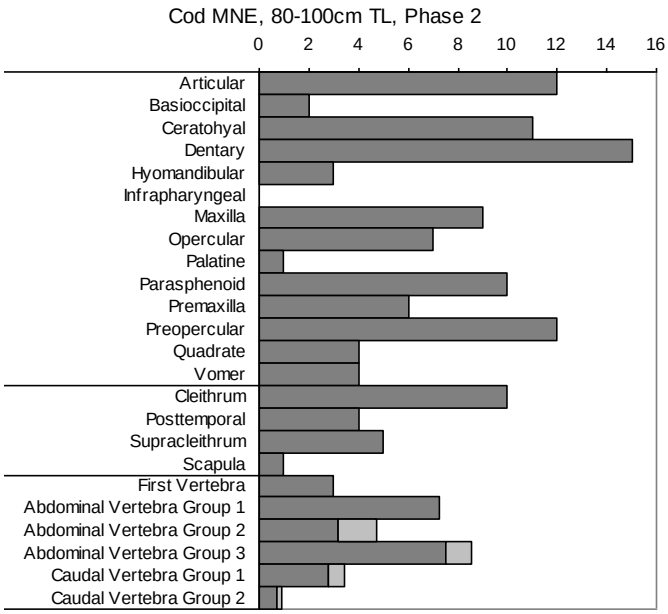


Figure 2: Cod size histograms, based on regression formulas applied to selected measurements


Cod MNE, >100cm TL, Phase 1
0 5 10 15 20 25 30 35
Articular
Basioccipital
Ceratohyal
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid
Premaxilla
Preopercular
Quadrate
Vomer
Cleithrum
Posttemporal
Scapula
Supracleithrum
First Vertebra
Abdominal Vert. Group 1
Abdominal Vert. Group 2
Abdominal Vert. Group 3
Caudal Vert. Group 1
Caudal Vert. Group 2


Cod MNE, >100cm TL, Phase 2
0 5 10 15 20 25
Articular
Basioccipital
Ceratohyal
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid
Premaxilla
Preopercular
Quadrate
Vomer
Cleithrum
Posttemporal
Scapula
Supracleithrum
First Vertebra
Abdominal Vert. Group 1
Abdominal Vert. Group 2
Abdominal Vert. Group 3
Caudal Vert. Group 1
Caudal Vert. Group 2


Cod MNE, 80-100cm TL, Phase 1
0 5 10 15 20 25 30 35
Articular
Basioccipital
Ceratohyal
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid
Premaxilla
Preopercular
Quadrate
Vomer
Cleithrum
Posttemporal
Supracleithrum
Scapula
First Vertebra
Abdominal Vertebra Group 1
Abdominal Vertebra Group 2
Abdominal Vertebra Group 3
Caudal Vertebra Group 1
Caudal Vertebra Group 2


Cod MNE, 80-100cm TL, Phase 2
0 2 4 6 8 10 12 14 16
Articular
Basioccipital
Ceratohyal
Dentary
Hyomandibular
Infrapharyngeal
Maxilla
Opercular
Palatine
Parasphenoid
Premaxilla
Preopercular
Quadrate
Vomer
Cleithrum
Posttemporal
Supracleithrum
Scapula
First Vertebra
Abdominal Vertebra Group 1
Abdominal Vertebra Group 2
Abdominal Vertebra Group 3
Caudal Vertebra Group 1
Caudal Vertebra Group 2

