Fish Bones, Isotopes, and Microscopes: A Pilot Study in Applying Analytical Methods to Iron Age Faunal Remains

by ALEX FITZPATRICK

Abstract: Previous research on the Iron Age in Britain has argued that no fishing occurred during this period in Britain. This argument has now been complicated by large assemblages of fish bones that have been excavated from Iron Age sites in the Northern Isles. Further investigation into this issue became the focus of the author’s MSc dissertation research in 2016, specifically on the recently excavated fish bone assemblages from the site of Swandro on Rousay, Orkney. Analytical methods, including stable isotope analysis and scanning electron microscopy, were applied in an attempt to determine how the fish may have been utilised at the site. Results have revealed evidence that could be interpreted as fishing activity and possible consumption by humans at Swandro.

This paper disseminates and further examines these results and considers how this particular project is useful as a pilot study in the application of analytical methodologies to problematic faunal remains such as fish, and why this could be important to future zooarchaeological and environmental archaeological research.

Keywords: Iron Age, Fish, Zooarchaeology, Isotope Analysis, Scanning Electron Microscopy

Introduction

Dobney and Ervynck (2007) have previously argued that fishing was an insignificant source of subsistence in the British Iron Age. This argument has been supported by the widespread absence of archaeological and textual evidence related to fishing activity during the period. However, there have been significant amounts of fish bones recovered from Iron Age sites in the Northern Isles and North Atlantic Scotland (Cerón-Carrasco 1998; Dockrill et al. 2015; Nicholson 1997; Russ et al. 2012).

The Knowe of Swandro

The Knowe of Swandro, located on the island of Rousay (Figure 1), is part of the Orkney Islands north of mainland Scotland. The Orkney Islands are known for having a high concentration of archaeological sites, with Rousay referred to as the “Egypt of the North” (Tait 2011:464) due to the many tombs that have been discovered on the island. The majority of archaeological remains from the Orkney Islands reflect the Norse expansion during the Viking Age, although there is also a significant amount of cairns and brochs dating to the Neolithic and Iron Age (Fenton 1997:2; Tait 2011:464-468).

Figure 1 Location map of the site at Swandro on the island of Rousay, Orkney
Source: Ruth Maher, Gateway to the Atlantic Project, 2012
The site at Swandro is a multi-period site, with a complex narrative that spans approximately 4,000 years, from the Neolithic to the Viking Age. Buildings at the site have been identified as a Neolithic chambered cairn, with several Iron Age buildings nearby (Dockrill and Bond 2013a). Archaeological finds from Swandro illustrate the reoccupation of a Pictish settlement by the Vikings, an example of a prevalent cultural exchange between the Pictish and the Vikings that can be observed at sites across the Orkney Islands (Fenton 1997:12). Rising sea levels and heavy erosion caused by global climate change have radically altered the coastline of Swandro, unfortunately destroying much of the archaeological site (Dockrill and Bond 2013a).

The site was originally uncovered in 2010 by Dr. Julie Bond (Towrie 2014). Current excavations at Swandro are part of an ongoing project called Gateway to the Atlantic; this also includes an intensive summer field school to excavate the site by students from the University of Bradford, the University of the Highlands and Islands, William Patterson University, and the City University of New York. The focus of this project, which is also associated with the North Atlantic Biocultural Organisation (NABO), is to examine the cultural and environmental changes that occurred at Swandro and how these changes may have affected the relationship between the inhabitants and the surrounding environment (Dockrill and Bond 2013b).

Fish bone assemblages recovered from recent excavations at Swandro were analysed as part of the author’s MSc dissertation at the University of Bradford (Fitzpatrick 2016). The aims of this dissertation research were twofold: to determine the role of fish within the Iron Age context of the site, and to reconstruct the Iron Age environment from which these fish were from. These aims were to be fulfilled through analysis that emphasised scientific methodology that has only recently been used for investigating small archaeofaunal such as fish bones.

