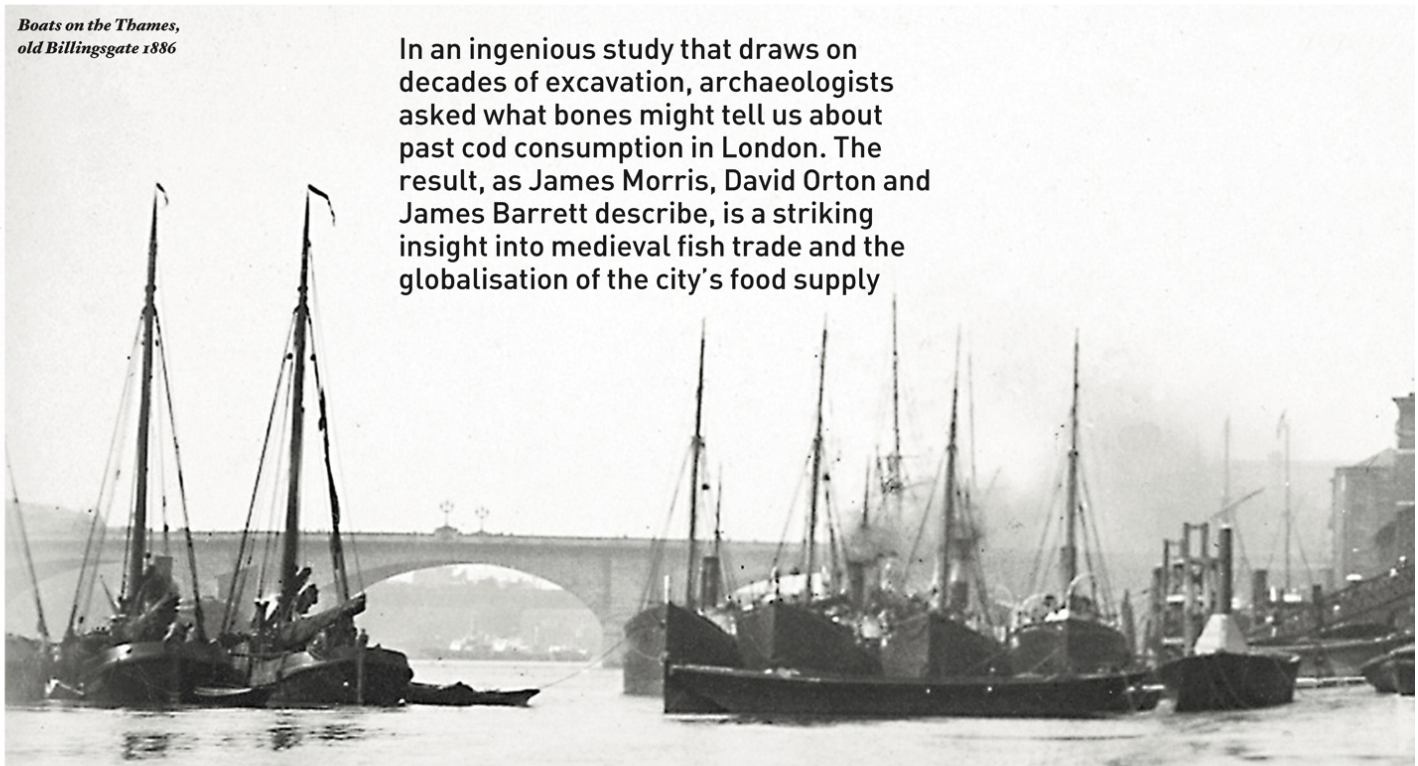


Boats on the Thames, old Billingsgate 1886

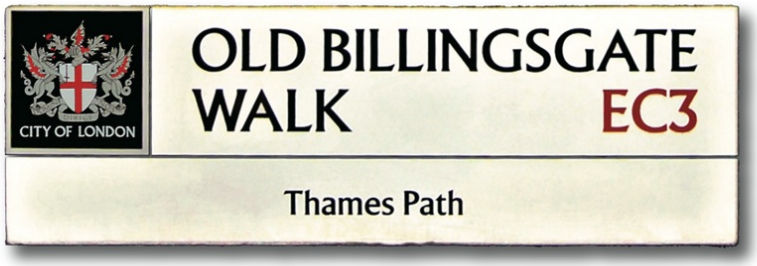
In an ingenious study that draws on decades of excavation, archaeologists asked what bones might tell us about past cod consumption in London. The result, as James Morris, David Orton and James Barrett describe, is a striking insight into medieval fish trade and the globalisation of the city's food supply

