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ARTICLES

OYSTER SHELLS AS HISTORY BOOKS

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Introduction

A collaborative project was established in 2002 that has brought together geochemistry and archaeology in order to investigate environmental change and the harvesting strategies of ancient peoples. The objectives of this study are to decipher the life history and environmental information contained in shells of the European oyster, *Ostrea edulis*, by analyzing geochemical variations along shell growth. This approach provides an independent measure of age and season of death, as well as a record of environmental change in temperature and salinity through the life of the oyster. By understanding the life history and environmental records contained in modern oyster shells, we can analyze shells from archaeological sites to gain an historical perspective of harvesting practices and environmental change in ancient shellfisheries.

Archaeological Background

Shell middens are found worldwide. These are sites where people must have congregated or lived at various times of the year for hundreds and sometimes even thousands of years. Continuous exploitation of shellfish at these sites resulted in the discard of shellfish, which over time form large mounds of rubbish. Although people ate other food as well such as fish, deer, fruits etc., it is the quantity of shellfish deposited that makes these mounds so impressive. In Brazil the mounds can reach 20 metres in height. In Denmark (the key case study area for this research) the middens tend to stretch length-ways along the ancient coastlines, some measuring up to 300 m long, 20 m wide and 1.5 m deep. Recent calculations have suggested that in just one cubic metre of midden there can be up to 83,000 shells!

Many of the European middens date to the Later Mesolithic period, about 5400-4000 BC, a time before farming when people hunted, gathered and fished for their food. It is argued that coastal resources played a major role in their economy. One of the major topics of debate in Archaeology is the transition to agriculture, one of the most important cultural transformations in the human past. Questions are asked as to why people turned from hunting, gathering and fishing to farming. There are many hypotheses. Some of these focus on changing environmental conditions which could have reduced the availability of marine resources but bettered the conditions for farming, whilst others focus on changing economy and social relations.

A shellmidden in Australia (G.N.Bailey)

Preliminary analysis of the oysters from some of these sites has suggested that further investigation could provide information both on the harvesting practices of people in the past, as well as on environmental change through time. By using incremental growth analysis it has been possible to test in what seasons the oysters were gathered. By taking modern samples of oysters every month for over a year and then sectioning the hinge, the typical growth patterns of the oyster could be monitored and changes identified through the seasons. Oysters grow like trees and an annual line is formed in spring (see Figure 1). This identification of annual lines has also been confirmed using oxygen isotope analysis. The results from an archaeological application have shown that, for many sites, oysters were collected in the spring in the Mesolithic period. However, at the time of the transition to agriculture a change can be seen – the oysters are still being exploited but the gathering takes place through the spring and summer, if not all year round at some sites.

Geochemistry of Oyster Shells

Oxygen isotope ($^{18}O/^{16}O$) composition ($\delta^{18}O$) sampled parallel to shell growth can be used as an indicator of seasonal change in temperature and salinity. Several studies suggest that $\delta^{18}O$ values of shells correspond

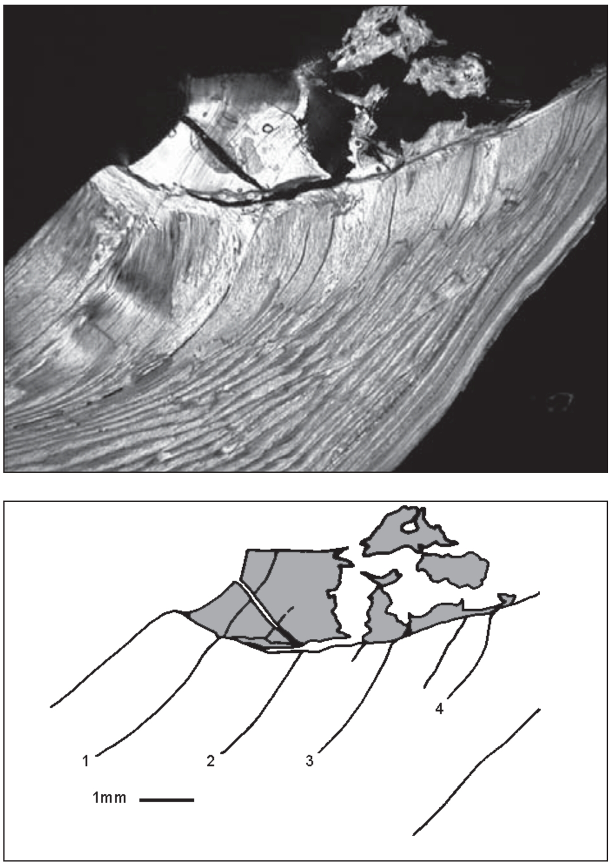

Figure 1. A thin section of the hinge of an oyster collected from the River Blackwater, Chelmsford in October. Four annual lines can be seen

to $\delta^{18}O$ values of inorganic calcite or aragonite (the mineralogy of shells) precipitated under the same environmental conditions. Seasonal temperature change results in a more or less sinusoidal variation in $\delta^{18}O$ such that lower values correspond to warm temperatures and higher values correspond to cold temperatures (Figure 2). In coastal settings, mixing of fresh and marine water can also affect the $\delta^{18}O$ of shells because freshwater has lower $\delta^{18}O$ values than marine water. To decouple the combined effects of temperature and mixing of fresh and marine water, Mg/Ca ratios will also be used as a temperature indicator. By constraining temperature with Mg/Ca ratios, salinity can be estimated using $\delta^{18}O$.

