WINCHESTER
A CITY IN THE MAKING

Archaeological excavations between 2002 – 2007
on the sites of Northgate House, Staple Gardens and the former Winchester Library, Jewry St

Section 13

Marine Molluscs
by Greg Campbell

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Introduction

Sea-shell must have been imported to Winchester from the coast, and at some speed, since they have a limited 'shelf-life'. Shellfish at inland sites are therefore good indicators of variation in long-distance transport efficiency between periods. Also, shellfish in the shell are a luxury food inland, since a better yield of protein and animal calories is achieved by consuming almost any other locally available animal (even one with little flesh), or by importing marine animals with a better proportion of flesh to waste (such as sea fish, or preserved shellfish flesh). So marine shells are not simply another component of the diet, they are the main, and usually the sole, means of studying perishable luxury imports at past inland sites.

An assemblage of approximately 21,000 marine shells was recovered from 1050 contexts, the greater part by hand, but some 3600 shells were retrieved by wet-sieving of bulk soil samples for recovery of charred plant remains by flotation. For all these 260 samples (almost all of which were of 40 litres excavated volume), shells over 10 mm were recovered by wet-sieving during the initial processing, and the fraction sized between 10 and 4 mm were examined, and retained and sorted if more than a dozen or so shell fragments were noted. In cases where shell was very common in the finer fraction this was retained for sorting by the analyst.

Methods

Whole shells and quantifiable elements of broken shells (umbones of bivalve shells, and apices or bases of apertures of gastropod shells) were extracted by the author from all the material over 4 mm available from hand-retrieval and sample wet-sieving. The resulting assemblage was identified to genus (and to species where preservation allowed), by reference to standard works such as Beedham (1972) and Tebble (1966), and to comparative material in the author's own collection and in the national reference collection held by English Heritage Environmental Archaeology Laboratory at Fort Cumberland, Eastney, Portsmouth. Nomenclature follows Poppe and Goto (1991 and 1993). English common names are taken from Hayward *et al.* (1996). The habitats for these species are taken from these two references. The shells of each variety recovered in each deposit were counted. Left and right valves of bivalves were not counted separately, but left and right valves were always present in roughly equal numbers for any variety in any deposit.

To reconstruct the shell sources being exploited prior to the post-medieval period, some of those deposits predating the post-medieval which had statistically comparable quantities of shells over 10mm long were selected. In these selected deposits, shape and surface characteristics were assessed, and in some deposits the shells were measured. For edible gastropods, three dimensions were measured to the nearest 1mm (or nearest 0.1 mm if less than 10 mm): overall shell height Hs, shell width Ws, and aperture height Ha. These are the dimensions recommended by Reid (1996) and employed regularly (e.g.: Cummins *et al* 2002, 11; Barry 2001, 18). To compare shell shape, two ratios were calculated: the relative aperture size (Hs/Ha) of Crothers (1992, 92), used by Cummins *et al* (2002); and the width-height ratio (Ws/Hs).

A recent study by the author showed that measurements of dimensions across the shell lining are less variable than those of oyster shell maximum height and length; they are also better measures of the oyster within the shell. Therefore oyster shell size was reconstructed and compared via averages and histograms of the commisure height (Hc, distance from the hinge across the shell lining). Measurements were taken to the nearest 1 mm (or the nearest 0.1 mm if the dimension was less than 10 mm). To reconstruct shell sizes at previous ages, the height of each growth-check ring in bivalves from the selected deposits was measured to the nearest 1 mm. Measuring growth-ring heights is an estimate for height at earlier ages, since not all growth-check rings are annual (they can also be caused by disturbance), and not all annual rings are clear (subsequent erosion can remove early growth rings, and later growth rings can be too tightly packed at the shell edge to be discriminated).

The relative proportions of shell dimensions (their allometry) tend to vary with shell size exponentially (Seed 1980, 38-39), so ratios of dimensions can vary across the size range of a population. For the measurable assemblages of edible gastropods, the distribution of common logarithm of shell width $\log_{10}(Ws)$ and of apertural height $\log_{10}(Ha)$ with that of shell height $\log_{10}(Hs)$ was compared, since conversion to logarithms converts exponential relationships into straight lines, and this transformation produces precise lines in molluscs (eg Gaspar *et al*. 2002, 76-78). The exponential coefficients for the allometries, and the measures of goodness of fit to a straight line (r^2) were generated by least-squares regression of the log-transformed data for each population.

