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INTRODUCTION

The study of fish remains from archaeological sites is an exciting and important element of environmental archaeology, a subject which is principally a development of the second half of the twentieth century and is concerned with the relationship between mankind and the rest of the natural world. Although pioneering studies of fish bones were carried out more than a century ago, the study of fish remains from archaeological sites could only emerge as a discipline in its own right once ichthyologists and archaeologists had developed their subjects, techniques and expertise, and had become aware of fields of mutual interest.

The earliest studies on archaeological fish remains appear to have been mainly the result of eminent and experienced zoologists being invited to examine remains recovered from excavations without necessarily being involved in their interpretation. As a result the identification of species was unassailable, but their importance was not always appreciated, and sometimes dubious explanations of their significance were advanced.

An early critical study of fish remains was made in the 1840s by the distinguished Dutch zoologist Herman Schlegel of the Rijksmuseum van Naturlijke Historie in Leiden. According to Clason (1986), Schlegel studied the remains of fishes, together with those of other animals, from excavations at the early medieval town of Dorestad in 1842. The fishes he identified included the sturgeon, *Acipenser sturio*, the pike, *Esox lucius*, and the wels catfish, *Silurus glanis*, the last being a particularly significant, but for a long time unrecognized, identification. According to Clason, the Danish zoologist, Japetus Steenstrup was involved in the identification of fish remains from Ertebølle settlements or shell mounds around 1851, although this work has rarely been cited by zoologists. Somewhat later, the French zoologist Henry Emile Sauvage examined material attributed to the Upper Palaeolithic period from caves in the Dordogne region of France and reported his findings in a little-known 'Essai sur la pêche pendant l'époque du renne' (Sauvage, 1870). He also contributed to Lartert and Christy's *Reliquiae Aquitanicae* (1875), which is usually cited as the original publication.

The true significance of these studies was not always realized. Thus, the occurrence of the remains of wels catfish at Dorestad showed that this species was endemic to the Netherlands. *Silurus glanis* is today very rare in the area and it has been frequently alleged that this species was introduced from the Danube. Its status as an endemic species was firmly established by Brinkhuizen (1979b), who found *Silurus* bones at other archaeological sites in the Netherlands, thus confirming Schlegel's earlier record. This is an example of important evidence from archaeological work which was long overlooked by zoologists. The opposite is true of Sauvage's work. Sauvage concerned himself with interpretation of the fish remains from the 'Reindeer Age' sites, relating his findings to human settlement patterns and procurement activities. He noted that head bones of salmon were absent while those of the smaller members of the carp family were present in the assemblages he examined. From this he postulated that the heads of salmon captured at some distance from the sites were removed before the bodies were brought to the cave. This was seized upon by Clark (1948) and apparently supported by analogy with aboriginal fishing practices in British Columbia. Clark suggested that members of the Palaeolithic community cut off the heads of salmon, but retained the vertebrae (eventually to serve as beads), thus facilitating transport of the edible portions of the fishes. As Wheeler (1978a) pointed out, this appealing picture is seriously flawed. During their residence in rivers, mature salmon resorb most of the calcium from their cranial skeletal elements, reducing them to weakly mineralized cartilage, which is unlikely to survive in archaeological sites. Although necklaces formed from salmonid vertebrae have been found with Palaeolithic inhumations in the Grimaldi caves in south-east France, salmonid vertebrae have a relatively large central hole, which carries the notochord from head to tail throughout the animal's life, and not all have been used in the manufacture of necklaces. This example shows that without sound ichthyological knowledge interpretation of fish remains may lead to dubious conclusions.

As wet-sieving samples becomes standard practice, the fish remains recovered from excavations will become more representative of the exploited fauna. The fish bone researcher has therefore to be prepared to identify small elements from a wide range of species and to recognize minute fragments of common food fishes. Knowledge of the habitats and natural history of fishes has expanded enormously in recent years and a great deal of information is now available to archaeologists. Fish bone studies containing statements such as 'fish bones of cod size were recovered' and wrongly identified illustrations of fish remains are not acceptable. (Both may be found in the literature, although it would be invidious to name the authors of these reports in this context.)