Fish in the Archaeological Record

In order to stress the importance of further research in the analysis of fish remains, it is necessary to provide a brief overview of current archaeological approaches to fish bones. When compared to other zooarchaeological research, the research literature in archaeoichthyology is lacking. This is likely due to a lack of resources and specialists at hand (Wheeler and Jones 1989:6-7) as well as the prevailing attitude among many archaeologists that fish bones do not warrant as careful examination as other faunal remains.

Within the last few decades, however, zooarchaeologists have re-examined the benefits of focusing analysis on fish bone assemblages, especially with advances in technology and scientific methods. Much of the recent research undertaken on fish bones has been aimed at extracting as much information as possible out of these fragile and often highly fragmented bones; for example, Van Neer et al. (2002) have built on previous research on size estimation of fish from Watt et al. (1997) by investigating the usefulness of otoliths as another indicator of age. More recent research has utilised stable isotope analysis to further investigate questions on the locality of fish remains (Barrett et al. 2011; Orton et al. 2011; Orton et al. 2014), as well as the effect of marine sources on diet in the past (Barrett et al. 2001; Barret and Richards 2004; Craig et al. 2013).

Materials

A total number of 1,884 individual fish bones were identified and further analysed for the author’s dissertation research. These samples were recovered from excavations at Swandro from 2011 to 2015, following the standards and procedures established in the excavation manual used at the site (Dockrill et al. 2005:73-86). Larger specimens were recovered by hand during excavation as “tray finds”, but most specimens, due to the average size, were recovered from bulk samples that were processed using water flotation and sieving with a 1mm mesh. Further sieving and sorting of bulk samples to retrieve small fish bones was undertaken by placement students during post-excavation analysis.

Due to the time constraints of MSc dissertation research, it was impossible to consider every single fish specimen excavated from site. However, a conscious effort was made during sample selection to represent each of the five areas (referred to as Areas A-E) of the Iron Age section of Swandro. It should be noted for clarification that the Iron Age section was originally divided into four areas (Areas A-D), but a new area between Area A and Area D was opened during the 2013 excavation season; Areas A and D were consolidated with this new area to form Area E (Dockrill and Bond 2013b). To reflect the original recovering and
recording of these samples, however, all five areas will be referred to within the discussion and analysis of the specimens below.

Specimens were identified to both species of animal and bone element (i.e. humerus, tibia, etc.) using comparative osteology (Perdikaris et al. 2004). Many specimens were only identifiable to family level, and others were completely unidentifiable with regards to species; however, all were identifiable to bone element. Preservation overall was good, as demonstrated by the large amount of small bones to survive.

Element Identifications

A total of 54 cranial elements were identified, with premaxillae making up the majority (Figure 2). Most bones, however, were identified as post-cranial, specifically vertebrae (Table 1); this is not surprising, as vertebrae have a high survival rate (Nicholson 1992). The high volume of vertebrae and time constraints led to the decision not to identify each individual vertebra to species. One otolith was recovered from the Area E assemblage, but fragmentation prevented conclusive species identification. No further analysis was undertaken on the otolith in order to preserve it for future reference; otoliths are notably rare to recover due to their structural composition (Disspain et al. 2016). 1,824 fish scales were also recovered from Area E, but were also not identified to species due to a lack of resources for fish scale identifications. Smaller elements, such as teeth, ribs, rays, and spines, were recovered, but not included in the total quantification; this is due to a possible issue of overrepresentation for certain species (Nicholson in Dockrill et al. 2015:228).

Figure 2 Graph illustrating total numbers for each cranial element from each area of Swandro.

