Marine Shell from Australian Historic Sites: Research Design and Data Standardisation

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This paper describes a computer-based system designed to facilitate both description and interpretation of environmental and cultural information about marine molluscs from colonial-period sites in south eastern Australia. The study is based on work in progress on materials from primarily nineteenth-century contexts at the Quadrant site in Sydney excavated by Dana Mider & Associates Pty Ltd. ahead of development work under NSW legislation. Potential research questions linked to marine molluscs are outlined. Only some of these can be addressed solely on the basis of shell data previously recorded to a 'basic minimum standard' to meet statutory requirements. The link between data, research questions, research design and research context are discussed. Good research design is argued to be an open-ended and flexible process which can accommodate the interpretative nature of archaeology. This has broader implications for debates about standardisation of artefact recording currently topical in Australian historical archaeology.

INTRODUCTION – MARINE MOLLUSCS FROM THE QUADRANT EXCAVATIONS

The Quadrant site is located at 46–60 Mountain Street and 147–179 Broadway, Sydney. Extensive open-area excavations were undertaken by archaeological consultants Dana Mider and Associates Pty. Ltd. ahead of a large urban development by Australand Holdings between 2001 and 2004. These uncovered the remains of both Indigenous and colonial-European occupation dated from approximately 4000 years ago to 1906 which overlay significant environmental deposits dating from approximately 36 000 years ago. Historically the site formed a distinct neighbourhood within the City of Sydney and from the 1830s to the 1860s a variety of industries were located here including breweries, sugar works, tanneries and slaughterhouses. The excavation uncovered thousands of archaeological contexts associated with early to mid-ninteenth-century use and occupation including a slaughter-house, a blacksmith's shop, stables, an inn, private dwellings and associated infrastructure. Over a million artefacts were recovered some of which were marine molluscs (Mider 2004).

Studies of marine molluscs and similar faunas excavated from Indigenous Aboriginal shell middens are well reported in the literature. Marine molluscs are also common in colonial period historical sites in urban Sydney and elsewhere. Methodologies developed for study of Aboriginal shell middens are of some value to historical archaeology in areas such as taxonomic identification and environmental reconstruction. However analysis of marine molluscs from historic-period sites in urban contexts presents its own challenges, especially for large-scale projects conducted in response to the development process as was the case at Quadrant. Almost nothing has been published on this topic in Australia. While consultancy reports and databases often include raw data about shells further interpretation and discussion is rare (e.g. Karskens 1999).

The Quadrant excavations resulted in the recovery of an unusually large sample of marine shells for an Australian historic site. Over 185 archaeological contexts produced approximately 19 000 fragments of shell weighing over 68 kg and representing over 60 biological taxa. The majority of these contexts date from the mid to late nineteenth century. Comprehensive discussion of the archaeological significance of the shell material and what it can reveal about past environments, economy, diet and other aspects of life for people who lived and worked in the area is currently in progress and contingent on further analysis of other archaeological and documentary data sets from the Quadrant site. Yet experiences to date in identifying and classifying the molluscs, and entering the data into commonly used computer programmes to facilitate analysis, raises a number of important issues of methodology and research design which are of broader interest to Australian archaeologists.

MINIMUM STANDARDS AND INTERPRETATIVE ARCHAEOLOGY

Standardisation of artefact recording continues to be a contentious issue in Australian archaeology (e.g. Hiscock and Clarkson 2000; Crook et al. 2002). This stems in part from a key theoretical debate in archaeology about the extent to which it is possible to separate description and interpretation (e.g. Hodder 1999). Meaningful data are always generated, recorded and interpreted in a particular research context guided by a theorised set of research aims linked to a methodology. These are the key aspects of archaeological research design (Black and Jolly 2003:3).

In Australian archaeology, especially that conducted for heritage management purposes, some disagreement arises here because theorised research aims are often at best only weakly articulated and linked to explicit methodologies through an ongoing process of research design. As the rationale for the excavation is usually to recover information from a site which will otherwise be destroyed by development the excavator is under pressure to make a 'full' and 'accurate' record of 'everything' that is uncovered by the excavation to a basic minimum standard. Even with limitless time and resources, it is impossible to record 'everything' about a site. Excavators make decisions about what is relevant or important according to previous standard practice, their own experience, project management constraints and only sometimes in response to clearly articulated and theorised research questions. Disagreements about 'recording standards' frequently arise from disagreements about research questions, and in particular the difficulty of articulating and addressing them effectively, given the constraints of much consultancy practice.