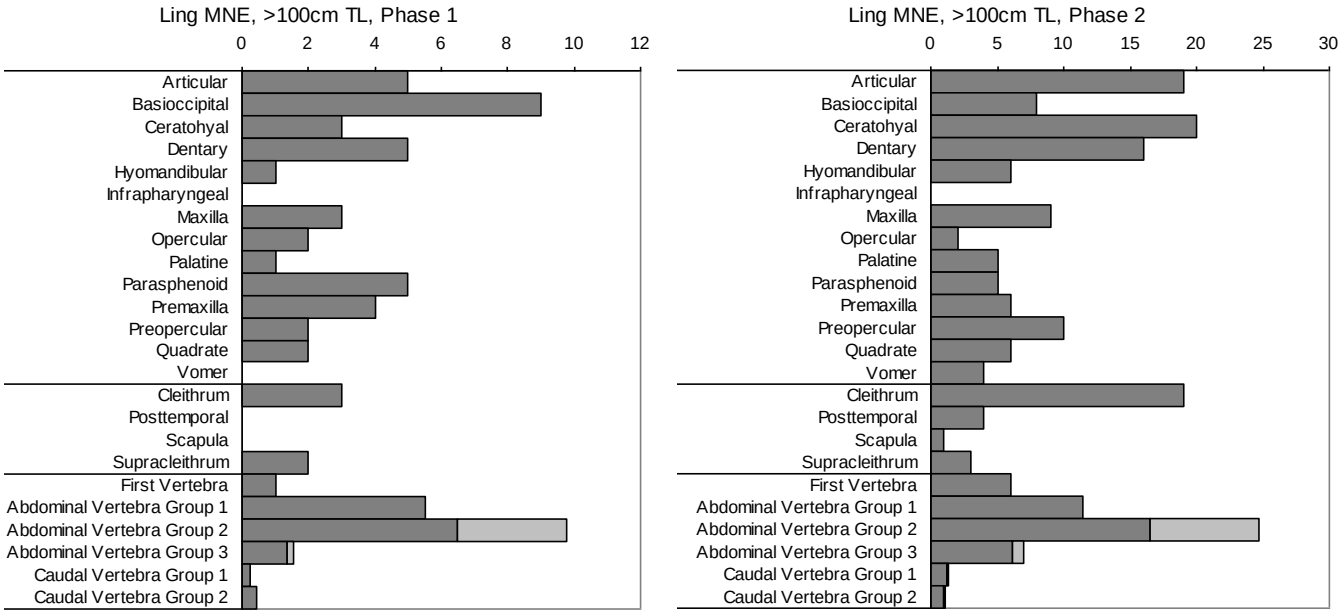


Figure 3: Cod and ling minimum number of elements for phases 1 and 2, hand collected data only, taking into account fragmentation and number of elements in the body (lighter bars indicate the range of MNE for vertebrae, because there is natural variation in the numbers of vertebrae in cod and ling)

Figure 4: Six butchered cod caudal vertebrae, viewed from posterior, each with a sagittal chop removing part of the left posterior vertebral centrum, feature C1 Pit 015 (scale 1cm)

Figure 5: Butchered cod abdominal vertebra photographed from posterior, displaying sagittal chop from posterior towards anterior that did not fully split the vertebral centrum, feature C2, Spread 043 (scale 1cm)

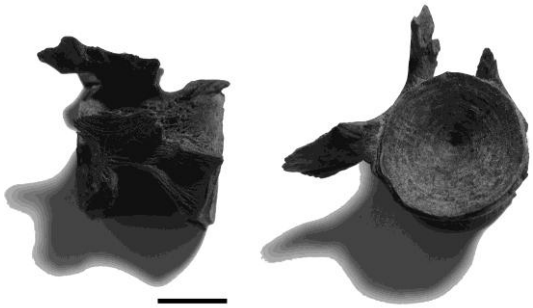


Figure 6: Two views of the same ling vertebra, showing sagittal chop to remove left processes, travelling from posterior towards anterior, feature C2 Layer 003 (scale 1cm)

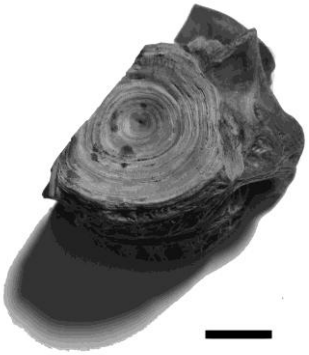


Figure 7: Two articulating cod vertebrae, butchered in the sagittal plane to remove a diagonal slice of the left side of the centra, angled towards posterior, photo taken from posterior, feature C2, Pit 037 (scale 1cm)

Figure 8: Cod vertebra with small knife mark in sagittal plane, on left process, feature C2, Spread 043 (scale 1cm)

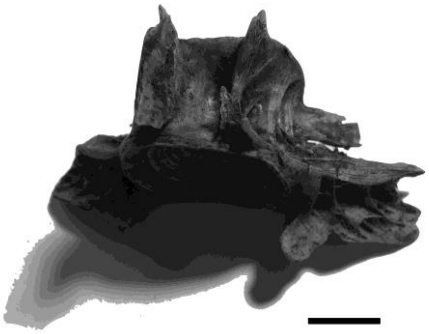


Figure 9: Butchered cod abdominal vertebra, small sagittal knife marks to left process, feature C4, Posthole 003 (scale 1cm)

