CHAPTER 7

INTRASITE VARIATIONS IN OYSTER SHELLS FROM SITES IN THE NORTH WESSEX AND LONDON REGIONS

In this chapter the results obtained for oyster shell samples from sites in the broadly defined area of north Wessex and in London are presented. The sites comprise Ludgershall Castle near Andover and Brown Street in Salisbury, Wiltshire; Cross Street, Wokingham and Reading Abbey Wharf in Berkshire; and Moorgate and Coleman Street, Guildhall House and Pudding Lane in London. Whereas in Chapters 5 and 6 the sites from which oyster samples were examined were generally clustered around locations known to support native oyster populations, the sites in Chapter 7 contained oysters which could have come from any one of a number of sources.

MARINE MOLLUSCS FROM LUDGERSHALL CASTLE

The shells from this site were the first to be examined in detail in 1983 when methodology was being developed. The shell of the common flat oyster was the most common marine mollusc found at Ludgershall although a few other species did occur. The relative abundance of shells from the three sectors through time is described and some significance attached to the ratio of left to right valves and the degree of damage. Shells from the kitchen area and some latrine pits in the East Sector are studied more closely as these are considered to be areas of special interest. It should be noted that the examination of the material from this site was undertaken at the very beginning of the research into oyster shells from archaeological sites. Analytical and presentation methods were still being evaluated.

Numbers

The number of shells for each phase of each sector was tabulated showing the minimum number of individuals (MNI) and the number of damaged shells which was also expressed as a percentage, (Tables 7.1, 7.2 & 7.3). A table was also drawn to summarise this information for all three sectors (Table 7.4).

From the viewpoint of area excavated and period of active occupation it is not surprising that least shells were recovered from the South-West Sector, a few more from the South-East Sector and most from the East Sector. In the South-West Sector the greatest number date from the 12th century with numbers decreasing up to modern times. In the South-East and East Sectors the opposite is true. This also tends to correspond with periods when the area was most in use. Overall, there were very few shells and it is likely that oysters would have been a rare addition to diet rather than a staple food.

More right valves than left were found though the difference was not great. The percentage of damaged left valves is greater than right except for the South-West Sector where sample size is small. Left valves are vulnerable to damage because infestation affects and weakens the left or lower valve more than the right and the cup-shape is more prone to break when the shell is trodden on. This probably accounts for the differing proportions found. The number and proportions of valves could possibly reveal something of the nature of the deposit. For example, there would be a high probability that shells occurring in small but almost equal numbers of left and right valves represented an individual meal opened by the consumer. Deposits like this were found at Alton (Coy, pers. comm.). Larger samples with markedly higher numbers of right valves and a very high incidence of damage and infestation in the left valves could be waste that has been discarded from a kitchen or preparation area in which shells were opened prior to serving at table in their own liquor in the cupped left valve. This type of deposit has been found at Rockbourne Roman Villa (Winder, forthcoming). Samples of left valve only, in good condition, could be waste from the table disposed of separately.

In Ludgershall, early deposits of oyster shell probably came from individual meals. The larger collections from later phases could represent the debris from either a series of individual meals or a larger gathering of people consuming oysters on a single occasion.

Sizes

The sizes of the shells in the Ludgershall samples varied greatly. The arithmetic mean, variance and standard deviation were calculated for each sample in which the minimum number of individuals was at least five. For the South-West and South-East Sectors the samples were all grouped into phases. In the East Sector all phases were represented by grouped data but also individual contexts were used where the overall sample size met the above criterion (>5). Only the samples from the East Sector were closely examined (see Tables 7.5, 7.6, and 7.7a - d).

The arithmetic mean of the grouped data for each phase of the East Sector was plotted on a graph. A trend for the average measurement to decrease from the earliest to the most recent phase of the site could be detected. However, the arithmetic mean was considered inadequate for comparative purposes because the sample numbers and variances differed so much. The high means in earlier phases could have been the result of small samples being used and vice versa (see Figures 7.1a - d).

Plots of size frequency for each measurement expressed as a percentage were drawn for the grouped data of those phases with larger shell numbers (>25). These showed that the size of oyster most frequently occurring was much below what is considered today to be the size of a best grade oyster at 4 years, i.e. 3½ - 4" (about 9 - 10 cm); and that sample construction was different from phase to phase but not whether this was significantly different.

The basic data for all samples were therefore transformed logarithmically to remove heterogeneity of the variances and then tested for significant difference between samples. The computer program incorporated a compensation factor for small samples. Information regarding the phases for which there were larger numbers and also the grouped data for each phase were extracted and plotted separately to facilitate their examination (see Tables 7.8, 7.9, 7.10a - d, and 7.11a - b).

Even though precautions were taken to minimise the inequality of the samples, some results were definitely less reliable than others among those samples with low numbers. The criterion for this was a dividing factor less than 30 and a t-value between 2 and 3. This kind of result has been denoted by a separate symbol on the charts.

The patterns of similarity and difference obtained were complex. It was hoped that all four measurements for a sample would give the same result for the same comparison. However, it was not surprising that they sometimes differed because the numbers of left and right valves for the same sample were often different and so were the number of width and length measurements since damage prevented some measurements being taken. Consequently, even with this fairly objective method of comparison some personal judgement was necessary to interpret the results. Generally, whichever comparison result was in the majority had to be used. Also the fact that left valve measurements tend to be less accurate gave weight to results from the right valves.

It was noted that there was a correlation of results between the length and width comparisons. It was decided to test the length/width relationship by linear regression to determine the degree of correlation. Details of this linear regression analysis are given later. A very good correlation between the two parameters was generally found. In future work, if this good relationship can be proved on a sample of shells at the beginning of analysis, it should be possible to take only one measurement for each valve. This would save a lot of time and simplify size comparisons. Although a constant relationship also exists between the right and left valves, with the right valve copying the shape of the left and tending always to be smaller, no use can be made of this to cut back further on work because the two valves of a pair rarely occur together.

The charts showing significant difference were here used to study samples of oyster shell from areas of Ludgershall Castle thought to be particularly interesting. Details of this follow. The meaning of the other patterns of similarity and difference was not fully investigated. Nevertheless, some mention must be made of the kinds of discoveries made after a brief examination of the charts. Some contexts were most distinct; for example, in D19 layer 9 (Destruction phase) 84% of possible comparisons of left valve maximum width showed a significant difference; in A21 layer 5 LVMW (Destruction phase) 87% were significantly different; and in A21 layer 3 LVMW (Farmyard phase) 77%.

Other contexts were noticeable in that they showed mostly no significant difference from other contexts, e.g. LVMW D21 layer 16 (HL4), J13 layer 9 feature 1004 (HL4), C11 layer 8 (Destruction) among others.

A look at the right valve comparisons of contexts from the Farmyard phase showed that shells from all contexts within a layer were alike but a significant difference existed between the layers except for layers 3 and 4 which were similar. It is hoped that these random examples have given an idea of the use of such comparisons in describing inter-site variability. They can also be used for intersite comparability.

An aspect of the shape of the shell is reflected by the relationship between width and length. Linear regressions of length and width measurements of oyster shell shows that in most samples examined there was a very good relationship between the two values with an angle of slope often approaching 45^{o} and correlation co-efficients nearly 1. Linear regressions for some samples in the South-West and South-East Sectors can be seen in Table 7.12, and for the East Sector in Table 7.13. One would expect this regular relationship in neat rounded cultivated oysters where individuals are separated out at an early stage of development.

An examination of linear regression results from the East Sector (Table 7.13) shows an interesting trend in that for smaller shells the left valve is wider than the right valve of the same length as one might expect, while for a larger than average shell the opposite is true with the right valve being wider than the left valve of the same length. This could be a natural phenomenon of growth related to the thickening of the shell with age or it could possibly be the result of trimming prior to transit. That part of the left valve that overlaps the right has been seen to be trimmed before packing for marketing in present-day oysters.

To sum up, in future analyses it would only be necessary to take one measurement, e.g. maximum width, for each shell or maybe use a ratio such as width divided by length, if it was proved from a test sample that a good relationship existed between width and length. This would save time at the recording and analysis stages. There would be no need to draw graphs and histograms, but if graphs were required these should use the transformed or geometric means of samples. Since there is some question of reliability in small samples used in significance tests, then it could be argued that only samples of more than thirty should be used. Obviously, if shells are really numerous on a site, it would be advantageous to use samples of more than 100. It would also be advisable to use a computer more extensively, particularly for plotting the charts of significant difference (a facility not available in the completion of the analysis of the Ludgershall shells - which was the first attempted for this research project). Comparisons of small numbers of samples can be done manually.

Infestation

Tables were drawn showing the number of shells in which each infestation type was recorded for each phase of the site. Some of the sample sizes were very small and this complicated interpretation. To obtain a better idea of relative proportions, these numbers were expressed as a percentage frequency for the whole of the East Sector sample, and percentage frequency for individual larger samples in the South-East and East Sectors.

The sixty-seven shells of the South-West Sector were relatively free of infestation. Signs of Polydora ciliata were most frequently noted, 11.9% of all shells were affected. Polydora hoplura occurred to a lesser degree, 4.5% of all shells. There were occasional records of Cliona celata, calcareous tubes, barnacles, drill holes and saddle oyster (Table 7.14).

More shells were recovered from the South-East Sector, 261. Polydora ciliata was again the main infestation with 18.8% of all shells affected. Polydora hoplura followed in frequency with 11.1%. Drill holes were present in 7.7% Cliona celata, calcareous tubes, barnacles and saddle oysters were present in small proportions (Table 7.15). In the larger samples from the Post-castle, Post-castle destruction and Modern phases there was a steady increase with time of the proportion of shells affected by Polydora ciliata. This is matched by a corresponding decrease in the abundance of Polydora hoplura. It would be interesting to determine whether this could be a reflection of a change of fishing locality or change of sea-bed conditions.