<table>
<thead>
<tr>
<th>Cranial Element</th>
<th>Area A</th>
<th>Area B</th>
<th>Area D</th>
<th>Area E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dentary</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ceratohyal</td>
<td>1</td>
<td>11</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Articular</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Cleithrum</td>
<td>1</td>
<td>11</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Epiphysal</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Opercular</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pharyngeal</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Preopercular</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Maxilla</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Vomer</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Quadrat</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Premaxilla</td>
<td>6</td>
<td>13</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hyomandibular</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Precaudal Vertebrae</th>
<th>Caudal Vertebrae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area A</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Area B</td>
<td>11</td>
<td>47</td>
</tr>
</tbody>
</table>
Table 1: Total numbers of precaudal and caudal vertebrae from each area of Swandro.

<table>
<thead>
<tr>
<th>Area</th>
<th>Precaudal</th>
<th>Caudal</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>D</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>E</td>
<td>219</td>
<td>1483</td>
</tr>
</tbody>
</table>

Species Identifications

Although many specimens were identifiable to species level, most were only identifiable to the Gadididae family (Figure 4, Table 2). Other species represented in the assemblages include Atlantic cod (*Gadus morhua*), saithe (*Pollachius virens*), and ling (*Molva molva*). One monkfish (*Lophius piscatorius*) specimen was also recovered from Area A (Figure 3).

Specimens that were missing diagnostic components and which could not be identified to any level of taxa were recorded as “unidentified”. Although vertebrae were not identified to species, brief examination shows that most are probably from gadid species, specifically small saithe. The largest vertebra recovered was identified as Atlantic cod.

Figure 3: Monkfish (*Lophius piscatorius*) dentary bone from Swandro

*Source: Author, 2016*
Assemblage

Figure 4 Graph illustrating number of individual specimens (NISP) totals for each identified species (based only on cranial elements) from each area of Swandro.

<table>
<thead>
<tr>
<th>Taxa</th>
<th>NISP Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gadidade Family</td>
<td>23</td>
</tr>
<tr>
<td>Atlantic cod (Gadus morhua)</td>
<td>10</td>
</tr>
<tr>
<td>Saithe (Pollachius virens)</td>
<td>7</td>
</tr>
<tr>
<td>Ling</td>
<td>3</td>
</tr>
<tr>
<td>Monkfish</td>
<td>1</td>
</tr>
<tr>
<td>Unidentified</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 2 Total numbers of NISP of cranial elements for each identified taxa

Analytical Methods

Scanning Electron Microscopy

Due to the average size of the fish bones, scanning electron microscopy (SEM) was utilised to examine a sample size of twenty saithe vertebrae for any characteristics indicating anthropogenic modification (butchery, cooking) or consumption (either by humans or other animals – this could not be differentiated through physical markers alone).

The FEI Company Quanta 400 scanning electron microscope was used for analysis. No coating was used on samples as the SEM microscope was only used for the purposes of imaging, which were acquired using Oxford Instruments Inca Software. To capture entire samples for imaging, they were viewed at magnifications between 25x-200x and under a low vacuum, with a working distance between 10-16mm. Accelerating voltage was kept at 20kV to ensure good resolution without damaging samples (Richards et al. 1999).

Stable Isotope Analysis

The carbon and nitrogen values of the collagen in nine specimens from the Gadidae family were determined using stable isotope analysis. Selected specimens were chosen to represent both cranial and post-cranial elements, due to issues with locality; cranial elements often reflect locally caught fish, while post-cranial elements may reflect local fish or long-distance traded fish (Barrett et al. 2011).

Each sample was measured to between 500-700mg for collagen extraction when possible, although several samples could only be weighed out to between 200-400mg. Collagen extraction and preparation followed procedure established by Richards and Hedges (1999); although fish collagen is highly variable in composition and may have higher C : N ratios than human collagen (Korzow 2009), a traditional 2.9 – 3.6 range used for determining good quality ratio values (DeNiro 1985) could still be applied to fish bones without alteration (Szpak 2011).

Samples were filtered using filtered using 8µ Ezeec© filters (Elkay Laboratory Products (UK) Ltd) to remove any unwanted particles and then placed in the Heto Drywinner freeze-dryer after kept in a freezer at -35 °C for several days. These samples were run through a Delta Plus XL mass spectrometer with Flash 11-12 series elemental analyser alongside in-house standards (fish gelatine and bovine liver) and international standards (IAEA-600, IAEA-N1, and IAEA-CH3).