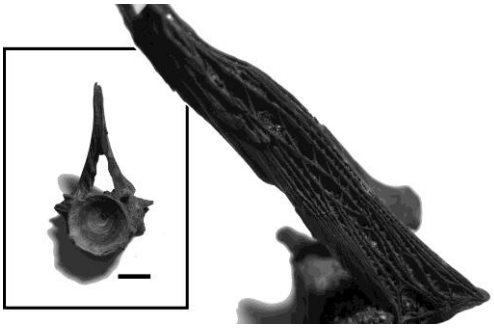


Figure 10: Butchered cod vertebra (inset) with detail of sagittal cut marks on neural spine, right side, feature C1, Pit 015 (scale 1cm)

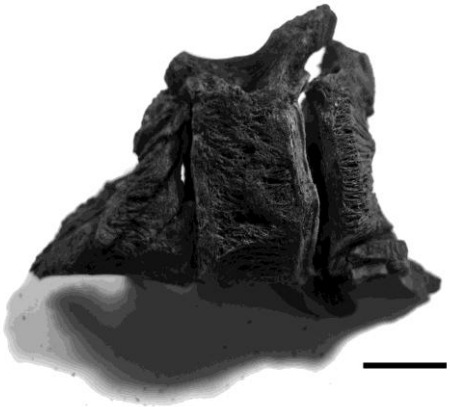


Figure 11: Sequence of ling basioccipital, first vertebra and abdominal vertebra, with multiple butchery in the frontal and transverse planes , feature C1, gully 001 (scale 1cm)

Figure 12: Butchered ling abdominal vertebra showing transverse chop mark on ventral surface, feature C2, Pit 025 (scale 1cm)

Figure 13: Butchered cod caudal vertebra, showing transverse chop mark to left side, feature C4, Posthole 003 (scale 1cm)

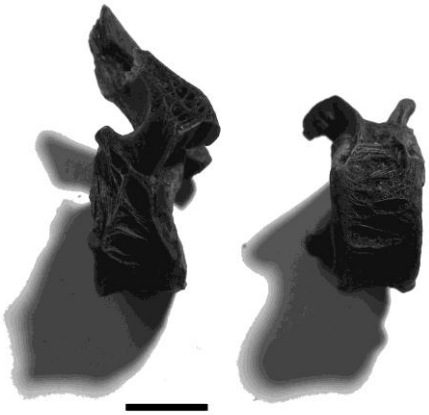


Figure 14: Two aspects of the same cod abdominal vertebra, showing transverse cut to the ventral aspect, right side view (left image) and ventral view (right image), feature C4, Posthole 003 (scale 1cm)

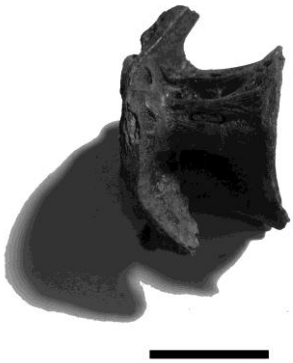


Figure 15: Butchered cod caudal vertebra, showing small transverse knife mark on right side, unstratified (scale 1cm)

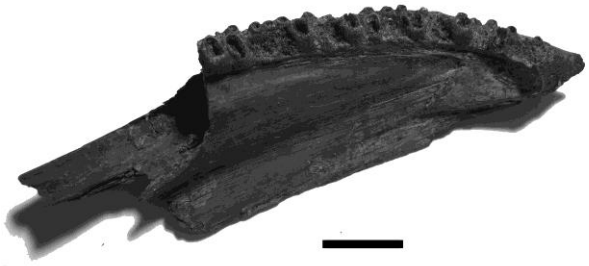


Figure 16: Butchered cod dentary chopped in the sagittal plane at the medial articulation, feature C2, Pit 018 (scale 1cm)