Overall in the East Sector Polydora ciliata and Polydora hoplura are the commonest infestation and occur in almost equal quantities, 13.7% and 13.6% respectively. Drill holes are found in 8.1% of shells. Saddle oysters and oyster spat both appear 3.5% of shells. Small percentages of all other types of infestation were present (Table 7.16 and Figure 7.2).

Examination of samples with more than fifty shells, and the combination of samples closely related in either time or origin provided a clearer picture of the pattern of infestation. Percentage frequencies of infesting forms can be seen in Tables 7.17 and 7.18. Whereas in most samples the two Polydora species were recorded in equal proportions, in HL4 phase P.ciliata predominated, and in HL5 and HL5/Destruction had a lower incidence of all types of infestation.

Other marine molluscs

Only a few specimens of marine mollusc other than oyster were recovered. These were the edible mussel Mytilus edulis L., the cockle Cerastoderma edule (L.), winkle Littorina littorea (L.) and whelk Buccinum undatum L. Their numbers and distribution can be seen in Figure 7.3.

Some mussels and cockles were attached to oyster shells and were possibly cultch. Winkles occurred in insignificant numbers. The inclusion of the occasional winkle with oysters could possibly be accounted for if the oysters were held in storage pits on the shore prior to transit. These shallow pits, the use of which in oyster culture is documented from Roman times, may sometimes have had abundant growth of filamentous green weeds. A known method of control has been to place some ordinary winkles in the pit to browse on the weeds and other growths on the shells to keep them clean (Cole, 1956). There were two groups of mussels and one of whelks that might represent individual meals.

Areas of special interest

Certain latrine pits and the courtyard area of the East Sector were examined to see whether the oyster shells differed from the rest of the site. There were few shells from the kitchen area; most of these came from layer 8 of the courtyard. Only one valve and fragment came from the Great Hall. The latrine pits, features 67, 442 and especially 1004, held most shells.

The sizes of shells from the courtyard area were compared with those from the latrine pits and all other contexts using the significant difference charts. There seemed to be no obvious distinction in size between the courtyard and the rest of the site, but there was some degree of difference between them and those from the latrine pits, with the exception of layer 9 of feature 1004. There was no significant difference in size between the shells from all three pits. So there was some size distinction in shells from these three pits compared with the rest of the site.

The shells from all layers of pit 1004 were very uniform in size. Statistically there was no significant difference in their measurements. Examination of the length/width ratio by linear regression for shells from layer 4 of this pit showed that left and right valves had almost identical slope, correlation co-efficient and y-intercept. This was not seen in any other sample and indicates a remarkable degree of uniform roundness in both valves.

Infestation did occur in shells from these areas. However, it has already been noted that the shells from HL5 and HL5/Destruction had the lowest incidence of infestation for all samples. These phases were mostly composed of shells from pit 442.

Shells from courtyard layers 8 and 28, pit 1004 layers 4 and 12, and pit 442 layer 15 were noted as frequently being of purplish or pinkish hue. Shells like these have been found in the Paradise Street excavations at Poole. The colour is believed to be an indicator of excellent condition. Iron stains and concretions are also recorded fairly often in pit 442 layer 214, courtyard layer 43 and on all valves from pit 1004 layer 4. What this signifies is not understood.

General note

Some evidence of opening and handling was observed. Four parallel cut marks were found on the inner surface of the left valve on shells from HL4 D19 layer 15, Destruction A21 layer 5 and Destruction J24 layer 3. These compare well with those illustrated from Saxon Southampton (Winder, 1980). W-shaped notches were also found on the margins of the shell opposite the umbo in HL4 F21 layer 15 and Destruction J21 layer 6. These have also been recorded at Poole (Winder, 1992).

Conclusions

Counting the shells showed that abundance was greatest in the East Sector and in the later phases. It was concluded that the right to left valve ratio could yield information about the nature of the deposit, i.e. whether the shells represented an individual meal, a series of such meals, waste from the kitchen or waste from the table. Here reference was made to work on other sites which tended to support this hypothesis.

A technique was evolved for comparing shell size in the most objective way possible and suggestions made on ways to save time in this procedure for future analyses. This technique showed that there was a great deal of variability in the samples from Ludgershall. It is hoped that the archaeologist could use this more extensively to compare and contrast areas of the excavation.

The study of measurements and infestation attested to the fact that the courtyard area and certain pits (67, 442 and 1004) contained shells which were of distinct size and appearance, and were distinguishable from shells found elsewhere on the site. They seemed to be specially selected top quality oysters.

OYSTERS AND OTHER MARINE MOLLUSCS FROM 39 BROWN STREET, SALISBURY

Introduction

Oyster and other marine mollusc shells were recovered from floors and levelling layers within a domestic building. An intrasite comparison of shells from the different phases of occupation of the site was made.

Numbers of oysters

A total of 321 valves of the oyster (Ostrea edulis L.) were recovered from the Salisbury W139 site. Table 7.19 shows how these were distributed through the various phases of occupation. A minimum number of 184 oysters is represented by the valves. Very few shells were found in the earlier phases of the site. From the 13th to 15th century (phases 2a, 2b and 2) 58 shells or 18.07% of the site total were recovered. From the 15th to 17th century (phases 3a, 3 and 4) 59 shells or 18.38% of the site total were recovered. Most oyster shells were in deposits phased to the 17th century (phase 5) with 108 shells or 61.06% being found. Only 2 shells, less than 1%, were discovered in phase 6 contexts.

More right valves survived than left valves (182 RV cf. 140 LV). Breakage rate was higher in left valves than right valves (45% LV were unmeasurable of 30.2% RV unmeasurable).

Size of oysters

Table 7.20 shows a summary of the right valve maximum width size data for the three samples from Salisbury W139. Despite grouping of contexts into those of a related time span, the sample numbers in Salis 2 (the computer file name for phase 2) and Salis 3a (the computer file name for phases 3a, 3 and 4) were small - 25 and 21 respectively. There were 77 shells in the Salis 5 (phase 5) sample. For the site as a whole, the smallest size was 30mm and the largest 95mm. Salis 2 and Salis 3 have a limited range of sizes (44-73mm and 30-78mm respectively) while Salis 5 had a much greater range of 35-95mm. The means and medians of the samples reflect oysters of limited dimensions.

Figure 7.4 shows computer-style histograms of the distribution or frequency of the different sizes in each sample, with the measurements grouped into 5mm bars, the asterisks denoting actual counts. The three histograms cannot really be compared because the sample numbers are so different.

Figures 7.5, 7.6 and 7.7 are histograms of size frequency distribution of the right valve maximum width measurements again for Salis 2, 3a and 5 but with the counts converted to percentage frequency to aid comparison. In Figure 7.5 of Salis 2 there is a restricted range of sizes from 40-75mm, with an approximately normal distribution and a peak at 60-65mm. There are no very small or very large specimens. In Figure 7.6, Salis 3a, the range is slightly wider - 30-80mm with a peak at 55-60mm but the distribution of sizes is relatively even. Figure 7.7, Salis 5, shows the widest range of sizes from 35-100mm. Whilst there are no very small shells there are quite a few large ones. The peak of abundance is in the 60-65mm band and the distribution is approximately normal.

Since it is difficult to assess the relevance of the variations demonstrated in the histograms described above, two sample *t*-tests were carried out to determine whether there was any statistically significant difference between the samples. Figure 7.8 shows two matrices of some of the results obtained from comparisons made between each of the Salisbury samples. The upper matrix gives the actual *t*-values obtained from the comparisons. The lower matrix has the symbol "-" for those values that were below and the symbol "+" for values above the number 2 which is considered the criterion for significant difference. There is no significant difference (-) in the size characteristics of the three samples from Salisbury W139.

Age and growth rate

Figure 7.9 gives histograms of the distribution of age groups in the oyster samples (based on right valves only). Although the range of ages represented varies from sample to sample, with the greatest range from 1-9 years in the Salis 5 sample, there is a marked peak of abundance of 3-year old oysters in all of the samples. Most other shells are clustered around this peak in the 2- and 4-year groups.

The combination of the size and age information was used to calculate absolute growth rate in the samples. The resultant curves are plotted in Figures 7.10, 7.11, and 7.12 for phase 2 (2a and 2b), phase 3a (including 3 and 4) and phase 5 respectively. In these graphs the vertical axis represents the mean maximum width in mm for each age group. Age in years is represented by the horizontal axis. The encircled points represent the mean size of oyster shells of each age group. The vertical lines through the points represent the 95% confidence intervals. There is no such line if there was only one shell in a particular age group. The points are joined by a solid line if the year group contained at least 5% of the sample. A dashed line between points is conjectural where the intervening point represents less than 5% of the sample.

Infestation

The rate of infestation and encrustation by various organisms is tabulated for the three Salisbury samples in Table 7.21. The oyster shells were not badly affected. Evidence of burrowing by Polydora ciliata was most common but even the highest rate recorded was only 16.7% in phase 2 (cf. 8.1% in phase 3 and 6.6% in phase 5). There were only five possible records of Polydora hoplura but identification was not certain. In phase 2, in addition to Polydora, one example each of the calcareous tube of Pomatoceros triqueter, a barnacle embedded in the heel, polyzoa, a borehole and sand tube were noted. In phase 3 P.ciliata was present, Cliona celata in one shell and boreholes in two. Phase 5 shells showed four instances of the boring sponge, three of calcareous tubes of P. triqueter, one of Polyzoa, five of boreholes and two of sand tubes. Figure 7.13 gives histograms of the degree of infestation in the three phases.

Other characters

Of all the oyster shells from the site, seven showed V-shaped or W-shaped notches on the edge in a position more or less opposite the hinge end. One shell had a mussel shell attached at the heel on which the young spat had originally settled. Some of the shells had pink or purplish coloration which is natural and associated with diet. In two instances young oysters were attached to older ones. Twenty-five oyster shells were noted as being exceptionally thick and heavy for their age and size, and three of these showed chambering or chalky deposits. Four shells had a peculiarly triangular shape as opposed to the more normal rounded or broadly oval one. Some of the shells were blackened; this could be the result of either burning or staining. Rust-coloured encrustations were apparent on quite a few shells.