Stories from the city stories from the sea

Atlantic cod (Gadus morhua)

London's Billingsgate is one of the largest fish markets in the world. On average 25,000 tonnes of fish products pass through it each year – 40% imported, some from as far away as New Zealand. This is nothing new: Billingsgate has been at the centre of London's fish trade since medieval times. Until its move to near Canary Wharf in 1982, it was located around a dock in the City, close to the Tower of London. The Thames provided fish for the market. As we discover, it also facilitated trade from much further afield.

Fish were an important part of the medieval diet and Christian doctrine, often substituting for meat during Lent and on other fasting days throughout the year. Yet as archaeologists we give fish too little attention, especially compared to mammals. As anyone who has accidently swallowed one knows, fish bones can be very small and thus difficult to recover through normal archaeological means. Particular bones such as the cleithrum (which supports the pectoral fin just behind the gill opening) from large fish, are sometimes spotted during excavations, but the collection of fish remains is really reliant on sieving.



Luckily, archaeologists have long known the value of wet and dry sieving and of taking environmental samples. The chance of finding fish remains is one of the reasons English Heritage recommends samples of at least 5 litres for each archaeological context. Within Britain there is a long history of dedicated environmental sampling in cities such as London, York and Southampton. There is therefore an untapped wealth of environmental and fish remain data from some of Britain's urban centres.

James Barrett and colleagues had already used these data to identify a revolution in fish consumption in England's medieval towns from approximately AD1000. Before this date bones of freshwater fish such as pike and wild species of the carp family – and migratory species such as eel, smelt, salmon and trout that were probably caught in fresh water – are the most commonly recovered. Conversely most eleventh century and later assemblages are dominated by the marine fish, herring and gadids (cod family). Consumption of herring at some proto-urban trading centres, such as Lundenwic, Hamwic and Gipeswic (modern-day London, Southampton, and Ipswich), can be seen in the seventh and eighth centuries, but again the relative contribution of herring along with gadids increased dramatically in the eleventh century. The detection of such distinct changes in the archaeological record, especially for faunal remains, is very rare. With tongue in cheek, we duly called it the "fish event horizon".

What caused this revolution in sea fishing? Changes in Christian fasting practices may have increased demand for fish, but their impact beyond the cloistered monastic walls remains to be fully understood. There may have been technological innovation around this time, with use of floating drift nets: yet such nets are unsuitable for cod, which were typically caught on hook-and-line until the post-medieval development of cod nets and trawling. Another documented innovation was the increase in cargo ship capacities, linked to a rising trade in staple goods driven by the growth of towns. But if the fish event horizon was connected to urban growth, was it the result of increased demand, or were people taking advantage of a new source?

To investigate such questions further, we needed a city with a continuous, well-recorded and sieved archaeological dataset. London offered just such a settlement, with its rich and deeply stratified archaeology. The London Archaeological Archive & Research Centre (LAARC) estimates

Above: Excavations at medieval Billingsgate on the site of the later fish market. Many of the bones in the authors' study came from here or similar sites along London's Thames waterfront

that nearly 8,500 sites have been investigated in the Greater London area over the past century, with LAARC holding the full archive of over 3,500 excavations. Since 1973, many of these sites have been excavated by Museum of London Archaeology (MOLA), in its various guises.