Results

Results from the analytical methods were inconclusive due to several factors. The short amount of time allotted for MSc dissertation research meant that only small sample sizes could be analysed. Swandro is also still in the process of being excavated, so data that could have been used for comparative analysis (such as human bone isotopes) was not available. However, the methods did produce usable datasets that were utilised for general interpretation and ultimately could be seen as evidence for the success of the project as a methodology-based pilot study.

Scanning Electron Microscopy

The main goal of SEM analysis was to identify any microscopic indicators of modification. Samples were selected based on physical characteristics that were observed by eye during identification and recording. Characteristics of interest included deformations of the vertebral body and breakage that could indicate instances of erosion. Several burnt vertebrae were also analysed.
SEM analysis showed that most vertebrae were only indicative of normal abrasion and breakage due to taphonomic processes. No signs of butchery or marks indicating modification were observed; however, it should be noted that such marks are usually found on the haemal and neural spines, ribs, and vertebral processes (Willis et al. 2008), which were not analysed for this research. Only one vertebra (Figure 5) showed significant compression of the vertebral body that can be attributed to digestion (Butler and Schroeder 1998).

Stable Isotope Analysis

Collagen yield for samples were relatively low, but all resulting atomic C : N ratios fell within the range from DeNiro (1985) that indicates good quality data. Analysis was performed twice for each sample, with the resulting values averaged together (Table 3). Results from the isotope analysis are normative with what would be expected from fish (Figure 6); generally, fish tend to exhibit higher nitrogen values in comparison to terrestrial animals, but carbon values may be lower depending on the individual’s diet. These values may also vary among fish depending on environmental factors (Richards and Hedges 1999).

The close proximity of the isotope values indicates that these fish probably originated locally from the same area. Two outliers, both cranial elements, were observed to have higher than average nitrogen values. As these isotopes will reflect dietary habits, it is likely that the outliers represent fish that consume smaller fish for sustenance. Alternatively, the outliers could reflect older fish, as trophic levels increase with age in fish (DeNiro and Epstein 1978; Minagawa and Wada 1984).
Figure 6 Graph illustrating carbon and nitrogen isotope values for select gadid cranial and post-cranial samples from Swandro.

Table 3 Table of carbon and nitrogen isotope values for select gadid cranial and post-cranial samples from Swandro.

<table>
<thead>
<tr>
<th>Sample</th>
<th>$\delta^{15}$N</th>
<th>$\delta^{13}$C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranial 1</td>
<td>12.72</td>
<td>-13.84</td>
</tr>
<tr>
<td>Cranial 2</td>
<td>12.61</td>
<td>-13.46</td>
</tr>
<tr>
<td>Cranial 3</td>
<td>14.86</td>
<td>-12.83</td>
</tr>
<tr>
<td>Cranial 4</td>
<td>12.47</td>
<td>-13.92</td>
</tr>
<tr>
<td>Cranial 5</td>
<td>15.51</td>
<td>-12.85</td>
</tr>
<tr>
<td>Cranial 6</td>
<td>12.95</td>
<td>-14.00</td>
</tr>
<tr>
<td>Cranial 7</td>
<td>13.63</td>
<td>-13.94</td>
</tr>
<tr>
<td>Postcranial 1</td>
<td>12.02</td>
<td>-13.32</td>
</tr>
<tr>
<td>Postcranial 2</td>
<td>13.22</td>
<td>-13.87</td>
</tr>
</tbody>
</table>

Discussion

It should be noted that despite inconclusive results, general interpretations can still be made based on the data that was available. The composition of the assemblages from Swandro reflected similar trends observed at other North Atlantic Iron Age sites, with gadid species, such as cod and saithe, making up the majority (Nicholson 1997; Cerón-Carrasco 1998; Russ et al. 2012). This could indicate a similar fishing strategy that has previously been observed in the Late Iron Age in the North Atlantic, as gadid species were specifically targeted as a marine resource (Nicholson in Dockrill et al. 2015:228). It can
be deduced, based on the species’ region and seasonality (Froese and Pauly 2018), that fishing at Swandro consisted of both shallow, coastline fishing as well as some deep sea fishing. Smaller fish would have been caught using nets, and larger fish would have been caught using basic hook and line fishing.