Types of shells recovered

Consumed species

Oysters: This was the commonest shell, making up 65% of the assemblage sieved from soil samples and over 90% of the hand-retrieved material. Oyster preservation was poor, with about 10% measurable. About 80% of the hinges were preserved well enough to be identified to species, virtually all of which were those of the native, common or flat oyster *Ostrea edulis* L. About one quarter of the valves smaller than 40 mm had features reminiscent of the oyster genus *Crassostrea* (irregular and clearly greater in height than length, with a hinge projecting over the body cavity). Flat oysters can be common on stable moderately wave-beaten and sheltered low inter-tidal shores and on stable sub-tidal beds to about 50m depth, where they can form extensive beds and reefs when not disturbed by harvesting.

Periwinkles: The common or edible periwinkle *Littorina littorea* (L.) made up 26% of the shells from sieving, and were especially common in Anglo-Norman deposits (Phase 5); occasionally they were the main shellfish in a deposit. Preservation of these robust shells was good: effectively all could be identified to species, and about half were intact enough to measure. Habitat, size range and distribution for this gastropod have been reviewed by Reid (1996, 111-113). A widely distributed and often very common grazer of sheltered or moderately wave-beaten shores from high-tide line to about 10 m depth, it is most common on inter-tidal solid shores amongst sea-weed, especially wracks (*Fucus* sp.). It is also found on muddy beds in harbours and estuaries, where at low tide it congregates on stable sections of shore, objects or under patches of inter-tidal wracks. The periwinkle can also be common amongst mussels, where small young winkles dominate inter-tidal beds but large older winkles dominate the shallow beds (Saier 2000).

The half-dozen from Sample CC171 of deposit CC1727 showed periwinkles were being brought to site early in the Roman period (Phase 2.1). There were no winkles from later Roman phases. Winkles were again being imported in low numbers in Phases 4.1 and 4.2, and were common in Anglo-Norman Phase 5: periwinkles were almost the only shell in shell-rich occupation layer CC1096, pit fill CC2333, and the most common shell in possible post-hole fill NH3314.

Mussels: This common shell formed 5.8% of the sieved assemblage. Preservation was very poor, which is typical for this thin fragile shell. Of the hundreds of valves observed about a dozen were intact enough to measure, and no deposit contained a statistically valid number of measurable shells. This poor preservation made identification challenging, but all appeared to be the common mussel *Mytilus edulis* (L.), with no convincing examples of the warm-water French mussel *Mytilus galloprovincialis* (Lamarck). Mussels are common on moderately to strongly wave-beaten inter-tidal shores (where they tend to remain relatively small) and on solid and stable soft sub-tidal beds to 40 m depth (where they become relatively large), but can attach to most bare stable surfaces. They often form dense mats which can expand into large beds and reefs (eg Buschbaum and Saier 2001) when not disrupted by harvesting.

Cockles: Only 25 valves of cockles (*Cerastoderma* sp.) were recovered, 20 of these from sieved samples, always in small numbers in deposits containing other shells. Preservation was poor, with half surviving only as the umbo with hinge. Therefore, separation into common cockles *Cerastoderma edule* (L.) and lagoon cockle *C. glaucum* (Poiret) was not attempted, and no valves were measured. These bivalves live just below the surface of moderately wave-washed or sheltered sandy or muddy beds from mid-tide to a few metres depth. Population densities are often very high (hundreds per square metre), and harvesting by hand-raking or digging at low tide is simple and productive.

Common Whelks: Some ten shells of common whelk *Buccinum undatum* L. were found, from deposits with other shells, more commonly in the later phases; five were found along with 38 oyster valves in Phase 6 pit fill NH3236 (Property BW3). This carnivore-scavenger of muddy sands and stony beds from extreme low tide to 100 m is a modern-day delicacy, fished by dredging or potting. Preservation was adequate, and all examples were large (over 30 mm) so identification was clear.

Carpet-shells: Some 38 valves came from deposits rich in other shells, especially in the Phases 4 and 5. Almost all were fragmented, but valve surface sculpture was consistent with the chequered carpet-shell *Tapes decussatus* (L.), so there was only a small chance that other carpet-shells were included in this group. While seldom consumed in modern-day Britain, these are the *palourdes* commonly consumed in modern France; they were fished in Victorian Hampshire, where they were specifically called 'butterfish' and preferred over cockles (Davidson 1999, 139-140). However, the Phase 4 deposit CC1577 (Property BE 3), which produced the largest group of carpet-shells (21 valves), included some with oyster spat. Of the five carpet-shell valves in Phase 5 pit fill NH7501, three were wave-worn and encrusted by bryozoans on their inner faces, and were therefore gathered dead. An oyster from Phase 5 pit fill NH2390 and from Phase 6 pit fill CC1296 each bore the impression of having grown to harvestable size following settling on a carpet-shell. Therefore some carpet-shells were used as cultch in these phases, and were introduced to the site attached to harvested oysters.