This continuous level of archaeological investigation in one area has created an unprecedented opportunity for synthesis, whose potential is mainly untapped. In addition, MOLA has been recording their zooarchaeological, artefactual and contextual information into one database for the last 20 years. This allows researchers to combine data on the level of individual archaeological contexts, rather than lumped phases or periods, enabling an unprecedented degree of temporal resolution. London was therefore an ideal city to test the link between urbanisation, population growth and fish supplies. We approached this by focusing on a single major species: cod.

Left: Old Billingsgate market – now a hireable "event space"

Raw data (and dried)

Using the MOLA and LAARC resources along with raw data supplied by individuals – notably the prolific freelance fish specialist Alison Locker – we gathered a dataset representing a very substantial portion of all recorded, well-dated cod bones from London. This includes frequency and anatomical information from 95 Roman, medieval and post-medieval sites excavated between 1972 and 2008. Conservative date ranges for the cod bones were calculated using the detailed stratigraphic and pottery information available in MOLA's database and in the archives of other analysts and contractors. The constant creation and intercutting of features encountered on urban sites, can result in problems of residuality. To counter this any contexts with a date range of

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over 300 years were excluded from the study. Even with this conservative approach, our analysis still includes 2,829 cod bones: London's archaeological archive is very large.

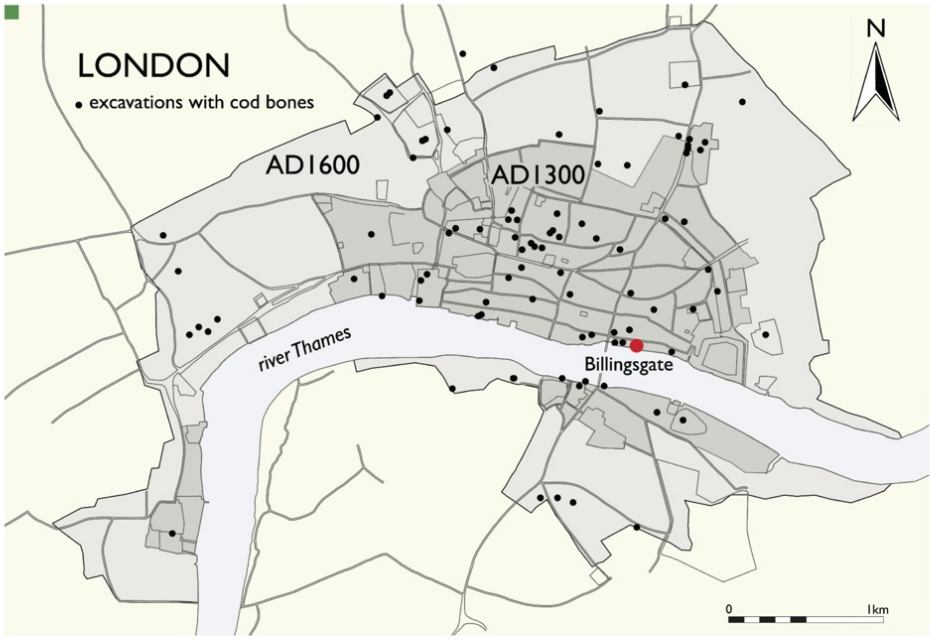
Thus armed, we could examine how the frequency of cod remains changed at different times. We divided the number of bones in each archaeological context across its date range. We then summed the results at five-year intervals from AD5 to AD1950, giving highly detailed estimates. With access to the raw zooarchaeological

records, we were also able to compare the frequencies of different body parts over time, particularly heads and vertebrae. The idea here is simple. Before refrigeration, cod were preserved for long-distant transport by drying, with or without salt, normally after the head had been removed. Head bones found by archaeologists are therefore likely to have been from locally caught fish, whereas vertebrae could also be from imported fish. The proportion of head bones to vertebrae is thus a guide to the quantities of fresh versus preserved cod.