The SEM analysis identified the presence of a digested vertebra in the assemblage, but this does not automatically indicate human consumption. This could be consumption from other predators, including otters; this point in particular is worth further investigation, as otter spraint (excrement used for the purposes of communication and marking of territory) has been observed in Britain near settlements and other centres of human activity (Kruuk et al. 1998). As there has been little research done on otter spraint in the Orkney Islands, Harland and Parks (2008) suggest utilising findings from the work of Kingston et al. (1999) on otter spraint found on the Aran Islands, located on the west coast of Ireland. Considering the results from this research, there is a possibility the digestion represents otter spraint rather than human consumption, but this cannot be confirmed. Although the digested vertebra matches the elemental composition found mostly in spraint, this interpretation cannot be totally confirmed as the Swandro vertebra has been identified as saithe, which is found less often due to the evasiveness of the fish.

Additional evidence recovered from site is also more indicative of human consumption; for example, the burnt bone and significant amount of cranial elements recovered suggests that this part of Swandro was used for processing (i.e. removal of heads) prior to preparation (i.e. hanging fish above a fire) and consumption on site. During excavation, an oven-like structure was recovered, providing further evidence for on-site processing.

On its own, the stable isotope analysis adds little to interpretation. Ideally, the results from analysis of the fish bone samples would be compared to available human remains from the same site to provide information regarding diet. However, no human remains had been recovered from the site of Swandro at the time of this research. Some general conclusions can be drawn based on previous isotope analysis that has been undertaken on human remains from other Iron Age sites in the Orkney Islands (based on Barrett et al. 2001). Low carbon isotope values seen in human remains from these sites indicate a diet with very little marine protein; assuming these results would be similar to a hypothetical set of isotope values from the humans at Swandro, this would imply that although fish were certainly caught and consumed, it was not in quantities large enough to significantly affect trophic values. Another interpretation based on excavated artefacts from Swandro, such as stone lamps, may be that the fish remains were waste from the production of fish oil (Nicholson in Dockrill et al. 2015:237-238).

**Conclusions**

If this research is ultimately being applied as a methodology-driven pilot study, it is important to consider both the data and the process of applying the methods as part of the results. Based on the general conclusions made from the available data, there is potential for further analysis that would be significant for the environmental and additional dietary reconstruction of Swandro. For example, microanalysis using SEM on smaller elements, such as haemal and neural spines, has potential for indicating butchery; preliminary analysis with an optical microscope prior to SEM analysis could identify more bones with potentially diagnostic characteristics for further examination. Stable isotope analysis of modern fish from the Swandro area could be used in a comparative study alongside the isotope values of the archaeological samples as a method of investigating the effects of climate change on the marine environment (Misarti et al. 2009); this would be especially apt due to the physical indicators of significant erosion and damage due to climate change that have already been observed at Swandro.

Due to the small scale and scope of this dissertation research, the results were inconclusive. However, this is not a failure – with continuing progress in the creation and adaptation of new technology and analytical methodology for further archaeological research, further questions are critical for continued growth in the field and should inspire re-evaluation of faunal assemblages. This pilot study proves that in-depth analysis of smaller faunal remains is not only possible, but may also illustrate a richer history of animal interaction and exploitation. It may be tempting to write off fish bones as a nuisance on site, but this pilot study reveals their hidden potential as vital clues to understanding the more indecipherable aspects of the ancient past.
Bibliography


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