Other species

Four other species of marine mollusc shell were recorded. These were Anomia ephippium L. (saddle oyster), Buccinum undatum L.(whelk), Cerastoderma edule (L) (cockle), and Mytilus edulis L. (mussel). The numbers were small. Their abundance and distribution is set out in Table 7.22. Mussels occurred most frequently with 26% in phase 2 contexts, 39% in phase 3 contexts, 22% in phase 4 contexts and 13% in phase 5. A total of ten cockle valves, four whelks and four saddle oyster valves were also found. Marine molluscs were generally sparse but most were in contexts belonging to phase 2 and 3, becoming less frequent in phases 4 and 5, with least in phase 6.

Conclusions and discussion

Considering the time span involved, from the 13th to the 19th century, not many marine mollusc shells were recovered. However, the contexts in which shells were found were all related to floors and levelling layers within a domestic building, so perhaps their scarcity is not so surprising. On other archaeological sites oysters have tended to be found in the greatest numbers in the deeper features such as pits or ditches. Oysters in this instance have probably been accidentally incorporated into floor layers although occasionally on other sites oyster shells have been recovered in large numbers from floor layers where foundations have been dug through midden-like deposits (e.g. Town Cellars, Poole) or where they have been apparently laid down like a mortar flooring (2nd-century buildings, Pudding Lane, London).

Right valves probably survived better than left because they are flat and less easily broken when trodden on, and are also likely to be quickly pressed into any soft soil.

Regarding the other species of marine mollusc recorded, the saddle oysters are frequently found attached to the edible oyster, and are not normally eaten themselves. The saddle oyster valves have probably become detached from the oysters at some stage although no chalky byssi or stalks were noticed on the oyster shells. Nothing much can be said about the mussels, whelks and cockles, which are common edible species, because they were so few in number.

The various analyses carried out on the size characteristics of the oyster shells highlighted how small were the shells. An examination of the ages of oysters represented in the samples from Salisbury demonstrated that small size could be, at least in part, attributed to young age since 3 years was the most common age. However, by looking at the curves of absolute growth rate, it is possible to see that the small sizes of the oysters are not only due to age but that these oysters were also noticeably slow-growing.

OYSTER SHELLS FROM CROSS STREET, WOKINGHAM

Oyster and other marine mollusc shells were examined from the excavations at Cross Street, Wokingham to determine whether they could add any information to the interpretation of the site. Only a few shells were recovered from a total of thirty-eight contexts. Slightly over 50% of the contexts contained only one oyster. Only two contexts yielded larger samples worthy of detailed examination. These were context 131 and context 138 with a minimum number of individuals of 66 and 37 respectively. However, context 138 was of uncertain dating or phase and therefore was not considered. Five contexts from disturbed, mixed or modern features were not examined.

The shells were generally in a poor condition, possibly due to predisposal wear or erosion during burial. The oyster shells had also been scrubbed after excavation; and this, no doubt, added to the deterioration of their condition and could also have removed evidence of organism that had infested or encrusted the shells. A large proportion of the shells were broken, with the left valves being more subject to damage.

The paucity of material precluded any possibility of intrasite comparisons of the oyster shells. It was considered worthwhile to fully record information regarding these shells so that they could be compared with shells from other locations and periods as part of a wider study of the exploitation of marine molluscs in Wessex over the past two thousand years.

Numbers

Table 7.23 summarises the abundance of oyster shell in the different contexts grouped according to date. This shows the number of measurable left and right valves for each context, the percentage of unmeasurable shells, the total number of valves, and the minimum number of individuals represented. No trend can be detected in the relative abundance of the oysters with time because the numbers are generally so few, and the contexts are allocated to dates or phases which overlap.

Size

The measurements obtained for the largest dated sample, context 131, were plotted as histograms to show the size frequency of the sample. The histogram for the right valve maximum width measurements can be seen in Figure 7.14. The frequency with which shells were recorded with each measurement in millimetres is expressed as a percentage of the whole sample. The results have been grouped into 5mm bars for clarity. The bar which represents shells with a maximum width from 35-39mm is based on only one shell. The shells range in size from 30-70mm with a mean of about 53mm (standard deviation 8.54). Most shells belong to the 55-59mm group.

Age

Figure 7.15 shows the age composition of the sample from context 131. The numbers of right valves belonging to each year group are expressed as a percentage of the whole sample. Oysters range from 1 - 9 years. The 1-, 2- and 9-year groups are represented by less than 5% of the sample (1, 2, 1 individuals respectively). Most of the shells are from 3 - 6 years with the majority occurring in the 4 year-group. Four years is the preferred age for marketing at the present time.

Growth rate

The mean size of the shells in each age group of the sample from context 131 was plotted as a graph to show absolute growth rate. This can be seen in Figure 7.16. The points for the 1-, 2- and 9-year groups may not accurately reflect growth because they are based on so few shells. However, the general appearance of the graph approximates to the typical sigmoidal curve typical of growth rate in modern bivalves, with rapid exponential growth in the first years declining with age.

Infestation

The evidence of infesting or encrusting organisms included the borings of the marine polychaete worm Polydora ciliata, the sealed-off boreholes of a predacious gastropod mollusc such as Nucella lapillus (L.) or Ocenebra erinacea (L.), the honeycomb-like boring of the sponge Cliona celata, calcareous plates of barnacles (Cirripedia) and sand tubes typical of Sabellaria spp. Infestation was slight. Only the borings of Polydora ciliata and barnacles occurred with any frequency (17% and 9% respectively in context 131.)

Other molluscs

A few edible molluscs such as mussels (Mytilus edulis L.) and cockles (Cerastoderma edule (L.)) were also recovered in small quantities.

Conclusions

Only a few marine edible mollusc shells were recovered from the excavation of the post-medieval site at Cross Street, Wokingham. These were mostly oysters with a few mussels and cockles. It is not possible to determine if the relative abundance of the species varied with time or from one area to another. Comparisons with other archaeological samples, described in later chapters on intersite relationships, were used to further understand the shells from this site.

OYSTER AND OTHER MOLLUSCAN SHELLS FROM READING ABBEY WHARF

The shells of oysters, other marine molluscs and some freshwater molluscs were recovered during the excavations of the Reading Abbey Wharf site. The shells were examined to see if there was any significant variability on an intrasite level in their abundance, size, age, growth rate, infestation, fragmentation and discoloration.

Particular attention was paid to variations from period to period in the use of the site, and also to differences in the shells from the channel contexts compared with reclamation contexts. Shells from unstratified contexts were not examined; neither were shells from site W61B because of the difficulties caused by intrusive material. Only shells from sites W12 and W61A were recorded and analysed in detail. The selective basis on which finds were recovered from periods 6 and 7 was borne in mind.

Numbers

Table 7.24 shows the abundance of oyster shells for the various periods in which the site was used. There were 140 contexts containing shells, mostly oyster (Ostrea edulis L.). The unstratified contexts and those in site W61B were not examined. A total of 897 oyster shells was recovered: 475 left valves, 422 right valves, 489 minimum number of individuals. The majority of the shells were found in contexts from periods 5 and 6 (33.9% and 27.6% respectively - total 61.5%). Only four periods contained enough right valves to permit statistical analysis; these were period 4 (68), period (154), period 6 (88), and period 7 (94).

Size

Table 7.25 shows the basic data for right valve maximum width measurements of oyster shells dating to the various periods. The smallest shell measured 23mm and the largest 93mm but the mean measurements of the samples were mostly around 57/58mm with the exception of the shells from period 4 which had a slightly higher mean of 60.3mm. The standard deviations of the samples were very similar: between 10 and 11.

The histograms shown in Figures 7.17 - 7.21 show the size distributions in the samples from periods 4 - 7 with Figure 7.19 showing the samples from periods 4 and 5 combined. The distributions are approximately normal. Shells less than 30mm and more than 85mm are rare. The size frequencies appear to be very similar.

Each period sample was compared with the others from Reading Abbey Wharf by using the standard error of difference to determine whether there was statistically any significant difference in sizes. No significant difference was found between the samples.

Age

The age distributions of the Reading Abbey Wharf samples are shown in Figure 7.22. Overall there is a range of ages from 1- to 8-years but the 3- and 4-year old oysters are the most commonly occurring in each sample. Very few oysters were more than four or less than two years old.

Growth rate

The growth curves can be seen in Figures 7.23 - 7.26. Growth appears to diminish from about the sixth year.

Infestation

Figure 7.27 shows histograms of the frequency of infestation in oyster shells from different periods. The most common type of infestation evidence was the burrows of Polydora ciliata. These were dominant in shells of all periods but were less abundant in shells from period 7 (28% cf. 36.2 - 39.1% in other periods). The related species Polydora hoplura may have been present. Some burrows were tentatively identified as belonging to this species on the basis of size but they were not the characteristic U-shape channels or blisters typically found on the inner edge of the shells.

Evidence of the boring sponge was found in low numbers of shells, just under 3% of shells being affected in most periods, up to 4% in period 7. Calcareous tubes made by Pomatoceros triqueter were found on 4% of shells from period 5 but were absent elsewhere.

The highest numbers of barnacles, Balanus sp., were on shells from period 7 (3.2%). Only about 1% of shells in periods 4 and 5 showed evidence of their attachment. None were recorded on period 6 shells. The Bryozoan sea mats were also absent from period 6 while period 7 shells had the most recorded instances with a 4% level of encrustation. Periods 4 and 5 had levels of 2.9% and 0.8% respectively.

Boreholes, probably caused by the sting winkle or dog whelk, were the second most common type of infestation evidence. 5.7% of shells from period 4 and 6.4% of shells from period 5 were bored by one of these creatures. There was about half this frequency in periods 6 and 7 (3.5% and 3.2%). Sand tubes were almost as frequent as the boreholes. The tubes were probably made by members of the Sabellid family of worms. Sand tubes were found on 6.4% of shells from period 7, 5.7% from period 4, 4.8% from period 5, and hardly any from period 6.