Overall, apart from around 70 Roman bones and a handful from Anglo-Saxon times, cod only becomes common from London sites within a few decades of AD1000, fitting the fish event horizon. The frequency of cod increases in the 13th century, with a dip in the late 14th before increasing again in the 15th and 16th centuries. It drops dramatically after AD1700. This last change is likely to reflect a number of factors. City diets were starting to be dominated by beef, while improvement in waste management may have reduced numbers of bones deposited in London's urban core. There is also a preservation problem within London, where many post-medieval archaeological layers – which are nearer the surface than medieval and older deposits – have been destroyed by Victorian and 20th century development. Finally archaeologists are generally less interested in these later periods (although this is changing), with the vital environmental samples often not taken, especially on older excavations.

The most interesting and important results emerged when frequencies of head bones and vertebrae were compared. Strikingly, the increase in cod bones in the 13th century entirely represents a surge in the number of vertebrae recovered – the frequency of head bones falling sharply at the same point. The sheer clarity of this change immediately raised suspicions of sampling or recording biases, but careful comparison of the data from different sources allowed these to be ruled out. Rather, the data suggest a dramatic shift from locally caught to imported preserved cod during the 13th century.

From this point onwards there is little change in the frequency of head bones, but major fluctuations are seen in numbers of vertebrae recovered. Two of these are of particular interest: a marked drop around the late 14th century, and a further surge in numbers around AD1600.



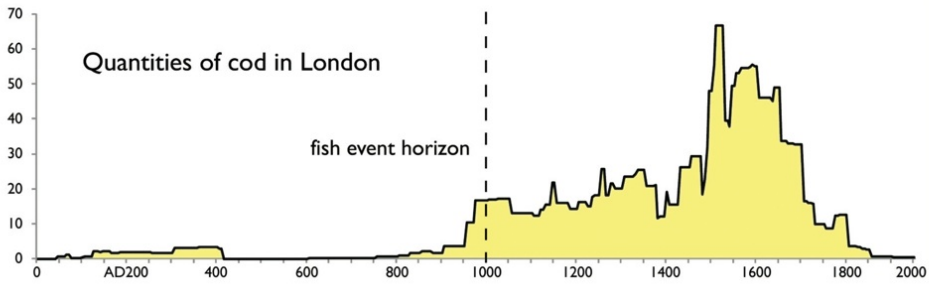
Top Left: Modern Billingsgate market

Top right: Trig Lane excavations in the 1970s, showing old Thames waterfront revetments, another important site for the study

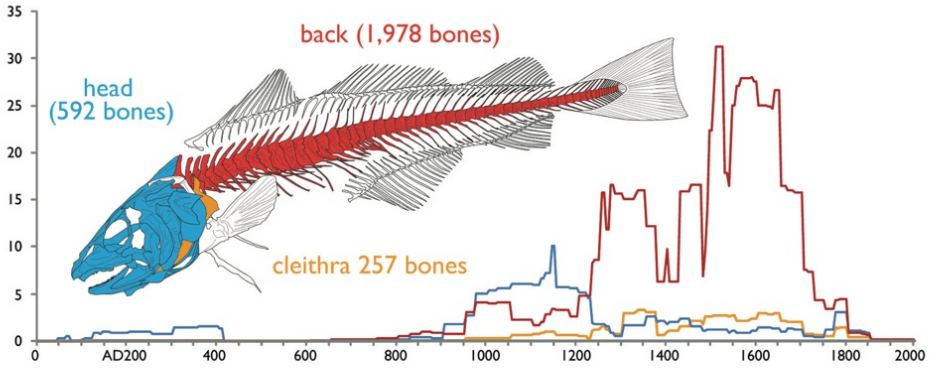
Below left: Modern Billingsgate

Below right: Sites where bones used in the authors' study were found; map shows estimated extent of urban London in AD1300 (light grey) and 1600 (dark grey), and site of old Billingsgate fish market

The high frequency of head bones from 11th and 12th century London suggests that cod then were primarily caught in fairly nearby waters. By the 13th century demand may have started to outstrip local supply, with the sudden shift towards vertebrae indicating the onset of large-scale imports of processed cod. Between AD1100 and 1300 London's population is thought to have quadrupled to around 80,000, which must have put pressure on local supplies of fish and other produce.