Heritage management agencies usually require applicants for excavation permits to produce an acceptable 'research design' as part of the approval process at the start of an excavation (see for example discussion of archaeological research design presented by the NSW Heritage Office at http://www.heritage.nsw.gov.au). Such documents typically describe the research potential of the site, linked to previous documentary and archaeological research, and set out a clear set of intended excavation procedures to recover information relevant to a generalised set of research questions or themes. In principle these conditions also apply to post-excavation analysis of any artefacts and other finds recovered from the dig. However research design documents presented in support of an excavation permit application at the start of a project are rarely able to set out a detailed research framework for post-excavation recording and analysis for very good reasons.

While Australian heritage agencies demand 'research designs' from those applying for excavation permits these documents should more accurately be described as 'initial research proposals'. Good research design, in common with project management, is an intelligent and conscious process which develops and changes as the project proceeds depending on what is found and the resources which are available. It is rarely if ever possible to predict exactly what will be found by an excavation before it starts. On-site fieldwork decisions are contingent on what arises as the excavation continues. Field methodology needs to be flexible enough to accommodate change. These conditions also apply to post-excavation analysis of artefacts and other materials. What *should* be recorded about artefacts and other finds (i.e. the 'minimum standard' of recording) is partly contingent on the way the site was excavated and the interpretation placed on the excavated features from which they derive. At the same time the interpretation of excavated contexts (e.g. dates, function) are often contingent on analysis and interpretation of the artefacts. Hodder (1999:33) has discussed these elements of the archaeological process in terms of a hermeneutic circle or spiral. In such circumstances attempting to dictate detailed 'minimum standards' for artefacts analysis at the very start of an excavation project, especially for large and complex sites of the kind commonly found in colonial period urban Sydney, is difficult if not impossible.

Most published discussion of post-excavation analysis has concerned common artefact types found on Australian historical sites such as ceramics and glass, building materials, metal objects and personal items such as buttons, clay pipes, ornaments etc (e.g. Casey 1999, Casella 2001). There has been almost no discussion of 'biological' or 'environmental' materials such as bone, shell, plants remains etc. which raise slightly different challenges. Work conducted to date on identification and computer coding of marine molluscs from the Quadrant excavation will be used to discuss some of these broader issues.

THE QUADRANT CODING SYSTEM FOR MARINE MOLLUCS

As is usual practice for these kinds of projects, remains of marine molluscs and other small marine animals with hard exoskeletons (e.g. barnacles, corals) were initially sorted from the excavated archaeological deposits by members of the Quadrant post-excavation team and bagged together as 'shell' for further specialist identification and analysis. Land snails and chicken egg shells were also placed in the 'shell' bags by the sorters.

The 'shell' was identified and manually recorded onto datasheets by members of the Quadrant post-excavation team under the direction and supervision of Dominic Steele. The data were subsequently re-coded and entered into a relational database system by the current author to facilitate further analysis which is currently in progress.

While the initial manual recording and identification of the shells was generally internally consistent it was necessary to clarify terminology and standardise recording for computerised data entry. Records for chicken egg shell and land snails were removed from the 'shell' dataset and dealt with separately as they require a different interpretative approach. Although the manual recording system provided coding and separate columns to enter data about shell fragmentation and condition, in many cases the recorder had ignored these in favour of their own freehand comments in the 'Notes' field, which required translation and recoding into the new system. The manually recorded data for scientific and common names of shells contained numerous spelling mistakes and duplicated and/or ambiguous codes. Further research of scientific literature was necessary to clarify taxonomic identifications and standardise spelling and terminology.