All these consumed shellfish are common on the modern shores near Southampton, and were being brought into that town since Saxon times (Winder 1980).

Minor shells

Half the 26 small winkles could be identified, and these were from two common British species, *Littorina obtusata* (L.), and *L. saxatilis* (Olivi). However, some diagnostic elements had been lost, and some forms are similar between these species and the other common British flat winkle, *L. mariae* Saachi & Rastelli. There is therefore a small chance that some of the small winkles should have been assigned to a different species, and that some were very young edible periwinkles. These species are all plentiful on stable inter-tidal shores covered with sea-weed, especially wracks, but never achieve a size worth gathering. The small winkles were usually found in deposits in which common periwinkles were also recovered, and periwinkles and small winkles are commonly found together on sea-weed dominated shores. Therefore these small winkle species were principally being brought to the site as by-catch with the periwinkles.

There were only thirteen valves of saddle-oyster *Anomia ephippium* L., a shellfish which colonises hard substrates and which is found regularly with oysters. This is a small number given the number of oysters in the assemblage, and suggests most oysters were cleaned and sorted before being brought to the site. A single netted dog-whelk *Nassarius reticulatus* (L.), a common small scavenger, was recovered from Phase 5 shell-rich pit fill CC2333.

Type bias

There was a serious difference between sieved and hand-retrieved assemblages in the range of species, with sieved deposits producing a much greater range. For example, hand-collection from Phase 4 pit fill CC1577 recovered only oysters, while sieving produced five other species, including four edible shellfish types (mussels, winkles, cockles and carpet-shells). Unfortunately only about a half-dozen of the deposits productive of shell were also sieved. The composition of the assemblage therefore significantly under-estimates the relative proportion of edible shellfish compared to oysters, especially mussels which are very fragile. It also seriously under-estimates the non-edible species, which are the better indicators of habitat exploited.

Change over time

Table 1 shows the relative contribution of each phase to the samples, as well as the sieved shell assemblage, in percent. The difference between these two percentages indicates the relative rate at which shellfish were being brought to the site during that phase: if the percentage of the shell assemblage is greater than the sample percentage, shellfish were being transported to site in greater than average amounts in that phase. Table 1 also shows the relative proportion of the various types of shell for the phase, in percent. These results were based on samples taken mainly for material other than shells, so they are of deposits in which shells were in typical or in low concentrations for the phase, rather than those in which shells were rich. To show variation through time in shell-rich deposits, the number of contexts in a phase which hand-retrieval showed to be rich in shells are also shown in Table 1.

Prehistoric (Phase 1)

Most deposits assigned to the prehistoric periods produced shells in such small numbers and so poorly preserved that they could all be explained as intrusive or from later disturbance.

Roman (Phase 2)

Shellfish were being brought to the site early in the Roman occupation (Phase 2.1), including periwinkles. While oysters were the most numerous, Roman periods favoured mussels to a greater extent than later periods. Importation appeared to peak in the late 3rd –mid 4th centuries (Phase 2.3), with the largest percentage of sieved shells and shell-rich deposits, but shellfish continued to be consumed late in the Roman period (Phase 2.4), including one shell-rich deposit. Overall, the level of shellfish consumption was low compared to later periods.

Late Saxon (Phase 4)

Shellfish were relatively common in this phase, and a wide range of species were consumed. Oysters continued to be the most common, but carpet shells were more common than cockles, although this may have reversed by the very late Saxon (Phase 4.2).

The shellfish from the less closely stratified deposits, assigned generally to Phase 4, were different from those from the more closely stratified deposits which could be assigned to sub-Phases 4.1 and 4.2. Shells seemed generally more plentiful in the general

Phase 4 deposits (Table 1). Only 7.8% of the shell-bearing samples came from this general phase, but they produced 21.5% of all the sieved shells. However, the closely stratified late Saxon deposits (Phases 4.1 and 4.2) had more than four times as many samples (32.2% of the total samples), but produced fewer shells (19.0% of the shells). Also, general Phase 4 deposits contained a higher proportion of mussels, periwinkles and inedibly small oysters than the closely-stratified late Saxon deposits. This may be due to differences in disposal practices in the period: rubbish richer in the early stages of food preparation ('kitchen-waste') may have tended to be discarded at some distance from inhabited areas such as waste ground, with post-consumption rubbish ('table-waste') more commonly discarded or lost nearer to structures.