Above: Estimated numbers of all cod bones between AD1 and 1950, from a sample of 2,827; especially in post-medieval times, these figures are affected by preservation and research biases



Above: Estimated numbers of bones from different body parts; the authors attribute the 13th century switch from heads to tails to a new import trade in processed fish, with further imports from c AD1500

A history of cod

Did the 13th century see the start of long-range fish trade into London? The zooarchaeological data cannot actually reveal the source of imports. However, chemistry can fortunately help to detect geographical origins of individual fish bones, through variations in stable carbon and nitrogen isotope ratios ($\delta^{13}C$ and $\delta^{15}N$). Using 177 head bones from 29 settlements, we established isotopic signatures for six regions, from the north-east Atlantic to the Baltic Sea (see map opposite). We were able to match isotopic ratios from 34 London vertebrae against these signatures, assigning each specimen to its most likely source.

The isotopic results closely support the zooarchaeological data, with all but one of the sampled 11th and 12th century cod vertebrae providing a southern North Sea signature. The exception is a vertebra from Westminster Abbey dated AD950–1050, which may have originated from Artic Norway or the north-east Atlantic. In comparison, from the mid 13th century, most of

AFTER ORTON ET AL 2014/ANTIQUITY/CC-BY (GRAPHS); HEAVENUPHERE/FOTER/CC BY 2.0, JAMES BARRETT

Below and Left: Unsalted cod or stockfish, dried by cold air on wooden racks on the foreshore in Norway

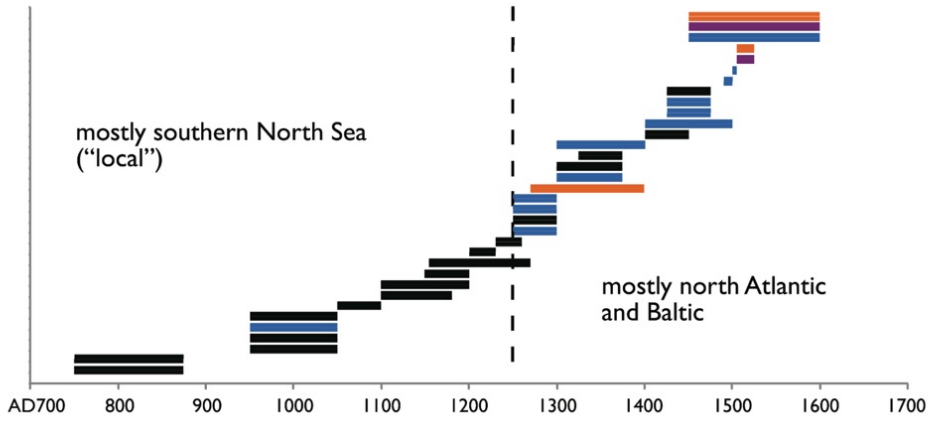
the specimens we studied appear to have come from the far north. It is notable that at this time, English coins and ceramics such as Grimston-type ware of 13th century date are abundant in Norway.

It therefore appears that a booming trade in preserved cod developed between Norway and England in the 13th century. The sudden decline in head bones at the same point suggests that local fishing may have been partly displaced by this import trade. With our modern outlook it may seem unexpected, but for cod it appears that preserved fillets were preferred over "fresh" locally caught fish. An alternative possibility could be that there was a decrease in local cod stocks, but further research would be required to investigate this – for example, by analysing changes in the size of locally caught fish over time.

The dip in vertebrae noted in the 14th century indicates a temporary drop in the amount of preserved cod coming into London. It is possible that this represents reduced demand following the Black Death, which also disrupted trade links across Europe and might have limited the supply of Norwegian cod. The recovery in cod imports in the 15th century is concurrent with historically known expansion of English fishing in Icelandic waters. Finally, the 16th century increase in vertebrae coincides with isotopic evidence for cod probably from the north-west Atlantic – following the European (re)discovery of Newfoundland by John Cabot, sailing from Bristol in 1497.