Although this book is about fishes and archaeology, it concentrates on fish remains, i.e. the fragments of fishes likely to be recovered from archaeological sites. It does not aspire to be a survey of the interactions between fishes and man. As a result the fascinating topic of the development of methods of capture of fishes is only touched on here, although references are made to detailed sources on this aspect, amongst them Wing and Reitz (1982), Brinkhuizen (1983), Brandt (1984) and Gunda (1984). Much can be learned of mankind's knowledge of fishes from the study of pictorial representations, in cave drawings such as those in Europe and Australia, decorations on pottery, in mosaics as at Pompeii and Carthage, while ancient Egyptian representations of fishes have been much discussed. Absorbing as the study of these pictorial representations is, it can serve as only a rough guide to the knowledge the respective cultures possessed of their fish fauna and is not covered in detail here.

Fish remains are powerful aids to understanding human exploitation of the environment. At a very basic level, identification of the fishes present at archaeological sites allows archaeologists to state whether freshwater or marine environments were exploited, and further to suggest the habitats which were fished. Analyzed with caution, fish remains may reveal seasonal exploitation, the methods by which fishes were captured and hence something of the level of technology of a culture.

The techniques involved in studying fish remains have greatly improved in recent years, and no doubt will continue to evolve and be refined. In the future we can confidently expect zooarchaeologists to study fish remains from a well-established basis, which will make a fundamental contribution to the knowledge we have of fishes and their exploitation in the past.

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FISHES AND THE ARCHAEOLOGIST

The importance of fishes to human economy

Because fishes live in water and as part of their strategy for survival are generally cryptically coloured, fast-moving and shy, they are not very conspicuous to land-based animals like man. As a result it is difficult for us to appreciate the diversity and abundance of the fishes inhabiting seas, rivers and lakes. Fishes outnumber all other vertebrates in both numbers of individuals and numbers of species. They live in almost all the waters of the earth. They are often astonishingly fecund, releasing enormous numbers of eggs at spawning times. For example, a herring may shed up to 50,000 eggs. As a result of this breeding strategy, immense populations of fish can be sustained despite heavy mortality from predation and adverse environmental factors.

The interaction between man and fish has been considerable in historic times and is known to have been so in prehistoric periods despite the inconspicuous nature of fishes.

The influence of the herring, *Clupea harengus*, on the fortunes of the Hansa merchants (generally known as the Hanseatic League) in northern Europe is well known. The Hanseatic League, which was a dominant economic and eventually a social force in Europe, controlled the herring trade from the Baltic for some two hundred years. The herring, which is represented in the Baltic by a small-sized race or possibly a subspecies, like many of its relatives in the family Clupeidae, is well known for dramatic fluctuations in abundance, which are not necessarily connected with over-fishing (although this may have a bearing on the fluctuations in modern fisheries). Such a decline in abundance during the fourteenth century led to the Hansa losing much of their power. The later rise of Dutch, Scottish and English herring fisheries in the North Sea led to considerable economic and social progress by each country in succession. Herring and wool were the key industries in England from the twelfth to the seventeenth centuries and Samuel (1918) suggests that the herring trade was important not only in supplying food but also in stimulating strong traditions of ship-building and seamanship, which in time helped to secure maritime dominance for that country.

Moreover, in the late nineteenth and early twentieth centuries the migrations of the herring southward in the North Sea during the summer and early autumn were followed by the fishing fleet (then mostly vessels using floating drift nets) from Scotland and northeast England and an associated overland migration by Scottish women who, following the fleet, processed the catch on landing (Hodgson, 1957). As well as securing an income of sorts for the men and women employed in catching and processing the fish, considerable economic benefit accrued to the fishing ports in East Anglia. More recently still, over-fishing of young herring in the North Sea has led to fishing being suspended for periods of several years with subsequent adverse effects on the livelihood of the fishermen and their communities.

Comparable examples can be found elsewhere. The Atlantic cod, *Gadus morhua*, which lives in the western North Atlantic, as well as in European seas, was one of the abundant natural resources which attracted European explorers and later settlers to the coasts of northern North America. The competing fleets of Portuguese, French and British fishermen played a part in the settlement of the northern Atlantic coast, as well as providing financial returns for merchants sending out these ships. Even earlier, the migrations of Vikings to the North American coast may have been related to the abundance of both cod and herring there (Jensen, 1972), and there is evidence of seasonal fishing expeditions for herring along the Norwegian coast, as well as established fishing stations in Iceland in the tenth century (Goodlad, 1971). Grahame Clark has recently suggested that the desire to exploit cod 'may have helped significantly in opening up the sea routes implied by the megalithic tombs of the Atlantic seaboard' (Clark, 1980).