Entering information about molluscs into a computer database for archaeological analysis requires the creation of a workable coding system linked to archaeologically meaningful categories. Scientific taxonomic nomenclature based on evolutionary relationships (e.g. Family, genus, species) forms a useful starting point for cataloguing zoological materials from archaeological sites and is essential for making non-cultural inferences, for example about past environments. However it is also necessary to categorise archaeological samples using cultural typologies which both reflect the nature of the samples themselves and which allow cultural inferences to be made.

Attenbrow (1992) discusses issues raised by the identification and taxonomic classification of marine shell from Australian archaeological sites. It is not possible to identify every shell fragment to genus and species due to preservation, fragmentation and the large number of shell species typically present in Australian waters. In many cases it is only possible to identify archaeological shell to Family or to an even higher taxonomic levels (e.g. Class). Scientific nomenclature of marine molluscs is subject to frequent review and change so that books, papers and internet sites can use different names for the same shell depending on their date of publication. This makes standardisation difficult. The simplest solution is to make clear reference to dated publications on which particular nomenclature is based. In this case nomenclature follows Macpherson and Gabriel (1962), Bennett (1992), Jansen (1995) and Attenbrow (1992, 2002).

When discussing marine mollusc shells from Australian archaeological sites it also makes sense to use common names as well as scientific ones to aid both interpretation and readability. People who eat 'shellfish' (i.e. the animals inside the marine mollusc shells) have their own names for them whether expressed in English, an Indigenous or some other language. Historical documents also refer to shells by common names depending on the context. Public audiences also understand common names for shellfish (e.g. oysters, mussels, pipis) while few people relate to or understand scientific nomenclature for taxa.

Common names do not map accurately onto scientific names and they cannot be used as unique and accurate identifiers of shell types for archaeological analysis without further careful definition. While some mollusc species have several common names, others have none. Some common names refer to culturally defined groups or classes of shells rather than to scientifically described taxonomic categories such as family, genus or species. It can make sense to devise cultural typologies for shellfish which more accurately reflect the way people may have used and collected them. The Quadrant shells were identified as far as possible to genus and species, but for some analyses it makes more sense to group these into larger categories. For example the people who collected top shells (*Family Trochidae*) may not have cared what species they were. Another example of the value of using looser culturally defined categories in some circumstances is that many of the shells at Quadrant could only be identified to a general group. While Sydney rock oyster (*Saccostrea cucullata*) was very common in the samples, examples of mud oyster (*Ostrea angasi*) were also recorded. However a large quantity of shell could only be identified as 'oyster' which could be either species. So using the broad category of 'oyster' is necessary for discussing some aspects of the data in a meaningful way.

For the Quadrant materials a series of codes and labels were devised to facilitate data entry, database queries and the production of tables and reports which meet the requirements of efficiency, accuracy, flexibility and readability without compromising the recovery of either scientific nomenclature or cultural information. The coding system contains elements of both description and interpretation which has implications for research design as discussed further below.

The key field is a 6–8 letter *Shell Taxon Code* which can be linked to the more reader-friendly *Shell Taxon Label* and other forms of scientific and common nomenclature using the database features. Short alpha-numeric codes are commonly used to enter archaeological data into computer programmes for analysis. Short codes are particularly useful for recording biological materials (bones, shells, plant remains etc.) which are usually categorised into scientifically described taxa many of which have long and complex names with spelling and punctuation that is unfamiliar to non-experts. Common names for biological materials can also be lengthy and, as explained above, the same taxon can have several different scientific and common names. Entering data using short codes saves time and effort, reduces the possibility of spelling and typographic errors and promotes standardisation and consistency.

Current database software (e.g. FileMaker Pro) allows drop down menus to be set up for data entry. In principle this sounds like a good idea because the person entering the data can select from a range of options without having to type codes or names using a keyboard thus eliminating spelling and punctuation errors and other inconsistencies. However this system of data entry, while technically possible, is not very practical for recording marine shells from Australian sites because of the large number of taxa with long and complex names which may need to be accommodated in any data entry layout on a computer screen. For example over sixty different marine mollusc and related taxa codes were needed to record the Quadrant samples (Table 3).