Anglo-Norman (Phase 5)

This phase saw the highest use made of shellfish: the phase contributed a little over one-third of the samples but over half the sieved shells. The high proportion of periwinkles in Table 1 is due to two periwinkle-rich samples. Removing these shows once again that oysters were the most common shellfish (75.4%) but periwinkles (7.2%) were still quite common. Periwinkles, and mussels (7.2%) had returned to the same level of popularity they had in Roman times.

Medieval (Phase 6)

Shellfish popularity seems to have fallen from that in the preceding phase, with few samples bearing shells and these with fewer shells. Periwinkles seemed to increase in popularity at the expense of mussels, and cockles at the expense of carpet-shells.

Oysters

Introduction and quantities

While over 1000 deposits contained oyster shells, only 33 later medieval or earlier contexts had oyster valves in statistically comparable quantities. These deposits contained 5760 oyster shells, about 32% of nearly 18,000 oysters from the excavations.

The poor preservation meant that only 17 deposits contained statistically comparable quantities of measurable oysters; these deposits contained 512 measurable oysters between them. The low incidence of sampling from shell-rich deposits meant that almost all of these 512 shells were recovered by hand; only one of these 17 deposits (Phase 4 pit fill CC1577) had a significant number of measurable oysters sieved from a sample (21 shells from Sample CC157).

Size bias

Pit fill CC1577 was the deposit which demonstrated the serious under representation of the full range of shells in hand-retrieval (see *Type bias* above). The average size of sieved oysters was slightly smaller (closure height, Hc of 47 ± 13 mm) than the hand-retrieved shells (Hc of 52 ± 12 mm), but the difference was not statistically significant (t = 1.47; P = 0.15). However, the distribution of closure heights in the sieved oysters was quite different (Fig. 1). The hand-retrieved oysters (Fig. 1a) were clearly biased towards larger shells, with no shells less than 35 mm and shells over 65 mm making up 30.8% large (Hc of 65mm or more), implying larger shells were deliberately sought during harvest. In contrast, the sieved oysters (Fig. 1b) were roughly normally distributed about the modal value, with the chances of finding a large valve (Hc of 65mm or more) about the same as finding a small oyster (Hc less than 35mm). Since the small shells were probably included by accident, the larger shells may also have been accidentally incorporated rather than deliberately targeted. The suggestion from the hand-retrieved shell distribution that larger oysters were being sought is an illusion, produced by the recovery method.

This bias reduces the reliability of conclusions based on measurements, such as average size or skew towards larger sizes. However, the hand-retrieved shells still had some potential to indicate broadly the nature of the oysters being sought and the beds being harvested, via encrustations, shell shape (e.g. Kent 1992, 25-27; Winder 1992, 196-197), and growth rate (Richardson *et al.* 1993).

Results

The number of deposits with significant numbers of hand-retrieved oysters in each phase, and the number of oysters in these deposits, is shown in Table 2. These 33 deposits contained 5400 oysters, just over one third (34.1%) of the hand-retrieved oysters.

Shell form and shape

There were occasional traces of colonising organisms, mostly the burrows of the bristle-worm *Polydora hoplura*, a regular burrower into stable substrates such as shell (including living oysters). There were rare instances of the complex hollows of *Cliona* (a burrow-etching sponge), of yearling or two-year-old oysters cemented to older shells (spat). Some shells were discoloured by sea water and wave-rounded, or bore colonies of bryozoans (sea-mats) or *Pomatoceros* (keel-worm) tubes on the inside of the shell, and which therefore must have been dead when harvested. The proportions of dead and spatted oysters in each phase are shown in Table 2. Spatted and dead oysters are absent from the Roman phases, and infrequent in later phases.

The larger shells (over 30 mm) came in three types. The most common type of left (lower) valve was oval (height was greater than length), the adductor scar was not unusually distant from the hinge, and the valve was bowl-shaped. The area of attachment was indistinct and blended into the curve of the outside of the valve.