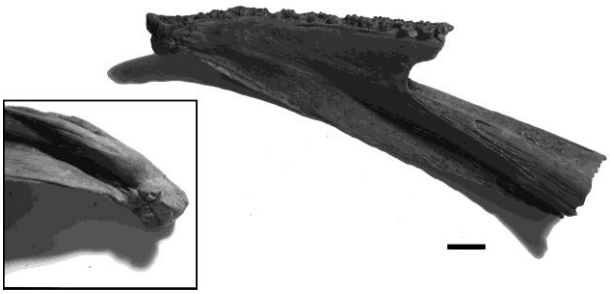


Figure 17: Butchered cod dentary chopped in the sagittal plane at the medial articulation, chopped from ventral posterior towards dorsal anterior, inset showing ventral view, feature C3, Layer 005 (scale 1cm)

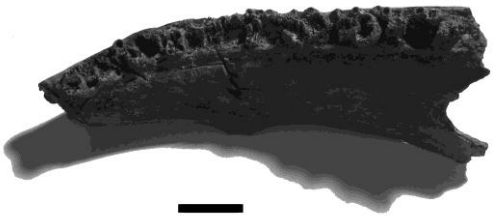


Figure 18: Butchered cod dentary, chopped in the sagittal plane to remove the medial articulation, with two additional butchery marks adjacent indicating direction of chop from posterior towards anterior, feature C2, Pit 034 (scale 1cm)

Figure 19: Butchered cod premaxilla, chopped in sagittal plane removing medial articulation, feature C2, Pit 025 (scale 1cm)

Figure 20: Butchered cod premaxilla, chopped in the sagittal plane removing small slice of medial articulation, and with additional parallel chop marks indication direction of chop was posterior towards anterior, feature C1, Pit 015 (scale 1cm)

Figure 21: Butchered cod cleithrum, chopped in the frontal plane leaving the dorsal tip, feature C2, Pit 024 (scale 1cm)

Figure 22: Butchered ling cleithrum, displaying small chop in the frontal plane on the dorsal, anterior edge, feature C2, Pit 024 (scale 1cm)

Figure 23: Butchered cod cleithrum, showing frontal knife marks on medial side, at the anterior edge of the dorsal tip, feature C4, Posthole 003 (scale 1cm)

Figure 24: Butchered cod supracleithra with small knife mark, feature C2, Spread 043 (scale 1cm)

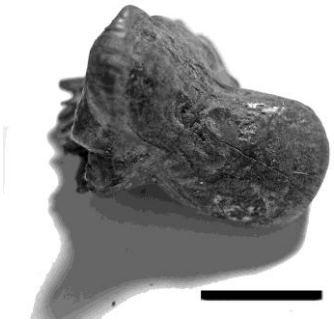


Figure 25: Pathological cod quadrate, feature C2, Layer 003 (scale 1cm)

Figure 26: Pathological cod maxilla, feature C2, Pit 034 (scale 1cm)

Figure 27: Pathological cod maxilla, feature C2, Pit 034 (scale 1cm)

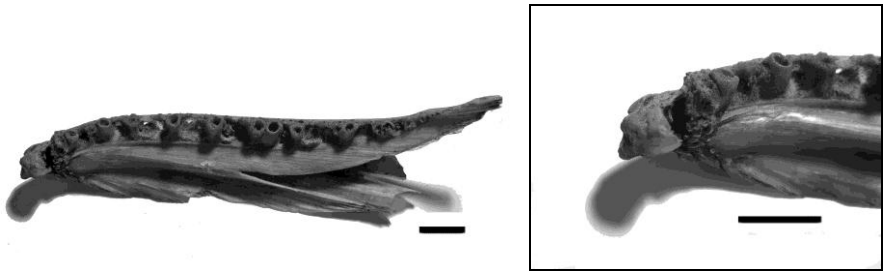


Figure 28: Pathological ling dentary, inset showing detail of medial articulation, feature C2, Pit 022 (scale 1cm)

Figure 29: Pathological cod dentary, feature C2, Pit 032 (scale 1cm)

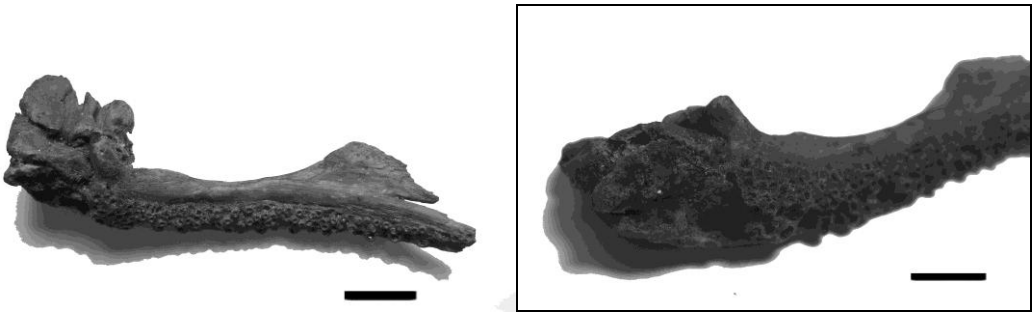


Figure 30: Pathological cod premaxilla, inset showing tooth row detail, feature C1, Pit 015 (scale 1cm)