In co-operation with the Essex Oyster & Seafood Company Ltd., water samples adjacent to an oyster bed in the Goldhanger Creek estuary, River Blackwater, Essex, will be collected fortnightly for one year to characterize ambient environmental conditions. Samples will be analyzed for salinity, $\delta^{18}O$, and Mg/Ca ratios. To measure seasonal temperature change, StowAway TidbiT® (Onset Computer Corporation) data loggers will be deployed at the oyster bed and programmed to take measurements at half-hour intervals. These parameters will be used to construct a predictive model shell against which to compare observed shell data from oysters collected alive from the oyster bed at the end of the sampling period. To map observed data onto the predictive model requires assigning dates to observed shell data points. Harvest dates of each live-collected

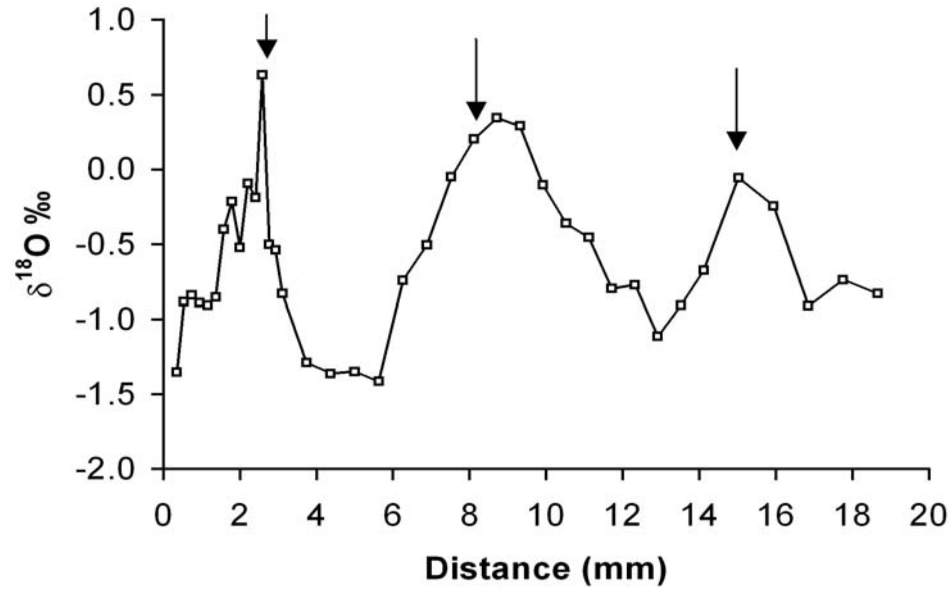

Figure 2. Oxygen isotope composition of oyster shell representing three years of growth. Individual was collected alive in August 1997. Peaks indicate winters and valleys indicate summers. Arrows correspond to winter growth breaks. Growth extension increases towards the right. Units are in per ml relative to the V-PDB standard

oyster can be used to anchor the last increment of growth to the model (i.e., the final increment of shell should record the ambient conditions just prior to the time of harvest). The remaining observed data points are plotted against the model using the predicted $\delta^{18}O$ as a correlation tool, with some rescaling (stretching or compressing) to account for differential growth rates or periods of no growth.

Expected Results

Comparing $\delta^{18}O$ values from live-collected shells to a predictive model allows assignment of dates to observed-shell data points. Date assignments provide the temperature and salinity at the time of shell formation. This knowledge will allow us to evaluate seasonal changes in growth rate, season of death, age of individuals, and environmental information through the life of an oyster. Armed with this knowledge of modern samples, specimens from archaeological contexts can be analysed to reconstruct changes in past environments and in ancient shellfishing practices, which in turn will help us to understand more about the transition to agriculture in Europe.

Acknowledgements

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THE RESPONSE OF SHOREBIRDS TO INTERTIDAL 'ON-BOTTOM' MUSSEL CULTIVATION

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Background

The mussel cultivation industry is the fastest growing and most valuable sector of the bivalve aquaculture industry in the UK. Areas used for cultivation, particularly the intertidal mud-flats and sand-flats used in 'on-bottom' cultivation, are often protected under various national and international conservation measures e.g. the European Habitat Conservation Regulations (Council Directive 92/ 43/EEC Annex 1). It is, therefore, important to establish the impact of expanding the extent of mussel cultivation in such locations.

LINK Project

The Centre for Ecology and Hydrology joined forces with The University of Wales, Bangor and two industrial partners (Myti Mussels Ltd. and Deep Dock Ltd.) to conduct research funded by the Natural Environment Research Council LINK Aquaculture programme. The project aimed to recommend a management plan to improve mussel productivity by determining stocking density and management strategies that would maximise mussel growth rate and reduce predation losses while minimising ecological effects on birds and invertebrate communities. The results concerning mussel growth and mortality were presented in the last issue of *Shellfish News*. Here we describe our experimental approach to determining whether the cultivation of mussels on intertidal mudflats has any affect on the assemblage of shorebirds that feed in that habitat

Sampling in progress on the experimental lays. The difference between the solid high-density cells and the more patchy low-density cells can be seen