Less commonly, the left valve was irregular, flaring (point of maximum length much nearer the ventral margin than the hinge), oval (clearly greater in height than length), and bore the adductor scar unusually distant from the hinge. The area of attachment was usually clear, and the base of the valve curved up from the attachment area at a sharp angle (less than 135º). Often the anterior or posterior margin bore a flattened face roughly parallel with the direction of growth, sometimes rich with bristle-worm burrows. Occasionally, two of the valves 're-fitted' along a flattened face, or were still conjoined along such a face.

In some oysters, the valve was round (shell height and length roughly equal, and the line of maximum length roughly the same distance between hinge and ventral margin), colonising organisms were less common. The area of attachment was indistinct and blended into the curve of the outside of the valve, or made a wide angle with the outside of the valve (more than 135º). For the measurable oysters, the number of the second type in each measured deposit is shown in Table 2 as 'reef' oysters, with the third type counted as 'round' oysters. Round forms were most common in the later part of the Roman period (Phase 2.3), with reef forms absent. Round oysters were least common in Phase 4, and the proportion of round oysters increased and the proportion of reef forms dropped over time.

In some valves the attachment area retained the object to which the oyster was cemented, or preserved its shape. Attachment was most commonly to mussel shell, followed by oyster shell. Attachment to cockle shell, carpet-shell, saddle oyster and to rounded flint gravel was rare. The proportions of the various types of this 'cultch' in each phase are shown in Table 2. 'Cultch' was almost absent in the Roman phases, and tended to increase over time from Phase 4 until Phase 6.

Growth rate

Figure 2 shows the average shell height at each observed growth ring in what appeared to be a representative Roman deposit (Phase 2.3 occupation spread NH4742), a representative deposit of the late Saxon and medieval (Phase 4 pit fill CC1577), and a sample of modern oysters from the Blackwater Estuary, Essex, probably the fastest-growing modern oysters reported (Richardson *et al.* 1993, 499). Average growth rate in this late Saxon deposit was clearly slower than those in Roman or modern fast-growing oysters, and was more like those typical of modern oysters on the English south coast, which achieve about 60-65 mm after six years (Richardson *et al* 1993, 499). A full analysis of the relative growth rates lies outside the scope of this report, but the perception that Roman oysters tended to be larger than later oysters was reinforced, and this was most likely due to faster growth in Roman oysters rather than over-exploitation of medieval oysters.

Discussion

The features of the tall type of oyster (irregular, flaring, rapidly growing away from the point of attachment, facetted, occasionally conjoined or re-fitting to similar-sized oysters) are those that would be induced in oysters growing in dense natural accumulations or reefs, where dense packing would inhibit anterior and posterior growth (lengthening) and competition with neighbouring oysters for access to sea-water (for food and respiration) would promote ventral growth away from the hinge (heightening). Common mussels growing in dense colonies have more pointed shells, while those in low densities have more rounded shells (Seed 1968, 572-4). Inferences regarding reef oysters in Atlantic Europe must rely on archaeological remains, since reefs have been effectively eradicated by dredge fishing (Holt *et al.*1998, 17). The exploitation of reefs seemed negligible in Roman times (Table 2). The gradual drop over time in reef oysters during the Late Saxon and medieval periods was likely caused by gradual reef destruction over time by dredge fishing.

The oval and round types are shapes that would be induced in oysters not on reefs, where the ability to lengthen would not be as inhibited. Winder (1992, 196-197) found moderately oval oysters more common in off-shore beds, and rounder oysters more common on harbour muds. Therefore the relatively high proportion of round oysters in the Roman phases are likely due to a higher exploitation of bays and harbours than the later periods. The gradual increase over time in the proportion of round oysters in the later phases also was likely due to a slight increase in the exploitation of harbours and bays.

The attachment to mussel and oyster shell shows that spent shell was probably being used as cultch (material intentionally discarded onto sea-beds to improve the productivity of the beds by providing better settlement sites for the infant oysters, called spat). This intentional management of oyster beds for good settlement seems to have begun as early as the later Roman period (Phase 2.4; Table 2) and reached its peak in Anglo-Norman times (Phase 5). The lack of dead and spatted Roman oysters may be due to intentional separation to promote rapid growth. Other attached shells, less common, may be waste shell used as cultch or accidental. The rounded flint gravel on a few Phase 4 oysters was typical of the gravelly parts of the sea bed off the chalk geology along the south coast, such as Southampton Water, and would suggest Winchester was receiving some oysters from this nearby coast.