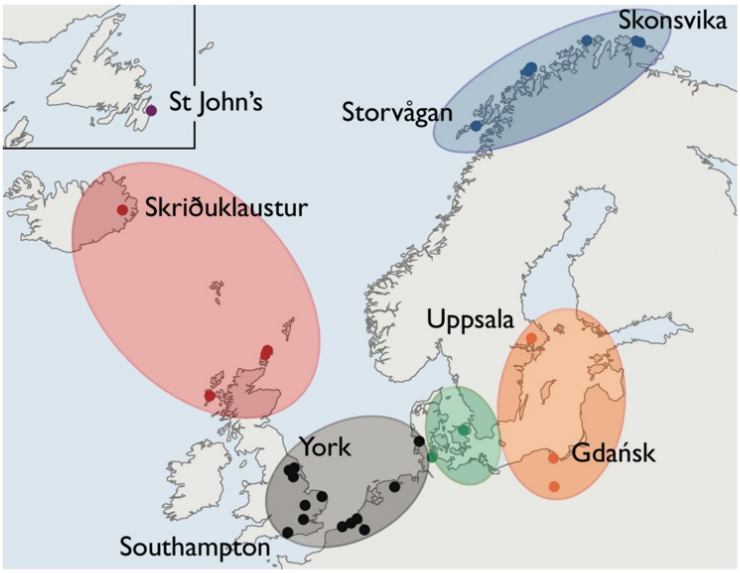
Unfortunately the isotopic signature for Newfoundland is not especially distinct, so we have turned to genetic provenancing of cod bones to provide more definitive evidence for transatlantic trade. Continuing ancient DNA research by colleagues at the University of Hull is thus far confirming the story told by the zooarchaeology and isotopic provenancing.

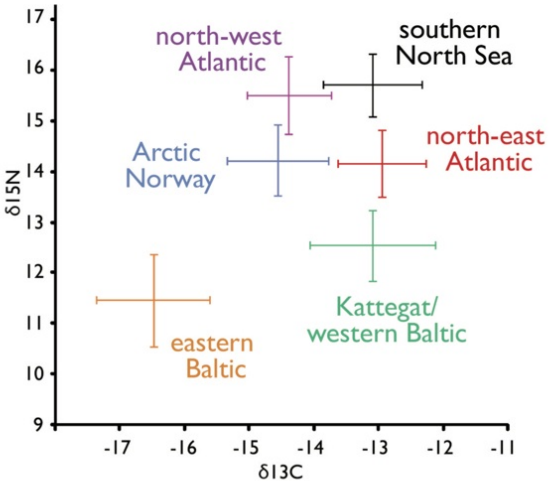
Our study shows that modern day Billingsgate market, with its globally sourced produce, is continuing a long tradition of fish imports into the capital. Food globalisation – the exploitation of resources well beyond local ecosystems – underpins contemporary overfishing problems, but the London fish bone record



Above: Isotopic provenancing of London cod; bars represent single bones, showing date range and most likely catch area

Below and right: Distinctive isotopic signatures for cod from six possible source areas, using 177 head bones from 29 excavated sites





shows that it has its roots firmly in the past. Research bringing London's archaeological record to bear on the city's environmental history and the long-term sustainability of its food supply is only just beginning. But this would not be possible without the records from decades of high-quality urban excavations and the hard work of the city's zooarchaeologists.

James Morris is lecturer in archaeology at the University of Central Lancashire, and was a zooarchaeologist at Museum of London Archaeology for most of this project. David Orton is an ERC research associate at UCL Institute of Archaeology. James Barrett is reader in medieval archaeology, University of Cambridge.

The research was funded by The Leverhulme Trust and The Fishmongers' Company. "Fish for the city: meta-analysis of archaeological cod remains & the growth of London's northern trade", by D Orton, J Morris, A Locker & J Barrett, Antiquity 88 (2014) is available for free online at http://antiquity.ac.uk/ant088/ant088516.htm. See also "Interpreting the expansion of sea fishing in medieval Europe using stable isotope analysis of archaeological cod bones", by J Barrett, D Orton & 18 others, Jnl of Archaeological Science 38 (2011)