While is may be technically possible to create a data entry layout with drop down menus for all these values, experience shows it is quicker and easier to enter the data manually on a programme such as Microsoft Excel using short letter codes. Data can then be moved into a database programme for further analysis. The database is used to automatically translate the short-letter codes into more reader-friendly and intuitive labels which are easier to work with. This system was used for recording the Quadrant shell data.

OVERVIEW OF THE SHELL DATABASE STRUCTURE

Separate database tables were created to record information about archaeological shells from each context at the site (SHELLDATA) and to hold further information about each taxon identified (SHELLTAXA) which was variably descriptive and/or interpretative. SHELLDATA was linked to SHELLTAXA using the key field Shell Taxon Code. The key field Context can be used to link the shell data to relevant information held in other databases. Tables 1 and 2 summarise the fields in the two database structures. Only those fields which require further comment are discussed here.

Table 1: Index of data fields in the SHELLDATA table.

Label	Brief Explanation
DBID	A unique record number for each mollusc shell fragment or group of similar fragments entered into the database.
Context	Unique context number for each separately recorded stratigraphic feature. Cross-links to other archaeological context information.
Quad	Grided excavation square applicable to some contexts within structures.
ShellTaxonCode	A unique 6–8 letter code for each individually identified mollusc or other animal, based on biological taxa. Cross-links to other information about shells in the SHELLTAXA database.
ShellFragmentCount	The number of shell fragments in each record.
ShellWeight	Total weight of shell in each record in grammes.
ShellCondition	Records presence and or extent of burning, erosion, fragmentation, use of shell in mortar and if the shell has been pierced or drilled.
Notes	Other interpretative information.

Table 2: Index of data fields in the SHELLTAXA table.

Label	Brief Explanation
ShellTaxonCode	A unique 6–8 letter code for each individually identified mollusc or other animal, based on biological taxa. Cross-links to other information about shells in SHELLDATA table.
ShellTaxonLabel	An interpretative label for each Shell Taxon Code based on a combination of scientific and common name, used to generate 'readable' tables and reports.
ShellClassFamily	Biological Class and or Family as applicable.
ShellGenusSpecies	Genus and or Species as applicable
ShellTaxonGroup	Allows molluscs and other faunas to be grouped by Family or other comparable category. Label based on common names.
ShellBodyShape	Describes the structural form of each shell (e.g. chiton, gastropod or bivalve).
ShellSydneyFrequency	Frequency of molluscs etc. in Sydney Aboriginal shell middens as recorded by Attenbrow (1992).
ShellEdibility	An interpretation of edibility.
ShellGeographical Distribution	Local to Sydney or likely to be imported.

Shell Taxon Code (Table 3)

A unique four to six letter code for each 'taxon' of mollusc or other type of material e.g. coral, barnacle, unidentified shell. The upper case shorthand code makes manual data entry more efficient. The code is devised using rules which allow new codes to be generated for additional types of mollusc. For molluscs identified to both Genus and Species the ideal is to use the first two letters of the Genus followed by the first two letters of the species, for example:

Scutus antipodes (false limpet) SCAN
Bankivia fasciata (banded kelp shell) BAFA

In case of duplication further letters from the species name are added:

Austrocochlea constricta (ribbed top shell) AUCONS
Austrocochlea concamerata (top shell) AUCONC
Austromactra contraria (pipi-like shell) AUCONT

For molluscs identified to Family only the first two letters are 'FA' (Family) followed ideally by the first two or three letters of the family name. In case of duplication additional letters from the family name are used:

Family Cassisidae (helmet shell) FACAS
Family Cancellariidae (cancellarias) FACAN
Family Conidae (cone shell) FACO

For other types of animals and categories of material the codes are intuitive (see Table 3).

Table 3: Shell Taxon Codes and Shell Taxon Labels.