Migratory fishes have been of particular significance in primitive societies. This is particularly true of anadromous species, such as the Pacific salmon, *Oncorhynchus* spp., on the west coast of North America, which formed a major food resource for riverine communities (Schalk, 1977). Other anadromous species (fishes which migrate from the sea into fresh water to spawn) such as the Atlantic salmon, *Salmo salar*, and various shads, *Alosa* spp., in Europe and eastern North America, and menhadens, *Brevoortia* spp., in eastern North America may have proved to be locally as important as the Pacific salmon. On the Pacific North American coast, the eulachon, *Thaleichthys pacificus*, played an important part in the early Indian coastal economy as a source both of food and of fat (Hart, 1973). The importance of anadromous fishes to aboriginal societies lies in their concentration in a confined space, even if only for a short season, thus making them highly accessible.

Similar spawning-related migrations brought herring close inshore and made them vulnerable to even primitive fishing methods, as were schools of shore-spawning capelin, *Mallotus villosus*, in Arctic waters, particularly Greenland (Jangaard, 1974).

Within the tropical Pacific Ocean the colonization of island groups was only possible because of the unfailing protein resources the sea offered. In his excellent analysis of archaeological fishing as an aspect of oceanic economy, Reinman (1967) addressed this topic from the evidence of early fish hooks, archaeological fish remains and some ichthyological data, and concluded that a mastery of the techniques of catching fishes contributed greatly to the invasion by man of the islands. Moreover, it has become increasingly evident that many of the fish hooks produced by the aboriginal inhabitants of Oceania, made from mollusc shell, wood or bone, were often specifically evolved to catch a single desired species of fish, or groups of fishes, and were highly efficient. The wooden, steeply angled hook with a strongly recurved tip, used for catching escolar or castor-oil fish, *Ruvettus pretiosus*, is a particularly well-known example. Similar specialized hooks were evolved to capture the Pacific halibut, *Hippoglossus stenolepis*, by Indians along the coastal regions of the North Pacific and the Gulf of Alaska. According to Thompson and Freeman (1930), the halibut was, next to the salmon, the most important food fish available to the Indians and very large quantities were caught between June and August and consumed or preserved. The highly evolved wooden hooks of the Indians proved to be more efficient than modern European wire, barbed hooks.

However, this book is not concerned with the part played by fish and fishing in the past; it is about the remains of fishes that can be found in archaeological sites. That small fish bones survive in a recognizable form in archaeological deposits for thousands of years may seem surprising in view of their size and fragility. In fact, fish remains are extremely common in certain archaeological deposits but few site reports include adequate accounts of the recovered fish bones. Until the mid-1970s it was common to see archaeological reports referring to all fish remains simply as 'Fish' rather than identifying them accurately (e.g. Harcourt, 1969); such incomplete identifications are still to be found in excavation reports (e.g. Cruse and Harrison, 1983). Although these and other similar unspecific references to fish are for small assemblages of remains, they illustrate the way fishes have been neglected by many archaeologists.

Yet text-books and general accounts of past cultures attempt to assess the importance of fishes and fishing. All too often authors are forced to make sweeping generalizations. For example, 'Mesolithic inhabitants of northern Europe drew upon birds, fish, marine mammals, shell-fish and plants for sustenance, as well as land based mammals' (Clark, 1980, p. 49).

There are several reasons why fish remains have been so neglected in the past. Firstly, there were, and still are, only a few people who can produce competent fish bone studies. The major difficulty for students, be they archaeologists or biologists, is access to adequate reference collections. Few institutions have skeleton collections which contain specimens of all the species likely to occur in archaeological deposits.

Secondly, there is a shortage of practical written accounts of how to carry out the work. Casteel's book, *Fish remains in archaeology and paleoenvironmental studies* (Casteel, 1976) gives copious examples of what could be achieved by studying fish remains from archaeological sites, based on what fishery biologists do with contemporary fish, but fails to give much practical advice for those finding fish bones for the first time.

Thirdly, fish remains are often neglected because they are relatively small and fragile. Many important food fish have small bones which are easily overlooked even if sieving to 1 cm is carried out. Because water offers more support to a fish than air does to a terrestrial vertebrate, fish bone is less dense and has different mechanical properties from other kinds of bone. Most fish bone is more easily fragmented than mammal or bird bone.

Finally, widespread ignorance concerning the information that can be gleaned from fish remains has meant that archaeologists have not always insisted that their fish material was accurately identified. It is only in the last few decades that archaeologists have begun to appreciate how abundant and informative fish remains can be. Fish bones can provide invaluable information on three main areas of interest: human diet; the economy of a settlement or culture; and the natural environment of a site.