The patterns of infestation were considered period by period as well as the distribution of individual infestation types. In period 4 (1315-1395) the burrows of Polydora ciliata were the most common type of infestation. Boring sponge holes, gastropod boreholes, barnacle scars, sea mats and sand tubes were also present in small quantities.

In period 5 (1395-1539) P. ciliata was again recorded in the highest numbers of shells. All the other types of infestation were recorded in low frequencies. In this period there were more shells affected by boreholes than in the other periods.

Period 6 (1539-1720) had the highest incidence of P. ciliata infestation. There were no calcareous tubes, no barnacles, no sea mats, and the lowest level of encrustation by sand tubes. In other words, encrusting organisms were virtually absent.

Period 7 (1720-1750) showed P. ciliata dominating again but occurring in a smaller percentage of shells than in other periods. Cliona borings were at the highest recorded level as were the number of barnacle attachment scars, sea mats and sand tubes recorded. Only calcareous tubes were absent. Encrusting forms were much in evidence in this period.

Fragmentation

Table 7.26 shows the degree of fragmentation in samples of oyster shell derived from the different context categories. Of 395 shells recovered from the channel type of contexts, 21% were too damaged to permit measurement. The same sort of broken specimens constituted 47.1% of the 365 oyster shells discovered in reclamation type contexts. In the various other contexts, conforming to neither channel nor reclamation type, the percentage of damaged shells was only 14.2%.

Discoloration

Shells that had lain in the fine, dark sediments of the river bed had become stained. Sometimes this was just in the form of grey patches but, at the other end of the scale, the shell could be totally black. The degree of staining would presumably depend on the length of time the shell had spent in the staining sediments. Table 7.27 shows the proportions of stained shells found in the major context types. Of the oyster shells from the channel contexts, 69.2% were blackened compared with 48.5% from the reclamation contexts and only 31.8% from the other contexts.

Other species

Table 7.28 shows the frequency with which mollusc shells other than oyster were found in the major context types. These species were the common whelk (*Buccinum undatum* L.), common cockle (*Cerastoderma edule* (L.)), edible winkle (*Littorina littorea* (L.)), buckie (*Neptunea antiqua* (L.)), common edible mussel (*Mytilus edulis* L.), carpet shell (*Venerupis decussata* (L.)), painter's mussel (*Unio pictorum* (L.)), a large freshwater mussel like the swan mussel (*Anodonta* sp.), and a few unspecified small freshwater species.

From the channel contexts, the only whole whelk shells and the only fragment of carpet shell were retrieved, along with most of the edible mussel shells (93%) for the entire site. 24% of all cockle shells were found here. There was one specimen of buckie and two intact individual specimens of freshwater painter's mussel. No winkles were found in channel contexts.

The shells found in the reclamation contexts included 68% of all cockles from the site but only 6.6% of the edible mussels. There was one buckie shell, a fragment of whelk, and the only fragment of winkle on the site. Freshwater species included one painter's mussel and a fragment of a larger type of bivalve from the family Unionidae, like a swan mussel.

The remaining contexts yielded only a few shells - a couple of cockle valves, an edible mussel valve, a buckie and the valve of a large freshwater mussel. There were no whelks, winkles or carpet shells. Other species of mollusc shell were considered not only according to the type of context in which they were found but also in relation to the period in which they were deposited. The distribution of other species by period is shown in Table 7.29. Only freshwater mollusc shells were found with the oyster shells in contexts dating to periods 1B, 2 and 3, i.e. the Saxon and Early Monastic phases of the site.

Contexts belonging to periods 4 and 5 contained the majority of edible mussels found on the site (91.7%) and most of the common whelks as well (75%). Period 6 was characterised by the highest percentage of cockles (48%) and two of the three buckies recovered from the site (the other one belonging to period 7). Cockles were found in contexts in all periods from 4-8, with most being retrieved from period 6.

Discussion

The majority of shells recovered from the Reading Abbey Wharf site were those of the common oyster (Ostrea edulis L.). The minimum number of individuals represented by these shells is only 489. This is a relatively small quantity of oysters considering that they were deposited over a period of about 600 years (although most came from deposits belonging to periods 4-7 (1315-1750). This seems to indicate that live oysters in the shell were possibly an unusual item on the menu and not a common commodity. Oysters are normally eaten alive. They have a limited life span out of water. Since Reading Abbey is some distance from the sea the cost of the necessary rapid transport for fresh oysters would have been high. However, the evidence from Poole in Dorset (Chapter 6) suggests that oyster meat pickled in brine may have been a suitable and cheaper alternative. Availability of oysters for despatch inland might well have depended on surplus being collected on the coast.

The beginning of period 4 (1315) coincides with the tail end of a "little climatic optimum" (1150-1300) during which time it is probable that warmer conditions promoted the natural propagation of stocks on wild oyster beds thereby producing a surplus. The beginning of period 6 (1539) saw the commencement of what is called the "little ice age" (1550-1850) during which phase the temperature and weather would presumably have gradually deteriorated to such an extent that natural oyster stocks would inevitably be depleted (having been affected by lack of recruitment in poor summers, and severe frosts and increased freshwater input from all kinds of precipitation including snowmelt and storm run-off in winter). The intertidal and estuarine areas favoured by oysters would be particularly affected by such conditions.

Bearing in mind the above, in periods 4 and 5 it would have been possible, in terms of oyster production, to reap the benefits of the warm climatic period which was just ending; while from period 6 onwards, worsening weather conditions could have led to a shortage of supplies. However, having made these comments about the abundance of oysters in relation to climatic change, the numbers of shells on this site are really too few to draw any definite conclusions. It would be interesting to examine oyster shells from similarly situated sites covering the same timespan to see if these ideas could be substantiated.

The average size of the oysters was small. The mean maximum width of right valves from period 4 was a little higher (60.3mm) than that obtained for the other periods (57.2 - 57.5mm). There appears to be a gradual reduction in mean size with time. However, the size frequency distributions in the samples are similar; and when the samples were tested, no significant difference in size could be demonstrated between them. The higher size limit in the samples is a reflection of the generally small size of the oysters but the lower limit could be an indication of the mesh size of the net bags on the dredges that one must assume were used for collecting the oysters. The one or two very small oysters could have been originally attached to older oysters.

If the technique used in aging the shells can be considered reasonably reliable, the most common ages of oyster found on the Abbey Wharf site were three and four years. This is common to samples from many archaeological sites.

The absolute growth rates determined for samples from periods 4, 5 and 7 were virtually identical and rather slow. This may be evidence of worsening weather conditions.

Infestation of the oyster shells was slight. The most frequently recurring evidence was the burrows of *Polydora ciliata*. This was the most common infestation in all samples although in period 7 there were fewer instances than elsewhere. A larger type of worm burrow was tentatively identified as *Polydora hoplura* but this was not typical of the burrows of this species. Small numbers of shells in periods 5, 6 and 7 were recorded with this type of burrow. The predominance of *P. ciliata* is potentially significant in a consideration of the possible source for the oyster.

Oyster shells in period 6 were characterised by an absence of encrusting organisms such as calcareous tubes of *Pomatoceros triqueter*, Sabellid worm sand tubes, sea mats and barnacles. It is difficult to account for this noticeable difference in the pattern of infestation in period 6 but it may be linked with the slow growth rate in being a possible response to cold weather conditions; or both features could possibly be a result of growth in deep water.

An examination of the degree of fragmentation in the samples of oyster shell revealed that shells from the reclamation contexts were twice as badly damaged as those in the channel contexts (47.1% cf. 21%). Since oyster shells are fairly brittle,some broken shells could logically be expected in most types of deposit. The higher proportion of broken shells in the reclamation contexts would be the result of activities related to dredging the river channel and dumping the riverine deposits in the bank. Where primary deposition had taken place, in pits or post holes for example, a higher percentage of shells would remain intact.

Deposition in fine organic silts on the river bed had caused staining of the shells. This varied from the presence of a few grey patches to complete blackening, presumably depending on the length of time spent in the silts. It was not surprising to find that over two-thirds of the oyster shells from the channel contexts (69.2%) were blackened compared with about half (48.5%) from the reclamation contexts and only a third (31.8%) from elsewhere.

The occurrence of marine mollusc species other than oyster, and of freshwater molluscs, was noted for the different context types. Valves of edible mussels, that disintegrate very easily, seem to have survived better in the undisturbed channel contexts and may be under-represented in other deposits. All the common whelk shells were found in the channel contexts. One specimen of the related, but more robust, buckie was recovered from each of the context types. Most of the freshwater species were also found in the channel contexts.

The various species are distributed unevenly through time on this Reading site. In deposits belonging to the Pre-Monastic and Early Monastic periods only freshwater species were found with the few oysters. In contexts dated to periods 4 and 5 the majority of edible mussels (91.7%) and most of the common whelks were found. Period 6 was characterised by the highest percentage of cockles (48%) and two of the three buckies recovered from the site. Cockles were found in all periods from 4-8.

The numbers of non-oyster molluscs are small; they may have been affected by differential survival or recovery. There is nothing to indicate that the large freshwater mussels, both Unio pictorum and the Anodonta species, had been used as food. They would have lived in the mud of the river bed and their inclusion with the other molluscan food refuse would have been incidental.

Most shellfish appears to have been consumed during period 5, which was a transition phase between the "little climatic optimum" and the "little ice age". A relatively high quantity of mussels, with whelks, cockles, and most of the oysters were found in deposits from this period. Although it is necessary to state again the need for caution in making assumptions based on such small numbers of shells, the relative abundance of shellfish remains around this time might be due to surpluses being available to coastal communities at a time when an extended phase of favourable weather conditions led to increased stocks of oysters and other molluscs.

Finally, intersite comparisons discussed in Chapters 9 and 10 made it possible to suggest the locality in which the oysters were being collected.