The growth pattern typical of flat oysters in this assemblage is the usual one for *Ostrea edulis*, of gradually diminishing annual growth with increasing age (eg Richardson *et al*. 1993, 498). Throughout England, Roman-period oysters tended to be bigger than medieval oysters at the same site (Harrison 1995, 55-6). This difference appears not to be due to medieval over-exploitation removing most big oysters, but to differences in the wider environment causing slower medieval oyster growth rates, similar to modern oysters. Whether this reduced rate was due to cooler medieval seas or poorer medieval nutrient content remains to be resolved, probably via the isotopic studies of the shell carbonate.

Conclusions

Only a broad picture of the nature of oyster exploitation can be drawn; a secure picture must await fuller retrieval of better-preserved oysters in a less biased manner from elsewhere in the town. However, it seems that most of the oysters brought to the site throughout the phases represented were already cleaned and sorted elsewhere and ready for consumption.

Oystering appeared to be a fully fledged craft under the Romans, based on fast-growing near-shore and embayment oysters with some use of cultch to ensure supply, and with negligible harvesting of reefs (in spite of reefs likely to be common at a time prior to intensive dredge fishing). Most oysters came from the late Saxon and medieval phases. Typical growth seemed similar to present-day oysters, making it likely that sea conditions had changed from the Roman period. Shell shape and growth rate combined to indicate both natural reefs and more dispersed beds were being harvested, mainly sub-tidal beds where harvesting would have been by dredging. This dredge fishery seemed to have slowly depleted the reefs, moving harvesting effort somewhat more towards bays and harbours. The fishery seemed intensive enough to have already fished out most of the large old oysters; management measures for some beds seemed necessary to sustain yields. These measures included the spreading of cultch (mainly mussel shells).

Periwinkles

Introduction and Quantities

There were three deposits which produced statistically comparable quantities of measurable periwinkles *Littorina littorea* L., all from Anglo-Norman Phase 5: slumped occupation layer CC1096 (Sample 110), pit fill CC2333 (Sample 262), and possible post-hole fill NH3314 (hand-recovered). All these deposits were rich in shells; periwinkles were almost the sole type of shell in CC1096 and NH3314 and the most common in CC2333. All the measurable periwinkles were selected from the sampled deposits, and from a 12.5% sub-sample of NH3314.

Results

Size

Results of the measurements are shown in Table 3. Periwinkles in these samples ranged in shell height from 17 to 30 mm. All the deposits showed a poly-modal distribution; the modal height was 23 mm with a slight concentration around 20 mm in CC2333 and NH3314, while the modal size in CC1096 was 25mm with a slight concentration about 27 mm.

Shape

The exponential powers generated by least-squares regression of the log-transformed sizes for each sample were consistent with the exponents that have been recorded for single samples in biological studies (eg Kemp and Bertness 1984, 812; Barry 2001, 21). Fit to the straight line was also good (r^2 between 0.78 – 0.84 were quite high for a restricted size range). Shells in a given sample had very similar allometries, so a given sample probably had shells harvested from a single source. Also, the allometries were quite similar for all three samples, and were effectively identical for CC1096 and NH3314. Therefore, periwinkles were harvested from very similar types of shore.

The statistics for the shell shape ratios for each deposit are shown in Table 3. There was no apparent variation of width-height ratio or relative aperture size with shell height except for very large shells (over 26 mm), in which relative aperture size was slightly larger than average and the width-height ratio was slightly lower than average. Deposit average width-height ratio tended to decrease with increasing average relative aperture size. Width-height ratios were also very similar for all three deposits (about 0.81), as were shell-aperture height ratios (about 1.48).

Discussion

Larger periwinkles were preferentially selected during harvesting, since average sizes in the deposits typically were slightly larger than the average sizes found in shore surveys. For example, in a survey of 124 shores around the coast of Ireland, average shell height strongly tended to increase down-shore, but even where they were largest (on the low shore amongst saw-tooth wrack *Fucus serratus*) periwinkles averaged about 21.5 mm (Cummins *et al.* 2002, 22). Periwinkles were smallest (average height 18mm) on moderately sheltered shores and larger in greater exposure (19.7 mm) or greater shelter (20.3 mm) (estimated from Cummins *et al.* 2002, 21). Selection of larger periwinkles was shown by the lack of small periwinkles: few periwinkles were less than 20 mm, while in most natural populations the majority of periwinkles are less than 20 mm (eg Cummins *et a.l* 2002, 24-26). Periwinkles over 20 mm are dominant low on the shore, and on sheltered weedy shores (Crothers 1992, 93).