For a long time it has been accepted that mammal and bird bones (which are often referred to as 'animal bones') should be collected and reported, and in the last 20 years or so many archaeologists have realized that small mammal bones, plant remains, insect fragments, etc. can also provide valuable information about life in the past. In order to recover these kinds of materials sieving techniques have been developed. These have resulted in the recovery of a wide spectrum of fish remains, which once were recovered rather sparsely. As a corollary, modern recovery techniques have produced a much greater range of fish material, which has increased the challenge of identification.

Furthermore, many excavators share the view that, because excavation is a destructive process, there is a duty to record what is present, however small, if it provides information concerning the life of the site's inhabitants.

Two main assumptions are generally accepted in archaeology. The first is that remains of past cultures reflect people's everyday lives and that an accurate understanding of the material culture will provide insights into past societies. The second is that ancient remains are of interest 'in their own right'. It is these two concepts which demand that all archaeologists ensure that fish remains are adequately recovered and studied.

Evidence of diet, economy and trade

While fish remains are intrinsically fascinating and their study can be justified on these grounds alone, they can also yield a wealth of information concerning life in the past. The most obvious is that they are an excellent source of information about human diet. There can be little doubt that most of the fish bones recovered on archaeological sites were deposited either after the flesh had been consumed, or after the flesh had been processed for later consumption. Fish remains are often the waste from kitchens and tables and may even comprise food remains which passed through the gut of the inhabitants of the site. An example of kitchen waste was provided at Barnard Castle, County Durham, England (Donaldson *et al.*, 1980). The contents of a drain running from the kitchen to the curtain wall of the medieval castle were carefully sieved and a large range of fish, mammal and bird remains recovered. Material from pits, floors, yards and other features within medieval tenements at Alms Lane, Norwich, England (Jones and Scott, 1985) showed that a restricted range of fish was consumed by the urban population from the twelfth to the eighteenth centuries. There did not appear to be major differences between the fish assemblages from the various tenements and from different feature types. The bones from this site can best be regarded as a component of domestic waste, discarded in an indiscriminate manner.

Evidence that fish bones were swallowed and passed with faeces comes from several sites where multidisciplinary studies of animal and plant remains have been undertaken. They clearly demonstrate that human excrement can contain large numbers of fish bones. Follett (1967) examined desiccated human coprolites containing fish remains from cave deposits in Nevada, North America. The Coppergate site, at York, England, contained many latrines or cesspits, which were recognized by the enormous numbers of eggs of two kinds of intestinal nematode worm parasites, whipworm, *Trichuris trichiura*, and the large roundworm or maw-worm, *Ascaris lumbricoides*. Plant remains from these same features were dominated by small fragments of the spermoderm (bran) of cereals (either wheat, *Triticum* spp., or rye, *Secale cereale*). In addition, seeds of fruits like raspberry, blackberry, apple, sloe and plum testify that the deposits were faecal in origin. These layers also contained substantial numbers of fish bones, mainly vertebrae of eel and herring. Many of the vertebrae bore signs of having been crushed during mastication.

Not only are fish bones found in unconsolidated layers rich in food debris and parasite ova; they are also occasionally found in 'faecal concretions' in waterlogged urban sites. Faecal concretions are a mixture of bran fragments, parasite ova and other faecal material bound by calcium phosphate into amorphous lumps. They are insoluble in water. Sometimes the lumps contain recognizable food remains e.g. sloe stones or fish vertebrae. Very rarely the vertebrae are crushed in a manner consistent with their having been chewed.

Indirect evidence for human consumption of fish has been revealed by parasitological investigations of ancient faeces. A number of researchers have examined archaeological faecal samples and identified eggs of the fish tapeworm *Diphyllobothrium latum*. This intestinal parasite depends on three kinds of host – the freshwater invertebrate *Cyclops*, a fish and a mammal – for the various stages in its complex life-cycle. Humans (and other mammals) become infected when they eat uncooked fish containing the immature worm (plerocercoid). The first archaeological record of fish tapeworm eggs is the account describing the intestinal contents of 'Karwinden Man', a peat-bog burial from Eastern Prussia, dated to AD 500 (Szidat, 1944). A recent review of records of parasite eggs, including *Diphyllobothrium latum*, from latrine fills has been given by Herrmann (1985).

Coastal sites and those located on rivers occasionally yield such large concentrations of fish remains that they must be interpreted as the remains of fish that have been processed for later consumption (e.g. Batey *et al.*, 1982).