MARINE MOLLUSC SHELLS FROM MOORGATE AND COLEMAN STREET, LONDON, 1986

A large pit containing domestic rubbish mainly dating from A.D.1050-1150 was excavated in Area A of the Moorgate/Coleman Street site. Two layers within Pit 120, context 51 and context 65, contained a high concentration of marine mollusc shells. These were examined to determine the species and quantities present. Detailed records were made of the macroscopic features of the oyster shells. The two contexts were compared and contrasted. On the basis of the data obtained, it was possible to suggest reasons to account for the similarities and the differences between the shells in the two contexts, and to infer the way in which the shellfish populations might have been exploited and in which types of localities.

Numbers

Shells were examined from two adjacent layers in pit 120. Context 51 was removed in two parts: one from the layer generally and a smaller portion, which appeared to differ, on the south side of the pit. Context 65 lay immediately below context 51. Removal of all the shell material in the two contexts was attempted but it was estimated that 90-95% of the shells had, in fact, been recovered by normal hand excavation.

A variety of marine mollusc species was found. Common whelks (Buccinum undatum L.), edible mussels (Mytilus edulis L.), oysters (Ostrea edulis L.), common cockles (Cerastoderma edule (L.)), and tellins (Tellina spp.) were found in both contexts. A few netted whelks (Nassarius reticulatus (L.)) were found in c.51 only. Several common winkles and periwinkles (Littorina spp.) were only found in c.65.

Table 7.30 shows the relative abundance of the various species in each sample. The "sub sample" from the south side of c.51 contained only whelks and oysters in the proportion 17:62 (21.5% : 78.5%) respectively. It showed an atypical character in containing only two species of which oysters were dominant. The contents of the south side sample have also been shown amalgamated with the majority of the context (known as "general") for comparison with c.65.

The order of ranking in the abundance of those species held in common by the two contexts was virtually identical, with whelks occurring most frequently followed by mussels, oysters, cockles and tellins. The percentage frequency of occurrence (shown in Table 7.31) of the same species was also remarkably similar, with a slightly higher percentage of whelks in c.51 (53.4% cf. 48.6%) and a higher percentage of cockles in c.65 (5.3% cf. 1.4%). The winkles and periwinkles, netted and dog whelks each accounted for less than 1% of the samples, and would not have made a significant contribution to the diet. Their inclusion may have been accidental.

The composition of the two contexts was therefore very similar with regard to the main species present and the proportions in which they were found. In both samples whelks comprised approximately 50%, mussels 34% and oysters 10%.

Size of oysters

Figures 7.28a-d, 7.29a-d, 7.30a-d and 7.31a-d show the size distribution of oyster shells in each sample. The horizontal axis gives the measurements in millimetres. The vertical axis is marked as percentage. Measurements have been grouped into 5mm bars for clarity. The percentage of the shell sample exhibiting the measurements in each group was plotted.

It is best to use just one type of measurement to understand what these histograms depict. The maximum width measurement of right valves (RVMW) has been chosen, and these are shown together in Figure 7.32. The character of the size distributions in the two component samples of context 51 (i.e. general and south side) is noticeably different. Context 51 general has a range from 21 - 95mm. The distribution is not "normal" in the statistical sense. There is no one preferred size group. There are several peaks to the distribution. Context 51 south side, however, shows a fairly "normal" distribution; the range is from 32-97mm; there is a peak around 65-70mm; very few shells are under 45mm but there are quite a few larger shells. The evidence seems to indicate that the sample from the south side of context 51 represented a single unit of dumped material, while the sample from the layer generally comprised several dumped units, as shown by the multiple peaks. If context 51 is considered in its entirety, then the range of sizes are from 21-97mm, with a peak about 55-60mm, but with still a suggestion of multiple peaks. It can be seen that most of the shells were larger than 55mm in all three histograms.

The histogram for context 65 shows a contrasting pattern. The range of sizes is much wider; 11-111mm. It includes both very small and very large oysters, but few of the sizes in between. Most of the valves, 73%, were under 45mm. Highest numbers are between 20-30mm. Clearly the two contexts 51 and 65 exhibit a great difference in the distribution of sizes. The possible reasons for this difference and some implications are discussed later.

Histograms give a good initial visual representation of the size data relating to the oyster shells. It is useful to determine whether apparent differences between the samples are significant in statistical terms. For this reason, two sample t-tests were carried out on all four measurements for each sample. The results of these tests on RVMW can be seen in Figures 7.33 and 7.34. If the t-value obtained was greater than two, then the samples being compared were considered to be significantly different. In Figure 7.33 this difference is denoted by the symbol +. Figure 7.34 shows the actual t-values obtained. The results confirmed that the oyster shells from context 65 were different in size. The values were -6.2 to -8.08: much higher than the 2 required to make a distinction. There was no significant difference between context 51 general and the south side portion. The matrices also show results for the Guildhall House site which is discussed elsewhere.

The print-out of the analysis of variance in Figure 7.35 illustrates in another way the degree to which the samples differ. The samples are listed in the first column on the left. N is the number of shells in the sample, followed by mean measurement and standard deviation. The horizontal dashed lines represent the maximum width measurement for right valves in millimetres. The asterisks denote the mean measurement of the sample (based on pooled standard deviation) and the dashes contained within the brackets on either side of the asterisk signify the individual 95% confidence intervals. It is again clear that the shells in context 65 are in a very different size category.

Age of oysters

The size variations found in the oyster shell samples are due not only to the large inherent variability exhibited by this species of marine mollusc, but also to age. By aging the right valves in each sample, which lend themselves more easily to this task, it is possible to plot a histogram of the distribution of ages represented. Figure 7.36 gives all four histograms with younger oysters predominating. In context 65 most of the sample was younger than 3 years with the two-year group dominating, followed closely by one year olds. Context 51 general, south side and the two combined show to a greater or lesser degree a bi-modal distribution with one peak around 4 years and another about 9 years.

The age patterns follow closely the size distribution patterns but accentuate the result because they take into account the variability in size shown within one year group. The age/size distributions in context 65 are unusual. On other sites examined to date, such large numbers of very young oysters have not been found. It is notable that older year groups in the sample are represented but not in any quantity except perhaps the 10-year group. The bi-modal distribution in context 51 confirms a previously established preference for oysters about 4 years old and also shows that larger oysters were being consumed. The relevance of these size and age phenomena is discussed later.

Growth rate of oysters

The mean maximum width of right valves in each year group was plotted to give a curve representing absolute growth rate in the oyster shells. Figures 7.37 - 7.40 illustrate these growth curves. The 95% confidence intervals are indicated for each mean measurement plotted. A smooth curve was not obtained for two main reasons. In the first instance, the procedure of aging tends to be subjective. In the older shells particularly, where yearly growth bands are narrow and closely aligned, the amount of human error in allocating the age increases. This error factor is exaggerated when the shell is worn or broken. Secondly, in some age groups there were very few specimens on which to base the mean (sometimes only one shell), and therefore a truly representative mean for that age group may not have been obtained.

Typically, bivalve shell growth is exponential with rapid growth in the early years that reaches a plateau and falls off with greater age. When this is plotted on a graph, a sigmoid curve is achieved. Bearing in mind the problems involved in aging archaeological oyster shells, the curves obtained are not a bad approximation to the expected curve.

It is possible that the growth-rate curve of a sample of oyster shells may be a unique feature reflecting the response of the oysters in a single location to the environmental conditions prevailing at the time of their growth. If this is indeed the case, then the degree of similarity between the curves of two or more samples might be taken as an indication of contemporaneity and/or derivation from the same locality.

Growth rate in contexts 51 and 65 was similar. From the archaeological evidence the two layers of the pit were dated A.D.1050 - 1150. However, the growth rate evidence might be interpreted as a suggestion that the two samples of shell were collected over a much narrower time scale (i.e. the same or subsequent years) or that they originated from the same or very similar (?neighbouring) localities. The infestation data which follow tend to support this idea.

Infestation in oyster shells

The percentage of shells in each sample that possessed evidence of each type of infestation or encrustation was calculated, and the results assembled as a histogram. The histograms drawn for both right and left valves separately can be seen in Figure 7.41. The left valves are typically more infested than the right valves. Figure 7.42 shows the results combined from left and right valves because it seems logical to consider them that way as both must have come from the same individuals in the same location.

The figures show that the samples had a fairly uniform pattern of infestation with the exception of the presence in small quantities of calcareous tubes in context 65. P. hoplura was absent from both contexts. P. ciliata was recorded, but this amounted to just one or two burrows in most individuals affected. Cliona celata and boreholes were also only present in insignificant quantities.

There was greater evidence of attached than burrowing organisms. The sand tubes in some cases attained massive proportions. Polyzoa occurred in small patches; and when present on the internal surface of a shell, indicated that the oyster could not have been eaten. Where such unoccupied valves are found in pairs by modern oystermen, they are called "clocks" and are discarded.

Not recorded in the histograms was the presence of the seaweed Corallina officinalis on a few left valves from context 65. Barnacles (of unidentified species but probably Balanus balanoides) were also found in all samples occasionally.

Other characteristics of oysters

Many features of varying significance were recorded for the oyster shells in addition to numbers, size, age, growth rate and infestation. These features are summarised in Table 7.32 and include relative thickness, presence of chambering, chalky deposits, distortion or irregularity of shape, man-made cut marks or notches, cultch type, grouping or clustering, whether spat oysters were attached, the ligament preserved, or whether the oyster was not eaten.

Table 7.32 summarises both the actual number of times a feature was recorded in a particular context and the percentage of shells affected. It is not possible to place a lot of emphasis on the minor differences in percentages. Table 7.32 shows which features vary considerably between contexts by the magnitude of the percentage difference. For example, context 65 shows twice the number of distorted specimens shown by context 51 (13.8% cf. 7.1%). Despite the high degree of irregularity in the shells, not many adults were attached in groups (1.1% c.65 cf. 2.1% c.51), but then most of the oysters found were under 4 years old. 5.5% of c.65 shells had spat attached which was comparable with the 4.5% in c.51.

An examination of the ratio of thick to thin shells in context 65, there were more than double the number of thin shells (47% to 18.2%). This is expected since most of the shells were so young. Preservation in context 65 was fairly good as shown by 6.6% shells with the ligament still intact. The shells of context 51, however, showed better preservation with 10% of ligaments preserved. This difference could be attributed to the differences in ages of the shells represented. Older shells have a correspondingly larger and thicker ligament. There was a big difference in the numbers of oyster shells collected dead, i.e. 7.7% from context 65 compared with only 0.8% from context 51.