Shell Taxon Code	Shell Taxon Label
ANTR	Anadara trapezia (mud ark, Sydney cockle)
AUCONC	Austrocochlea concamerata (top shell)
AUCONS	Austrocochlea constricta (ribbed top shell)
AUCONT	Austromactra contraria (pipi-like shell)
AUNI	Austrolima nimbifer (lima)
AUOB	Austrocochlea obtusa (top shells)
BAFA	Bankivia fasciata (banded kelp shell)
BARNACLE	Barnacle
BEAU	Bembicium auratum (true periwinkle)
BEHA	Bedeva hanleyi (common oyster borer)
BENA	Bembicium nanum (true periwinkle)
BESI	Bellastrea sirius (star shell)
BESP	Bembicium sp. (true periwinkle)
BILA	Bittium lacertinum (cerith)
CAAR	Calliostoma armillata (jewelled top shell)
CAGR	Cancellaria grandosa (grained cancellaria)
CALA	Cacozeliana lacertina (cerith)
CASP	Cabestana spengleri (triton)
CHITON	Class Amphineura (chitons)
COCO	Conuber conica (sand snail)
CORAL	Coral
COVI	Corbula vicaria (basket shell)
CYFR	Cypraea friendii (friendly cowrie)
CYMO	Cypraea moneta (money cowrie)
DIOR	Dicathias orbita (cartrut shell, thiad)
FACAN	Family Cancellariidae (cancellarias)
FACAS	Family Cassididae (helmet shell)
FACE	Family Cerithiidae (ceriths)
FACO	Family Conidae (cone shell)
FACYM	Family Cymatiidae (tritons)
FACYPR	Family Cypraeidae (cowrie)
FAEP	Family Epitoniidae (wentletraps)
FAHA	Family Haliotidae (abalones)
FALIM	Family Limidae (limas)
FALITT	Family Littorinidae (true periwinkles)
FAMI	Family Mitridae (mitre shell)
FAMY	Family Mytilidae (mussels)
FANAT	Family Naticidae (sand snails)
FANER	Family Neritidae (periwinkles)
FAOL	Family Olividae (olive shell)
FAOS	Family Ostreidae (oysters)
FAPAT	Family Patelloididae and Patellidae (limpets)
FAPEC	Family Pectinidae (scallops)
FAPYR	Family Pyramidellidae (pyramid shell)
FASTR	Family Strombidae (stromb, spider shell)
FATER	Family Terebridae (auger shells)
FATRO	Family Trochidae (top shells)
FATUR	Family Turbinidae (turban shell)
FAVEN	Family Veneridae (venus shells)
FAVOL	Family Volutidae (volute)
HARU	Haliotis ruber (abalone)
LISC	Littorina scabra (true periwinkles)
MISP	Mitra sp. (mitre shell)
MOMA	Morula marginalba (common black oyster eater)
MUSP	Musculus sp. (mussel)
MYED	Mytilus edulis planulatus (common edible mussel)
NAUT	Nautilus pompilius
NEAT	Nerita atramentosa (black nerite)
OSAN	Ostrea angasi (mud oyster)
PAPE	Patellanax peroni (scaly limpet)
PECH	Periglypta cheminitzi (pyramid shell)
PEFU	Pecten fumatus (scallops)
PHLU	Phillippia lutea (sundial shell)
PLDE	Plebidonax deltoides (pipi)
POSP	Polinices sp. (sand snail)
PYEB	Pyrazus ebeninus (club mud whelk)
SACU	Saccostrea cucullata (Sydney rock oyster)
SAFR	Salinator fragilis (fragile air breather)
SCAN	Scutus antipodes (false limpet)
THCO	Thalotia comtessi (top shells)
TRHI	Trichomya hirsuta (hairy mussel)
TRSPS	Tridacna sp. (clam shell)
UNBI	Unidentified Bivalve
UNGA	Unidentified Gastropod
UNSH	Unidentified Shell
VEAU	Velacumantus australis (southern mud whelk)

Shell condition (Table 4)

This field records the presence and/or extent of burning and erosion, the approximate proportion of the whole shell which remained preserved (fragmentation), evidence for use of shell in mortar and the presence of holes interpreted as deliberate drilling and/or piercing. The way these data have been coded reflects the original data entry. Research reasons for recording such data are discussed below.

For fragmentation of gastropods the proportion refers to the whole shell. For bivalves the proportion refers to each separate half of the shell. As information about fragmentation was recorded inconsistently on the original sheets a decision was made to simplify the data for entry into the computer database. Shells originally recorded as being between 70–100 per cent complete were coded as 'whole' (W). All other shells (variously recorded as 'tiny' 'fragments', as less than 70 per cent complete, 'fragmentation unknown' or for which no value was recorded) were left blank in the database. This allows the database to be queried to extract information about which shells remained whole or nearly complete and which were fragmented. However it does not allow information to be extracted about the degree of fragmentation.