Average relative aperture size (Hs/Ha) is about 1.52 on sheltered and about 1.46 on moderately exposed shores (Crothers 1992, 92; Cummins *et al.* 2002, 21), and less than 1.43 on exposed shores (Cummins *et al.* 2002, 21). Therefore, the range of relative aperture sizes in these periwinkles was consistent with harvesting of sheltered shores between the tides. Although shell shape variation with habitat is weak for this species (Reid 1996, 106), periwinkles tend to be increasingly globose (higher width-height ratios and lower relative aperture size) with increasing exposure to wave-action (Crothers 1992, 92; Cummins *et al.* 2002, 29). Therefore these quite narrow shells tend to be more common in quite sheltered conditions.

Conclusions

This would appear to be the first time that periwinkles have been measured from a British inland site. It would also appear to be the first use of *Littorina littorea* allometry to reconstruct periwinkle harvesting strategies, despite the nature of the variation in this species being fairly well-studied by marine biologists. Periwinkles imported into Anglo-

Norman Winchester were most likely harvested from very similar conditions (sheltered shores below mid-tide), where sizable shells would be quite common.

Discussion

Hand-retrieved material greatly predominated over sieved shellfish. Analysis of the difference showed hand-retrieval significantly over-estimated oysters compared to other edible shellfish, and the size of the oysters. It also seriously over-estimated the edible shellfish compared to the non-edible species, which are the better indicators of habitat exploited. Conclusions are therefore broad; robust comparisons and contrasts between phases or with other excavations or sites must wait for larger numbers of samples of larger volume from future excavations.

There was no convincing evidence for prehistoric marine shellfish. Convincing shellfish consumption began early in the Roman occupation (Phase 2.1), peaked in the late 3rd –mid 4th centuries (Phase 2.3), and continued into the late Roman period (Phase 2.4). Overall, the level of shellfish consumption was low compared to later periods. Oysters were the most common shellfish consumed, with some mussels and periwinkles. Oystering appeared to be based on fast-growing near-shore and embayment oysters to produce large shells, with some use of cultch to ensure supply, and with negligible harvesting of reefs.

Shellfish were relatively common in the late Saxon (Phase 4), and a wide range of species were consumed. Oysters continued to be the most common, but carpet shells were more common than cockles and mussels were less common than in Roman phases. The general Phase 4 shells were different from more closely datable shells from sub-Phases 4.1 and 4.2, possibly because more ‘kitchen-waste’ was discarded more often on waste ground, ‘table-waste’ more often discarded or lost near habitations.

The Anglo-Norman period (Phase 5) saw the highest consumption of shellfish in this part of the town, with a very wide range of types, implying the residents status and income had improved from the preceding phase. Mussels were as popular as they had been in Roman times. Periwinkles were very popular, so much so that they were discarded in masses; all were harvested for their large size from almost identical habitats.

In the later medieval (Phase 6), shellfish seems to have fallen off, giving the impression that the status and income of the residents had diminished. Mussels and carpet-shells became less popular, and periwinkles and cockles more popular, perhaps because of increased silting near the shore (inter-tidal mussels favour solid areas and carpet-shells favour coarse gravels, not muds).

Most oysters came from the late Saxon and medieval phases. Typical growth seemed similar to present-day oysters, making it likely that sea conditions were quite changed from the Roman period. Both natural reefs and more dispersed beds were being harvested, mainly sub-tidal beds by dredging. Dredging probably slowly depleted the reefs, moving dredging effort somewhat more towards bays and harbours. There seems to have been some intentional management of the oyster beds, such as the spreading of cultch (mainly mussel shells).

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Marine Mollusc Tables

Table 1: Identified marine shells from sieved samples

Phase	% of samples in phase	% of all sieved shells	Sieved shells in phase	Percentage of the phase made up by: oyster	baby oyster	mussels	winkles	cockle	carpet-shell	Shell-rich hand-retrieved contexts
2.1	4.3	0.4	13	38.5	15.4		46.2			
2.2	1.7	0.2	9	77.8		22.2				
2.3	4.8	0.6	22	63.6		31.8		4.5		2
2.4	1.7	0.2	9	88.9		11.1				1
2	11.2	1.5	53	64.2	3.8	18.9	11.3	1.9		
4	7.8	21.5	778	67.1	21.6	6.7	0.9	0.1	2.7	5
4.1	10.0	4.2	152	80.3	2.6	13.2	2.0		2.0	
4.2	22.2	14.8	538	86.8	1.9	7.6	2.4	0.9	0.2	10
5	35.2	54.1	1962	45.4	1.4	4.3	47.0	0.6	0.5	11
6	12.2	3.9	142	76.8	9.2	2.8	10.6	0.7		4