Other species

Whelks

The shells of the common whelk (Buccinum undatum L.), a carnivorous marine snail, were found in the greatest numbers in both contexts of Pit 120. There were 1295 shells which comprised over 50% of all shells found. Whelks live in the low intertidal zone down to deep water in estuaries and open seas on a variety of sea bottoms but with a preference for mud mixed with sand and shells. They are found all round our coast, but whelk fishing is only locally important to-day on the east and south coasts. In the sea the whelk meat grows white and fills the shell, and therefore provides the best commercial whelks; while in estuaries and rivers the flesh is darker and may be poor quality (Hancock, 1967).

The whelk can bury itself with just the siphon protruding when it lives on a soft substrate. It can detect and approach food rapidly as it moves against the flow of water. It is often found in large numbers associated with young mussels and cockles on which it is thought to feed, as well as scallops. Unlike many marine molluscs that rely on a warming up of water prior to spawning, whelks spawn from about November when the temperature drops below 9°C. Spawning takes place when the whelk is from 2 - 3 years or about 50mm high. Estuarine whelks are smaller than those from the open sea, but there is considerable variation.

Mussels

The edible mussel, Mytilus edulis L., is a blue-black bivalve, roughly triangular in outline, of variable length but marketable nowadays at about 50mm. It occurs commonly from high in the intertidal zone to depths of a few fathoms attached by byssus threads to rocks and other hard objects within sheltered harbours and estuaries as well as rocky shores of the open coast (Tebble, 1966) They are predominantly estuarine and the large commercial beds are all situated in areas subject to reduced salinity (Graham, 1956). In suitable estuaries, where there are large areas of stony or gravelly bottom exposed between tide marks, mussels may form very large banks or scars. There are prolific areas which are never uncovered by the tide but these rarely extend beyond the immediate sublittoral zone.

The mussels usually take about four years to reach marketable size. Mussel shells accounted for 34% of all shells found in contexts 51 and 65. However, each mussel would have yielded a much smaller quantity of meat than each whelk, for example. The real contribution to the shellfish diet would be correspondingly reduced. Mussels cooked in their shells in fresh water are high in food value. For every 100 grams of cooked meat, 16.8 would be protein, 2 grams fat and the total would be worth 87 calories which is comparable with the nutritional value of cooked whelks (17.8 grams protein, 1.9 grams fat and 91 calories), (Medical Research Council figures). Raw oysters, on the other hand, yield 10.2 grams protein, 0.9 grams fat and only 50 calories for every 100 grams, although they are high in vitamins and are said to be more palatable.

Cockles

Cerastoderma edule L., or the common edible cockle, has a solid bivalve shell, broadly oval in outline sculptured with radiating ribs and very fine irregular concentric lines. It varies in colour from dirty white, pale yellow or brown, and reaches a marketable size when about 25mm (Tebble, 1966). Cockles made only a small contribution to the pit deposits: 1.4% in c.51, 5.3% in c.65 or 3.3% overall. Their nutritional value when cooked is on a par with raw oysters with 11 grams protein, 0.3 grams fat and 48 calories per 100 grams meat.

This species is common and widespread in almost every sandy bay, but large commercial beds are nearly all situated at the mouths of large rivers like the Thames and in the Wash. Cockles seem to prefer muddy sand but may frequently be found in clean sand, in muddy gravel or almost pure mud. They tend to occupy only the first 50mm or so of the soil. They are sometimes taken below low water mark of extreme spring tides, with the greatest density between mid-tide level and low water or ordinary spring tides. (Graham, 1956).

The cockles are steamed or boiled on collection at the present time. The meats are then washed repeatedly to get rid of the grit before being salted or pickled. Obviously cockles were transported live to the Moorgate market since the shells are in evidence in the pit. Cooking opens the shells and dislodges the meat.

Conclusions and discussion

A high concentration of marine mollusc shells was recovered in two layers of a domestic rubbish pit dating from A.D.1050 - 1150. Whelks, mussels, oysters, cockles and insignificant quantities of other species were identified. The proportional representation by the different types was calculated and found to be almost identical in both contexts. A detailed examination of all the macroscopic features of the oyster shells was made and this provided evidence of a major difference between the two samples of oyster shell; but there were points of similarity as well.

The most noticeable variation in the oyster shells was in the size distribution of the samples. Certain factors such as genetics, age and growth rate govern the size achieved by each oyster. These factors do not, however, account for the size distribution which in context 51 was approximately bi-modal with peaks at 55-60mm/4 years and 85-90mm/9 years, while in context 65 the greatest numbers of shells were in the 20-30mm/2-year group. In both samples the larger, older shells had spat and young oysters attached. Maybe all or some of the loose young oysters were originally attached to the older shells.

Several inferences may be drawn from the fact that so many young oysters were found together with such old ones in the same sample. If the fishermen were able to see exactly what they were collecting, it seems unlikely that they would have deliberately gathered so many small oysters which could not have contained much meat. It seems logical to assume that the fishermen could not, in fact, see the oysters that were being collected. This implies that the oyster bed was under water and not exposed for hand collection at low tide. Some implement must, therefore, have been employed to gather the oysters, and this could have been a wooden handled or rope-hauled iron-framed dredge net, manufactured on a local basis, similar to that often used in recent times. The only other method of gathering underwater oysters that comes to mind would have been diving.

Whatever method was used to raise the oysters to the surface, no sorting of the catch was carried out prior to marketing. Pebbles covered with Polyzoa, and empty shells occurring singly or in paired "clocks" with encrusting organisms on the inner surface were included in the catch. Also, the fishermen could have had no idea of, or respect for, conservation or regulation of stock, otherwise they would have sorted out the loose small oysters, removed those attached to cultch or older oysters and thrown them back into the sea to provide mature oysters for a future season.

It is possible to surmise that some regulation might have been in effect from an early date from the Charter granted by Richard I in 1189 to the Corporation of Colchester which confirmed rights to the oyster fishery in the Colne and its creeks enjoyed during the two preceding reigns (the previous 89 years) and "from time immemorial beyond that", (Yonge, 1960). It is not until the 17th century that there is definite evidence of regulation. Bishop Sprat (1667) wrote "after the Month of May it is ...... punishable to take any other Oysters, unless it be those of size (that is to say) about the bigness of an half Crown piece, or when the two shells being shut, a fair shilling will rattle between them".

There is nothing to suggest any systematic farming or cultivation of the Moorgate oysters. Many of the shells in the two contexts had an irregular shape (context 65 had twice as many as context 51 - possibly this can be explained by the numbers of recently settled ones), which would be consistent with the oysters being derived from a natural bed. In addition, the spat and young attached oysters indicate a healthy breeding, self-perpetuating bed. High growth rates were maintained until about 10 years in both contexts. The conditions for growth, such as temperature and food supply, must have been very favourable.

Although the size distributions of the oyster samples were significantly different, the growth rates and infestation pattern in both of them were nearly identical, as were the numbers and proportions of the other marine molluscs present. The growth rate may indicate how closely related in time was the growth of the two sets of oysters. Since it is only with respect to size distribution that the two samples differ, and there are valid reasons for considering that the shells grew at a similar time (growth rates) and originated from the same or neighbouring locality (infestation), then it may well be that the size characteristics in context 65 can be attributed to local market conditions rather than the absence of the mid to large size group of oysters on the sea bed caused by, for instance, over-exploitation. For example, a late customer might have had to settle for the oysters that no-one else had wanted - the very small, very old and tough, and distorted specimens.

The oysters only constituted a small proportion of the individual molluscs present in the two layers. Whelks were the most abundant, followed by mussels and then oysters. Cockles were less popular than oysters. It is possible that there were taste preferences, or considerations of value for money at the market level that influenced which species ended up in the pot and the pit. These ideas can only be speculation.

It is more probable that some species were more readily available than others at the collection and subsequently at the market stage. Even if oysters were not protected by law at certain times of the year (a close season), there can be no doubt that the quality of the meat would vary, particularly during the summer spawning period. The old adage about eating oysters only when there is an R in the month is based on fact. While the spawning products are ripening in the oysters, they were referred to in the past as "white sick" or" black sick" according to the development stage of the larvae contained in the gills (Yonge, 1960). Such a description suggests that oysters were not considered fit for consumption while in this state. After spawning, when the oysters resources have been used up, the quality of the meat is poor and watery. A period of recovery is required before the oyster meat is palatable again. Basically, from May to August inclusive, while not being actually poisonous, oysters are not so good to eat and are generally considered out of season.

Whelks, on the other hand, spawn in the winter months from about November to February. Whelks can be exploited when oysters are not available and vice versa. Whelks live in the same areas as oysters so the fishermen would not necessarily have to change fishing grounds - only fishing tackle. Here then is one possible logical reason for whelks being found in greater numbers than oysters in the pit. It also suggests that the shells may have been deposited in the summer months.

Mussels and cockles can be collected from similar estuarine situations to whelks and oysters but further inshore, all the year round. Their collection would have been relatively easy. They would have been a useful supplement to the shellfish diet but may have been less palatable than other varieties.

There are various clues as to the general type of location supplying the shellfish to the London market but nothing specific. For example, the main species are estuarine with both the littoral and sublittoral zones being exploited. Whelks are often found on the same type of sea bed as oysters, and are thought to feed on young mussels and cockles. Mussels compete with oysters for settling space. In other words, there is a relationship between the type of habitat in which all four species are found.

The presence of one particular type of infesting organism, P.ciliata, is linked with the type of firm clay bottoms found in the mouth of the Thames, the north Kent coast and the creeks and rivers along the Essex coast. These areas remain the most important regions for both whelk and oyster fishing in Britain, with mussels particularly fished further up the coast and in the Wash.