On the original sheets some shells were recorded as having been used for mortar using the 'Notes' field with comments such as 'mortar', 'appears that some shell has been used for mortar' etc. The criteria for such an interpretation was not stated. In the computer database the code 'M' in the condition field indicates that at least some shell was used for mortar, but this can only indicate presence/absence rather than allowing quantification as this was inconsistently recorded.

On the original data sheets the Notes field was used to record that some shells were 'pierced' or had holes drilled through them. These comments were recoded into the condition field (see Table 4).

Table 4: Shell Condition Codes.

Code	Explanation
B	Shell is burned or charred
B1	Slightly burned or charred
B2	Moderately burned or charred
B3	Heavily burned or charred
E	Shell is eroded
E1	Slightly eroded
E2	Moderately eroded
E3	Heavily eroded
W	Whole or nearly complete shell (c.70-100% complete)
M	Evidence of use of shell in mortar
P	Pierced hole in shell
D	Drilled hole in shell

Shell Taxon Label (Table 3)

An explanatory label for each Shell Taxon Code used to generate tables and reports. The label combines a scientific and common name. These have been created to be more easily readable than the Shell Taxon Code.

Shell Taxon Group

An interpretative grouping based on the common name for each Family which allows individually recorded taxa to be grouped back together for analysis where appropriate or useful.

Shell body shape

Records the shape of the mollusc or other animal (e.g. gastropod, bivalve, chiton). This is relevant to quantification.

Shell Sydney frequency

This is based on Attenbrow's (1992) study of marine molluscs and similar forms of life from Aboriginal shell middens in the Sydney area and records the frequency of each Shell Taxon (i.e. dominant, common, rare or not recorded) across ten sites. These data are relevant to shell edibility as discussed below.

Shell edibility

Molluscs which are collected and sold for human consumption today, as regulated by the New South Wales government (e.g. http://www.oysterfarmers.asn.au/qap/nswsp.htm) are listed in the database as 'Good'. Many of these molluscs are also known from documentary sources to have been favoured for eating by British and other colonial settlers (e.g. Beckett 1984; Karskens 1999). Additional taxa which Attenbrow 1992 ranks as 'dominant' and 'common' in Aboriginal shell middens in the Sydney area are listed as 'edible' on the basis that these were favoured as food by Indigenous people and could also have been eaten by colonial settlers. All other molluscs and comparable forms of life are listed as having 'unknown' edibility. While none of these molluscs is poisonous many are very small or have other qualities (e.g. their flesh is tough and chewy) which make them less likely to have been collected as food. A few molluscs not native to the Sydney region have also been classified as 'edibility unknown'.

Shell geographical distribution

Local, tropical or unknown. Most molluscs found at the Quadrant site are known to occur in the Sydney region but a few shells are tropical taxa which are thought likely to have been imported as collectors items, curios or ornaments.

POTENTIAL RESEARCH QUESTIONS AND MARINE MOLLUSCS

Using the above system a range of data about marine molluscs and other 'shells' from the Quadrant excavations has been entered into a computer database and are now available for further analysis. To this extent the legislative requirements of recording this group of archaeological data to a 'basic minimum standard' have been met. A catalogue has been created. But how useful or meaningful is this catalogue for answering useful or interesting research questions? This requires a consideration of which questions might be addressed through a study of the Quadrant shell data in conjunction with other relevant archaeological and historical information. It also depends on which data were recorded and how.

Marine molluscs have the potential to answer several different kinds of questions. As they also occur naturally in the environment some of them may have nothing to do with human activity, so it's necessary to consider the likely origins of the shells and their potential to inform about different aspects of human behaviour. Possible origins for Quadrant shells include:

Naturally occurring shell or beach deposits which have become accidentally incorporated into archaeological deposits.