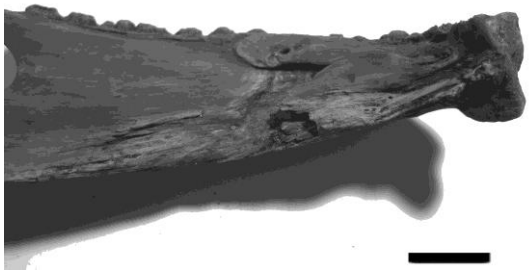


Figure 31: Detail of pathological cod dentary, feature C4, Posthole 003 (scale 1cm)

Figure 32: Pathological cod dentary, feature C3, Pit 034 (scale 1cm)

Figure 33: Pathological ling maxilla, feature C2, Layer 003 (scale 1cm)

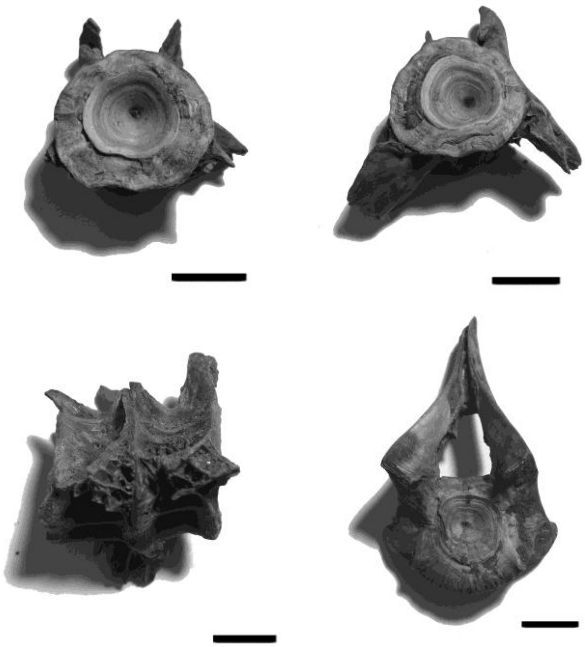


Figure 34: Pathological cod vertebrae, feature C1, Pit 015 (scales 1cm)

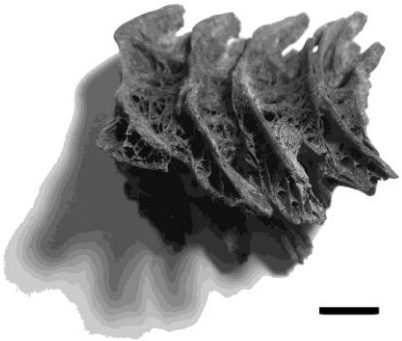


Figure 35: Pathological cod vertebrae, feature C3, Pit 047 (scale 1cm)

Figure 36: Pathological cod vertebrae, feature C1, Pit 015, ventral view and side view (scale 1cm)

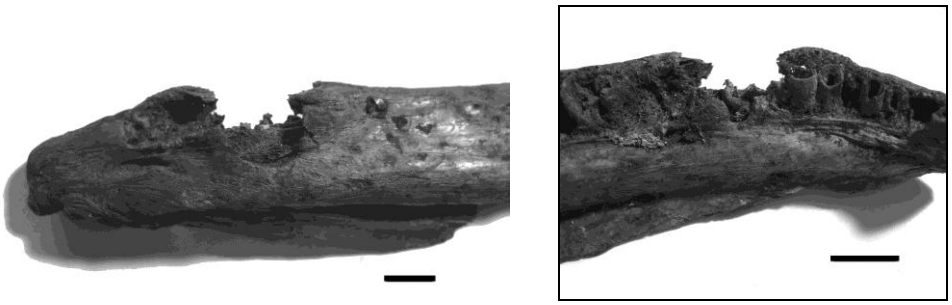


Figure 37: Pathological ling dentary, inset showing tooth row detail, feature C1 (or later), Pit 007 (scale 1cm)