It is probable that the shellfish at Moorgate were collected from one of these places and transported up the Thames to London. It might be possible to further pinpoint the localities of origin if more information was collated concerning the characteristics of modern mollusc populations and their ecology at specific locations along the coast, and if full details were documented for the archaeological specimens of all marine molluscs. [Data were later recorded for oyster samples from sites in East Anglia and are presented in Chapter 8. Comparisons of samples of oyster shell from both archaeological and modern populations are made in Chapters 9 and 10].

OYSTER SHELLS FROM GUILDHALL HOUSE, LONDON, 1985

Oyster shells were recorded from the two lower layers in Pit 437 in Area C of the Guildhall House site excavations in London. The upper fill of the pit was provisionally dated by pottery to the 10th century, context 309 contained no pottery, and context 409 had late 9th-10th-century pottery. The excavated part of the pit represented about half the original content. All of the shells in context 309 and about 75% of those in context 409 were collected. The oyster shells were examined to determine whether there was any significant difference between the shells in the two samples regarding size, age, growth rate and infestation; and whether anything could be deduced concerning their exploitation and consumption.

Numbers

The majority of shells were those of the European or flat oyster (Ostrea edulis L.) but there were a few mussels (Mytilus edulis L.), cockles (Cerastoderma edule (L.)) and one whelk (Buccinum undatum L.). There were 309 oyster valves from context 309 representing a minimum number of individuals of 153. There were 723 oyster valves from context 409 representing 365 individual oysters. Since only 75% of the shells were thought to have been recovered from context 409, the minimum number of individuals actually in the layer was probably nearer 487, which is three times the number found in context 309.

Size

The Figures 7.43a-d and 7.44a-d show the size distribution of oyster shells in context 309 and 409 respectively, for right valve maximum width (RVMW), right valve maximum length (RVML), left valve maximum width (LVMW) and left valve maximum length (LVML). The horizontal axis gives the measurement in millimetres. The vertical axis is marked in percentages. Measurements have been grouped into 5mm bars for clarity. The percentage of the shell sample exhibiting the measurements in each group was plotted.

It is best to consider just one type of measurement to understand what these histograms depict and how the two samples compare. The right valve maximum width charts were chosen, and are shown together in Figure 7.45. In context 309 the range of size is from 24 - 90mm; the most frequently occurring size group is 65 - 70mm. In context 409 the range is from 29 - 90mm and the peak of the distribution occurs in the 70-75mm group. Context 409 shows a more compact grouping of sizes than 309.

Figure 7.46 shows a matrix with symbols for the results of the two sample t-tests on the RVMW measurements of the Guildhall (and also the Moorgate-Coleman Street) samples. Figure 7.47 shows the actual t-values obtained. The matrices illustrate that there was no significant difference in size between the two Guildhall House samples.

In the analysis of variance shown in Figure 7.48 the means are very similar for the Guildhall House samples but context 309 has a greater 95% confidence interval.

Age

Figure 7.49 shows the distribution of age groups in contexts 309 and 409. The horizontal axis is marked in years and the vertical axis in percentages. The percentage of the samples belonging to each age group is plotted. Both samples have oysters ranging in age from 2 - 9 years, with a peak at 4 years. Oysters are often collected and marketed at four years at the present time. At this age they will have achieved maturity and possibly have bred for at least one season. The meat is at an optimum of palatability. It is cost effective to reap oysters at this age.

Growth rate

The mean maximum width for right valves was plotted for each age group. The resulting growth rate curves can be seen in Figures 7.50 and 7.51 for contexts 309 and 409 respectively. In both figures a rapid growth rate is indicated up to the 7th year when increase in width slows down. Less effort is then put into increase in width and length but more into thickening the shell, increasing the meat and producing future generations. Despite the similarity in the growth rate curves of the two samples, there is a possibility that oysters in 409 enjoyed slightly more favourable growing conditions (such as higher temperature and better food supply) than those from context 309 which, after a relatively poor first two years were able almost to make up in the third year to the average size achieved by the oysters in context 409.

Infestation

Only the presence, not the quantity, of each infestation or encrustation character was recorded for each shell. The percentage of shells in each sample that possessed evidence of each character was calculated and a histogram drawn of the results. The results for left and right valves shown separately are seen in Figure 7.52. Figure 7.53 shows the results for the left and right valves combined.

Polyzoa was the most frequently recorded encrusting organism for the shells in both contexts - 22.9% in c.309 and 31.2% in c.409. Sand tubes were the second most important encrustation with 16% of shells from context 309 and 15.3% from context 409 being covered with tubes probably made by Sabellid spp.. There were a few boreholes that had healed over in both contexts, slightly more in 409 - 7.1% cf. 3.6% in context 309. There was a very low incidence of barnacles and a few shells with Polydora ciliata. Polydora hoplura was absent.

Other characteristics

Table 7.33 gives a summary of all the other macroscopic features recorded for the oyster shells from the two samples. The shells in context 309 had more thicker specimens than those in context 409 (19.7% cf. 11.2%), and along with this a correspondingly greater proportion of chambering (3.9% : 1.4%) and chalky deposits (4.2% : 2.4%), features which are associated with rapid changes in salinity regimes. There were more thin shells in context 409 (42% cf. 8.7% in 309).

There was a slightly higher proportion of distorted shells in context 309 (6.2% cf. 4.2% in c.409). Some of these irregular shaped oyster shells were long and narrow like a shoe-horn and one was noted as being almost horse-shoe shaped. These odd shapes were common to both samples.

V-shaped notches were found on the outer margins of some shells in a position corresponding to 4,5,6,7, and 8 o'clock (if the hinge is 12 o'clock). There were twice as many cuts and notches in c.409 as c.309 (5% cf 2.3%). The cuts looked like knife marks on the smooth inner surface, in one instance three parallel cuts.

Cultch is any hard object on which the spat oyster settles after its free-swimming larval stage. Various cultch types were detected including mussels, cockles, oysters, and oyster shell debris. Some of the shells in both samples were attached in groups. Both samples had spat oysters attached to a large number of shells. Shells in context 409 had twice the number of ligaments preserved intact. 3.6% of the oysters were collected dead in the c.309 compared with 1% in c.409.

Conclusions and discussion

The size distributions of the oyster shells in the two samples were similar and statistically there was no significant difference between them. The age structure of the two samples was virtually identical and also shows a preference for oysters about 4 years old (a size of 60 - 70 mm). The growth rates were alike after the third year. Initially the oysters in context 309 were growing more slowly, but by three years they had almost caught up with those from context 409 - but not quite. The infestation patterns, which matched, suggest that the oyster beds were on hard sandy or clay grounds. The other characters of the oyster shells show that those in context 309 tended to be thicker with more chambering and chalky deposits and distortion; more of them were dead when collected. The shells in context 409 were thinner, with more noticeable cuts and notches, more specimens attached to each other, more spat attached, and a higher degree of preservation as seen by the number of intact ligaments.

It is not easy to interpret the data - to explain the differences between the samples. By way of general comment it is possible to suggest that the similarities in size distribution, age structure and growth rate are an indication that the two samples were collected at times not too far apart. The infestation data further suggest that the two samples were collected from a similar if not identical location which was probably downstream of London off the north Kent or Essex coasts. These ideas just tend to support what might be logically surmised from the stratigraphical and geographical evidence (although this implied trade in shellfish was not accompanied by pottery shipments from these areas in the 10th century).

There is no evidence of any systematic farming or exploitation practices. The oyster beds were probably natural giving quite a few very thick and distorted specimens, and adult oysters attached in groups (a characteristic of overcrowding on natural beds) or with spat attached (spat is normally separated from its cultch when oysters are farmed). The notches on the margins of shells show that the oysters concerned were probably eaten raw, since heat treatment either by boiling or roasting opens up the oyster naturally.

OYSTER SHELLS FROM PUDDING LANE, LONDON

Samples of oyster shells (Ostrea edulis L.) were examined from four contexts of the Pudding Lane excavations on the Roman waterfront in London. The earliest group (sample 3218) was found beneath the mid-1st century Roman landing stage and formed part of a massive dump or midden over 1m deep which had accumulated while the open-work landing stage was in use. The second group (samples 1714 and 1728) were incorporated in the foundations of second-century buildings. The last group (sample 1470) was from a pit dating from the 9th to 11th century (late Saxon to pre-Conquest).

Numbers

Table 7.34 gives a breakdown of the numbers of left and right valves of oysters found in the four samples and the proportions of damaged or unmeasurable shells expressed as percentages. The samples examined contained large but varying numbers of shells, the ratio to the total number of the context being unknown. The minimum number of individuals was obtained by counting the umbones.

The table shows that, with the exception of sample 1714 from the 2nd century, all the samples had approximately equal numbers of left and right valves. Sample 1714 showed a preponderance of right valves (about three-quarters of the total). In all samples more right valves could be measured than left though the difference was not so pronounced in the 2nd-century samples 1714 and 1728.

The degree of damage occurring in measurable shells was roughly equal for left and right valves in each sample. However, the damage varied from sample to sample. Nearly half the 1st-century and 9th- to 11th-century shells were unmeasurable. The percentage of damaged measurable shells was greatest in the 3218 1st-century sample (about 38%) and then the 1728 2nd-century sample (about 28%). The other two samples were under 15 per cent.

Size

A summary of the measurements and preliminary calculations is presented in Table 7.35. This shows that 3218 and 1470 have a greater range of size than 1714 and 1728 for all four measurements taken, i.e. maximum width and maximum length of right and left valves of each sample. The mean width measurement for each valve is always greater than the mean length. The mean measurements for 1714 and 1728 (2nd century) are greater than those of 3218 and 1470 (1st and 9th to 11th). The composition of the samples is easier to compare from the histograms of size frequency distribution seen in Figures 7.54a-d; 7.55a-d; 7.56a-d; and 7.57a-d.

The two sample *t*-tests on the four measurements for each sample gave the results expressed in Figures 7.58a-d. These demonstrate which samples were significantly different, something which could only be guessed at from the histograms and tables. It is clear that 3218 is significantly different from the other three samples (with the exception of left valves of 1470 which are similar).