This could be indicated by stratigraphy and other context information, but the range of taxa and size of the shells may also be relevant. For example Attenbrow (1992) notes that natural beach deposits contain a much wider range of shell types and sizes than Aboriginal shell middens. Analysis of the distribution and relative representation of different taxa across different types of archaeological contexts (e.g. house floors, wells, yard surfaces, drains, demolition rubble etc.) at Quadrant may provide some insights. However as no size data were recorded for the Quadrant shells this question cannot be fully addressed without further work. It might be possible to obtain data for average and maximum sizes for specific taxa from published literature which could be matched against the Quadrant shells using the database features. However as some taxa are very variable in size such an analysis would be inherently inaccurate. To answer this question effectively it would be necessary to go back to the shells and record this additional data.

In-situ Aboriginal shell midden deposits which remained undisturbed by later European activities.

Stratigraphy and other context information is obviously essential here, including any finds of Indigenous artefacts and other items usually associated with shell middens (e.g. charcoal, bones of fish, sea birds and native faunas in a fragmentary condition). Preliminary results demonstrate considerable differences in the relative frequency of different mollusc taxa in the Quadrant samples compared to the pattern noted by Attenbrow (1992) for Aboriginal shell middens.

Aboriginal shell midden deposits incorporated accidentally or deliberately into European contexts (e.g. ground disturbance for building works, mortar production, deliberate collecting activity of European inhabitants).

Answering this question relies heavily on the inter-pretation of stratigraphy and other archaeological information. Many of the Quadrant shells were recorded as having been used for mortar (i.e. they had mortar adhering to them). However inconsistent recording of these data have introduced a degree of ambiguity. Given the way data about mortar were recorded, only the presence of mortar in particular archaeological contexts can be determined. Clear criteria for establishing whether an individual shell fragment was used for mortar have yet to be established. These were not made explicit on the original manual data recording sheets and the degree to which mortar use was recorded or not also appears to depend on the diligence and observation skills of the individual recorder. For example one recorder seems to have observed mortar in a significant number of the samples they recorded, while another recorder hardly noted any even though the number and types of contexts they recorded were comparable. Fragmentation patterns may also be relevant to determining if shell was used for mortar. For example it could be a reasonable assumption that shells used in mortar were more fragmentary than shells used for food, although this would need to be established by further research. Yet the fragmentation data for the Quadrant shell were inconsistently recorded. It was only possible to divide shells into 'whole' or 'complete' (c.70–100 per cent of the shell remaining) or 'fragmented' (all other shells).

The source of the shell used for the mortar is hard to establish. In the early days of the colony there was not enough lime to make mortar so people collected shells, including many from Aboriginal shell middens, and ground these down and burnt them for this purpose (Proudfoot et al. 1991:39). Whether such conditions were likely to have applied to Quadrant requires further historical research. However this issue is relevant to interpretation of the Quadrant shell data in dietary terms. If shells from natural beach deposits and/or shell middens were brought into the site as mortar then this casts doubt on dietary inferences. Use of shell for mortar and how to recognise this in the archaeological record clearly requires further research.

Shells collected locally or purchased by the site's inhabitants from markets or vendors for food.

This relies on determining that at least some shells were food remains rather than used for mortar. Archaeological context information and further documentary research is relevant, as well as features of the shells themselves including habitat information, relative representation of taxa interpreted as being more edible, and fragmentation patterns. The physical location of shells in the soil could also provide clues here. For example large piles of articulated or semi-articulated oysters and other favoured species found in close proximity to each other may provide evidence for the remains of meals. Detailed studies of shell size and growth rings could indicate that shells were collected and/or harvested from the same environment at the same time of year which could also provide information about their use as food. However such data was not recorded at this site and is not normally recorded for other comparable excavations.

A further set of related question concern which shells were favoured for food during different periods of site use and/or by different households, which may themselves reflect different socio-economic groups. This links through to questions about diet, economy and lifestyle as well as the changing environment and the development of a 'shellfish' economy which need to be addressed in conjunction with further archaeological and documentary research.

Such analysis will require detailed tabulation of the diversity of shell types by context type in conjunction with analysis of other faunal and artefactual evidence. Documentary research is needed to allow comparison of archaeological evidence with historically known common food shells which would be available from vendors or which could be easily collected in the surrounding environment.