Table 2: Composition of the hand-retrieved oyster assemblage

phase	No. of cxts	No. oysters	dead	round	reef	spatted	cultch: oyster	mussel	cockle	carpet-shell	saddle-oyster	gravel	total cultch
2.3	2	174		20.1									
2.4	1	33		3.0			3.0	3.0					6.0
4	5	1280	0.4	0.6	1.8	0.9	0.3	0.9	0.4			0.2	1.8
4.2	10	1336	0.3	1.3	5.9	0.5	0.5	2.7					3.2
5	11	2269	0.8	3.3	3.7	0.7	1.2	3.3	0.1		0.4		5.0
6	4	251		4.0	3.2	0.8		0.4		0.4			0.8

Table 3: Average dimensions and allometry coefficients for the periwinkles (*L. littorea*)

Cxt	CC10 96	NH33 14	CC23 33
No. measured	79	76	127
No. in sample	372	1123	409
Hs	24.3	22.7	22.0
sd	2.1	2.0	2.1
Ws	19.4	18.3	17.7
sd	1.6	1.7	1.5
Hs/Ha	1.50	1.48	1.46
sd	0.06	0.06	0.06
Ws/Hs	0.798	0.807	0.805
sd	0.032	0.029	0.036
Height width allometry			
slope	1.308	1.305	1.643
exp, b	0.845	0.846	0.769
r^2	0.792	0.835	0.782
Height - aperture allometry			
slope	0.869	0.996	1.265
exp, b	0.918	0.875	0.802
r^2	0.785	0.805	0.799

Marine Mollusc Figures

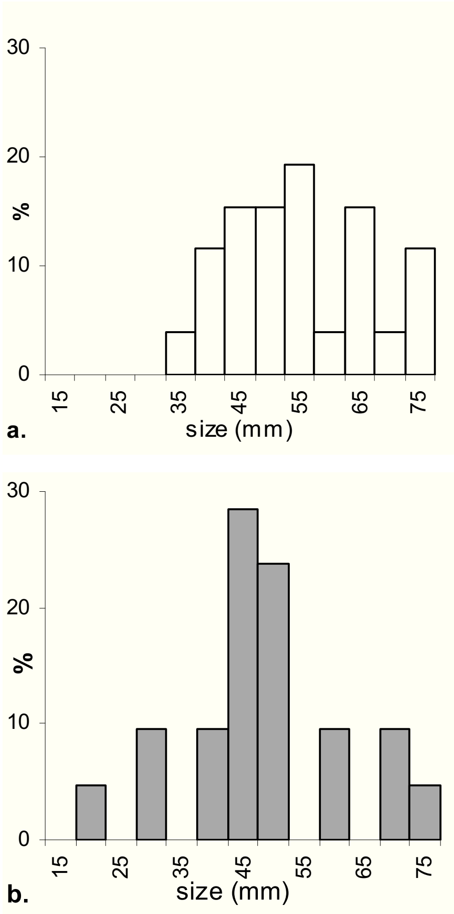

Fig. 1: Distribution of oyster size (Hc) from Phase 4 pit fill CC1577. (a): hand retrieved oysters (N = 26); (b): sieved oysters (N = 21).

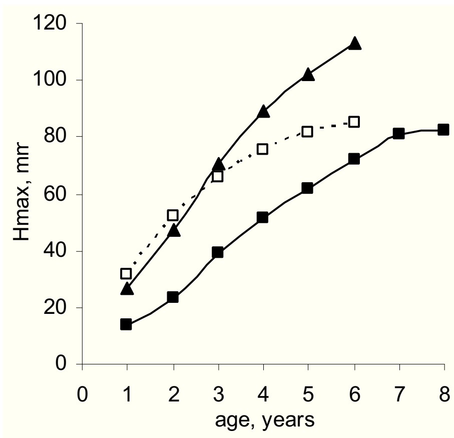

Fig. 2: Comparative growth rates for oysters (*O. edulis*) from selected deposits. Closed triangles: representative Roman deposit (Ph. 2.3 NH4742); black squares: representative late Saxon-medieval deposit (Ph. 4 CC1577); open squares: Fast-growing modern oysters (Blackwater Est., Essex).

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