1728 was different from 3218 and 1470 but in three out of four measurements was not significantly different from the other 2nd-century sample 1714 which shared an identical relationship with samples 3218 and 1470. 1470 was different from 1714 and 1728 on all counts but the left valves were similar to the left valves of 3218.

The linear regressions summarised in Tables 7.36a-b were calculated to show the degree of regularity of shell shape. The tables show a gradual but obvious increase in regularity of shape with time. The shells from 3218 were most irregular (angle of slope was 26.7^{o} and 35.0^{o} right and left valves respectively) and the correlation co-efficient showed that the scatter either side of this was quite wide (0.61 correct to 2 decimal places for both valves).

By the 2nd century the shape of the shells had changed considerably. The right valves of 1714 and 1728 show most clearly the difference with a slope of 40.7^{o} and 42.0^{o} respectively. Correlation is closer as well, being 0.75 and 0.77 correct to 2 decimal places. The difference is present but not so marked in the left valves of 1714 and 1728.

The shells from 1470 show the most regular shape of all the samples. Slope is nearly 45^{o} : 44.4^{o} and 43.3^{o} in right and left valves and the correlation co-efficients 0.89 and 0.86 showing more regular shape in a greater proportion of the sample.

Using the y-intercept obtained from the calculator computation of linear regression, it is possible to determine the expected width of a shell from any given length (and vice versa). If three expected widths are plotted on a graph and joined, this line will reveal the expected pattern of growth for the shells in the sample. It can be seen that each sample shows a characteristic pattern of the way in which the right and left valves grow (Figures 7.59a-d). The full significance of this has not yet been evaluated.

However, Figure 7.59a shows the calculated widths from given lengths (using the y-intercept) for oyster shells from 3218 (1st century). The right valve is always smaller than the left. The right valve only increases 5mm in width for every 10mm in length but is constant regardless of age. This means that the older the oyster becomes, the smaller the width in comparison with length, i.e. the right valve becomes more squat. In the left valve the relationship between length and width is not constant during development. In the young oyster left valve the width is much greater than length, e.g. 20mm long : 43cm wide; but later the difference diminishes until length and width are equal, e.g. 90mm long : 91mm wide. The shell is virtually circular.

In sample 1714 the calculated widths from given lengths (Figure 7.59b) shows a different pattern. For the right valve width is greater than length but the difference diminishes with increase in length, e.g. 20mm long : 35mm wide and 90mm wide (cf. 3218). So the right valve starts out twice as broad but ends up only slightly wider. The left valves echo this but with a greater initial difference between width and length, e.g. 20mm long : 46mm wide.

Sample 1728 is similar to 1714 but whereas the right valves show continuing reduction in the difference between length and width with increase in age/size, the left valves show a reversal of this trend in shells with a length greater than 9omm (see Figure 7.59c).

Sample 1470 shows virtually no difference between the right and left valves. The width is always about 10mm greater than length regardless of age or size (see Figure 7.59d).

The significance and usefulness of this type of plot to describe the general changes in size and shape in a population of oyster shells has not been fully ascertained yet and requires further examination.

Infestation

Evidence was found in the Pudding Lane shells of six types of associated organism: Polydora ciliata , Cliona celata, boreholes, usually healed over, caused by the European rough tingle Ocenebra erinacea (L.) or possibly the dog whelk Nucella lapillus (L.), Polyzoa (Bryozoa) or sea mats, Sabellid or fan worms, and barnacles.

Only the presence, not the number, of a particular infestation orencrustation type was recorded for each shell that was measured. Table 7.37 shows the number of shells and the percentage of shells in each sample for which each infestation type was recorded. Sample 3218 (1st century) was the most affected. Sample 1470 (9th to 11th century) was almost as bad. The former had 749 instances of infestation for 2052 shells, and the latter 332 instances in 956 shells. Samples 1714 and 1728 (2nd century) were noticeably less affected with only 81 occurrences in 363 shells and 45 occurrences in 203 shells.

The most frequently recorded infestation was the burrow of Polydora ciliata but its occurrence was not so severe as to have affected the survival or condition of the oyster itself. The 1st-century sample 3218 was most affected with approximately 55% of the left valves and 21% of the right valves having at least one burrow. Uniformly low percentages of the other samples had the burrows.

Cliona celata occurred infrequently. Barnacles were attached mostly to shells from the 2nd century (1714 and 1728), being present in negligible numbers of shells from other samples. Polyzoa (Bryozoa) was recorded mostly from shells in 1470 (9th to 11th century) where it was found on 15% of left and 5 per cent of right valves. Boreholes also were found frequently in this sample (1470): about 12% in left and 5% in right valves. The sand tubes of Sabellid worms, sometimes occurring in massive formations on the shell, were found mainly in 1470 where they encrusted nearly 18% of left valves and 2% of right.

Figures 7.60a and b show histograms of the percentage of occurrence of the different infestation/encrustation types in each sample. Shells from the earliest (3218) and latest (1470) samples had the most records of infestation but the composition of the infestation differed. In 3218 Polydora ciliata was dominant with other types present in only a very small percentage of shells. In 1470 shells were almost equally and significantly affected by the burrows of P. ciliata, sand tubes, boreholes and sea mats, with boring sponge and barnacles present in small quantities. Infestation of the two 2nd-century samples was only moderate, each with an equal number of shells affected, and the overall degree slight when compared with 3218 and 1470.

Other species

A few shells of other species of marine mollusc were found in Pudding Lane samples. These are cockles (Cerastoderma edule (L.)), limpet (Patella vulgata L.), mussel (Mytilus edulis L.), whelk (Buccinum undatum L.) and winkle (Littorina littorea (L.)). The numbers found in each sample are shown in Table 7.38. Mussels occurred in greater abundance than other species, especially in the sample 1470. With such small quantities, and without knowing what proportion of the whole deposit they represent, it is difficult to attach significance to the varying numbers. The other species were probably eaten in addition to oysters though in smaller amounts. The shell of the mussel is delicate and less likely to survive than other types and so the numbers of valves are possibly under-representative. They were second in popularity to the oyster.

Conclusions

Cultivation

The evidence provided by measurements, infestation, breakage and general appearance points to the fact that when the Romans first arrived in London and built the waterfront landing stage in the mid-1st century, they were exploiting a natural population of oysters. The sample (3218) showed a large size range, irregular shape, much attached shell debris, shells joined together and a lot of damage (possibly caused by separating clumps of oysters and inexpert opening of individual oysters).

By the 2nd century (samples 1714 and 1728) a great difference is discernible. The samples showed a smaller size range; larger average shell size; more regular shape; less infestation; less breakage and distortion; left valves with deep cups and clean white interiors; the heels attached to oyster, mussel and cockle cultch; and cut marks more clearly defined. All these features could suggest stock improvement.

The increasing regularity of outline found in the late, Saxon sample (1470) suggests the continued practice of some kind of oyster bed management with the young oysters being separated out at an early stage. However, the large numbers of encrusting and infesting organisms indicates that little care was being taken to keep the oyster beds clear, or to clean up the shells prior to marketing. Average size of the shells was small again, and there was a return to the wide size ranges found in the 1st-century sample. This shows a poorer quality stock and less discrimination over size for collection. There was a high proportion of broken shells (45% unmeasurable, 14% of measurable shells damaged) perhaps suggesting inept opening or handling. The two sample *t*-tests show no significant difference between the left valves of these shells and those of the 1st century. There was, however, a significant difference between 1470 and the two 2nd-century samples (1714 and 1728). It would be useful to examine samples of oyster shell from later Roman London to determine whether the improvement of oyster stocks was maintained at least until the end of the 4th century.

Processing

The presence of a very large quantity of oyster shells in a waterside dump beneath the Roman landing stage and obviously accumulated while the landing stage was operational poses a problem. The location and the almost equal numbers of left and right valves suggest that the oysters were opened on the spot. The oysters could have been eaten by the crew members of the coastal barges transporting them, or they might have been sold directly to eager customers from the moored boats. A third possibility is that the midden represents the residue of a process in which the meat was removed and preserved. To enjoy oysters at their best, they are normally eaten alive, which necessitates their rapid movement from seabed to consumer. Because of the difficulties and expense involved in transportation, at least some of those oysters destined for inland markets may have been pickled, a process certainly practised in the 17th century. Possibly the meat was removed from the shell and preserved in brine.

Place of origin

It has already been stated that the animals using the oyster shell as a habitat during its life can be indicators of seabed type. The presence of *Polydora ciliata* in great numbers of oyster shells at Pudding Lane (and the absence of the form *Polydora hoplura*) is an indicator like this. This worm is characteristic of hard sandy or clay grounds, particularly in warm shallow water. These conditions prevail along the Essex and North Kent coasts. Bearing in mind that the sea level in the 1st century A.D. was 3 or 4m lower than at the present time, then the salinity required by oysters (a range of between 28 to 36 parts per thousand, *c*.3%) would not have been found as far upstream as Roman London. The oysters from the waterfront excavations were not therefore grown very close to the city, but, it seems reasonable to suggest, may have been collected from beds further down the Thames estuary on the Essex and North Kent coasts. There is documentary evidence (Juvenal, IV, 140-2) that oysters were gathered near and exported from Richborough, which is adjacent to Sandwich Bay, by the Romans. No doubt many oysters would have also travelled inland via London from this location.

This chapter has added information to the database concerning the macroscopic characteristics of oyster shells by examination of material from a further seven sites, this time in the north of Wessex and in London. As in the previous chapters containing intrasite studies of oyster (and other associated marine molluscs) from the Southampton and Poole regions, the number of sites and their distribution within the area has been the result of availability of suitable material rather than specific acquisition policy. Chapter 8 continues the theme of intrasite variation with a consideration of oyster shells from East Anglia, in particular the site of Bury St Edmunds Abbey in Suffolk. Measurements and infestation data were also recorded from four other sites but this information has not been elaborated into a detailed intrasite analysis. Sites in this category include Leiston Abbey and Burrow Hill in Suffolk, and Colchester and North Shoebury in Essex.