While almost all fish bones found on archaeological sites are the remains of food waste, food offerings, or have been used by man in some way, a small percentage may have been brought onto sites by agents other than man. For example, at coastal sites the wind can deposit bones washed up on the beach; likewise otters, sea birds and other scavengers can bring fish carcasses onto a site or they may pass faeces or pellets rich in fish remains. A good example of animal-deposited fish remains recently came to light when bones from Orkney were studied (Colley, 1984a). A stone floor, thought to be in an abandoned building, was found to be overlain by a concentration of small fish bones, which at first sight resembled finely divided tobacco leaves. Closer examination showed that many of the fish were small species of shore fish which were unlikely to have been eaten by man. Otters were suggested as the depositing agents. It was also thought that otters were responsible for some of the bones reported in the Quanterness tomb, Orkney (Wheeler, 1979a). Similar finds of small mammal bones have been attributed to roosting owls (O'Connor, 1983).

Fish remains can yield valuable and interesting information, given careful and critical recording. The species represented may reflect the social status of the people inhabiting the site. Bones from twelfth-century levels in the Misericorde of Westminster Abbey, then a wealthy monastery in London, clearly demonstrated that the monks enjoyed a varied diet including over 20 kinds of fish. Of particular interest were relatively large numbers of remains of sturgeon, *Acipenser sturio*, John Dory, *Zeus faber*, and turbot, *Scophthalmus maximus*, species that are highly prized for their eating qualities. All are excellent food fish and today command the highest prices in fish markets (Jones, 1976).

Often the size and sometimes the age at death of the fish can be determined. At Great Yarmouth (Wheeler and Jones, 1976), measurements on cod jaw bones were used to estimate the size of the fish present in medieval layers. Noe-Nygaard (1983) presented similar information for pike lower jaws (dentaries) and after careful scrutiny of incremental growth rings on vertebrae of 100 modern pike caught at known dates throughout the year, she estimated the season of capture for Mesolithic pike from Praestelyngen, Denmark.

By considering the habits and ecology of the various species recovered, it is possible to reconstruct the sources likely to have been exploited by ancient fishermen and to learn something of the methods used to catch the different kinds of fish. Another approach to reconstructing fishing techniques is to compare histograms of the frequency of the different sizes of fish recovered from an archaeological assemblage with hypothetical selectivity curves for various kinds of fishing gear. Balme (1983) showed that three sites in the Darling Basin, New South Wales, Australia gave length distributions of golden perch, *Macquaria ambigua*, which indicated that gill nets were used.

Fishing practices develop as a local response to the geography and distribution of fish. For example, the Mesolithic community of Bua Västergárd Goteborg, Sweden, engaged in line fishing for large cod (Wigforss *et al.*, 1983). Finds of large cod, *Gadus morhua*, and ling, *Molva molva*, bones have been also reported from Mesolithic material at Morton, Scotland (Coles, 1971). At Varanger Fjord in northern Norway a seasonally occupied Neolithic site yielded an assemblage of fish remains dominated by large cod (Olsen, 1967), indicating that line fishing was practised.

Spears were used by Mesolithic Danish lake fishermen, for a pike with spear tips *in situ* has been excavated (Clark, 1948). Wicker baskets and nets have also been found in Mesolithic deposits in Europe (Clark, 1980). All are essentially simple technologies using locally available renewable resources. It is therefore probable that traditional fishing methods have ancient roots in many places. This has been elegantly demonstrated by Enghoff (1983) for coastal fisheries in Denmark. The bones of many small cod and whiting, *Merlangius merlangus*, were found in Mesolithic middens. The traditional fishing method in the area, still practised in this century, was setting wicker weirs at low tide and collecting trapped fish (mostly small cod and whiting) on subsequent low tides.

All these methods, harpooning, hook and line fishing, and building tidal traps, have been discussed in relation to early fishing in Oceania (Reinman, 1967); likewise, harpooning, line fishing, bow and arrow, and nets are used today by the aboriginal inhabitants of Amazonia (Smith, 1981) even though modern materials are now employed.

Evidence of environmental conditions

An assemblage of bones from a site is likely to reflect contemporaneous local ecological conditions in addition to providing economic information. For example, bones of stickleback, *Gasterosteus aculeatus*, and small dace, *Leuciscus leuciscus*, recovered from Roman drainage ditches in Southwark (Jones, 1978), provide evidence of the contemporaneous fish fauna. The distribution of stickleback remains at Bronze Age Fen-edge West Row, Mildenhall, Suffolk, England, indicated which areas of the site were flooded