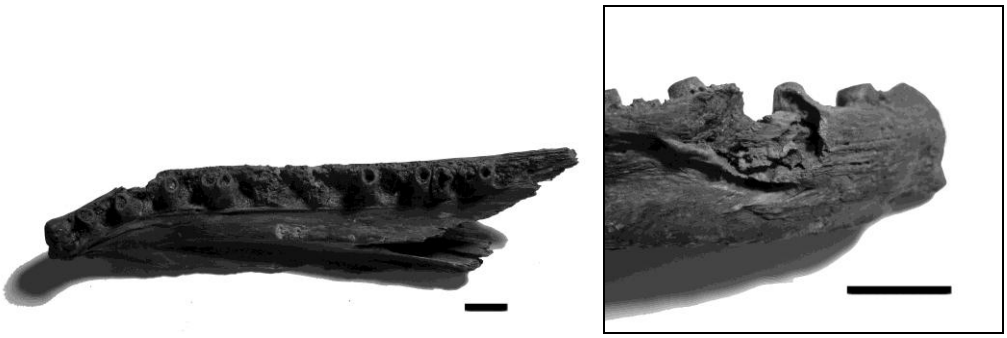


Figure 38: Pathological ling dentary, inset showing lateral details, feature C2, Pit 034 (scale 1cm)

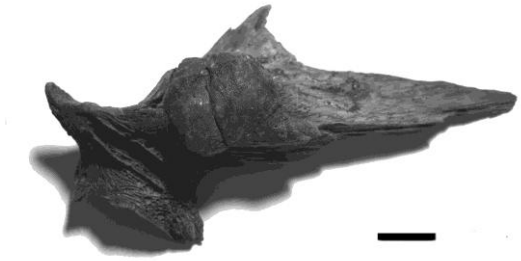


Figure 39: Pathological cod articular, feature C2, Hollow 002 (scale 1cm)

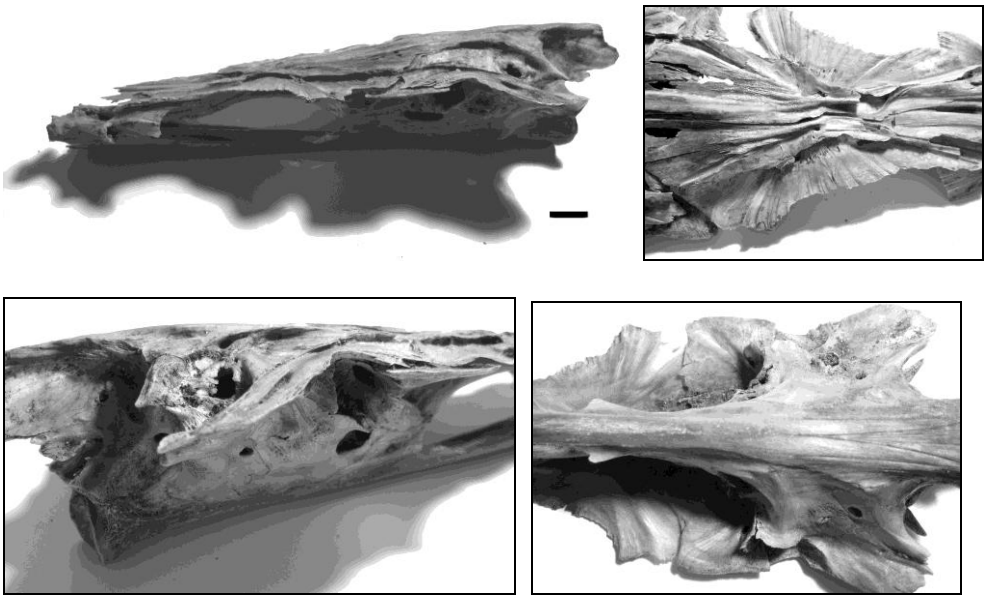


Figure 40: Pathological ling cranium, left side view (top left image), with details of frontal bone (top right image), right posterior cranium (lower left image) and ventral view (lower right image), feature C2, Pit 034 (scale 1cm)

Figure 41: Pathological cod ceratohyal, feature C2, Pit 032 (scale 1cm)

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