Shells from outside the Sydney region which were obtained by exchange (e.g. gifts, purchase, collector's items) as ornaments or curios.

Karskens (1999:143, 161) notes documentary and archaeological evidence for collection of 'exotic' shells, usually from tropical areas in the Pacific, for ornaments in houses in the Rocks district of Sydney in the nineteenth century. Habitat information is available for different taxa which indicates if shells were 'local' or 'tropical'. Tropical shells could be interpreted as collector's items or curios, which also depends on other archaeological context information.

A few shells were observed to have pierced or drilled holes through them which may be indicative of their use as jewellery. One shell was recorded to have been sawn through which may indicate use of shell as a raw material for manufacture of other artefacts. Such observations are interpretative. Shells sometimes have holes drilled through them by other animals and clear criteria need to be specified for determining whether holes and other marks are the product of deliberate human actions. Ideally these specimens should be re-examined and further research conducted to establish workable criteria for such interpretations.

DISCUSSION

Further insight into a range of substantive and methodological questions will require further analysis of the Quadrant shell materials in conjunction with other members of the Quadrant team. However work conducted so far demonstrates several points about aspects of the archaeological research process which apply for large-scale urban excavations in Sydney conducted ahead of development.

Despite being designed and conducted in the absence of explicitly stated research questions, the initial data recorded about the Quadrant shells clearly conforms to a basic minimum standard. It provides a relatively accurate overview of the range and abundance of marine mollusc taxa from the site based on biological taxonomy from which other non-cultural information can be gleaned (e.g. habitat and geographical distribution). Some cultural interpretation is also immediately possible (e.g. edibility, use of shell for mortar and ornaments) although some aspects of the data could have been better recorded.

To answer some questions it would be necessary to return to collected shells and record new data. Some data which was not recorded during excavation cannot now be retrieved (e.g. information about in-situ deposition of groups of related shells). It is also clear that answering many possible questions about and from the mollusc data requires prior and or concurrent interpretation of archaeological data (e.g. about the date and function of different contexts, the relative abundance of other dietary evidence and the presence of artefacts relevant to questions of diet and economy) as well as additional documentary research. As for all historical archaeology there is no point in using archaeological data to answer questions which are already well-understood from documents. The aim is to find contrasts between the different sources of evidence and/or use the archaeology to fill gaps in the documentary and historical records.

Further contextual analysis may also suggest that answering some questions from the shell data is not feasible and that some data already recorded in the database cannot be used or need not have been recorded. For example preliminary analysis of the Quadrant shell data by context shows that only some contexts contain a large enough sample of shells (by fragment count or weight) to merit further reliable discussion of the relative representation of different taxa. Had the size of the samples been established before the shell data were recorded it might have been more sensible to prioritise larger contexts for more detailed recording (including taking measurements for shell size, and more accurately recording fragmentation patterns and evidence for mortar). Smaller contexts and/or those of lesser archaeological significance could have been subject to a more basic analysis. Given that time and resources for any archaeological work are limited it is always necessary to make decisions about where to target different types of data recording for maximum research benefits. Yet making decisions about which contexts to prioritise also depends on project management issues which for an excavation the size of Quadrant are complex and equally apply to other comparable Sydney excavations. A key question here is the extent to which very detailed recording of minor aspects of marine shell in a large project like Quadrant are really justified by the time and costs involved. In this case the production of the basic shell catalogue was funded by the developer. However subsequent research is being funded by University of Sydney (primarily in paid research time) as part of an ongoing collaborative research project.

These comments do not suggest that initial recording of shell at Quadrant was somehow 'inadequate'. Indeed quite the opposite is true as the database is already providing a wealth of interesting and useful information which will eventually form the basis of further research publications. However this case study demonstrates some of the practical difficulties of dictating an absolute 'minimum' set of data ahead of the work which should always be recorded for all shells excavated from any Australian historic sites regardless of other research and project management issues. Effective data recording systems are always those tailored to the particular circumstances of the project and these need to be flexible. Research design is a process which needs to include frequent assessment of which questions could or should be answered and which data needs to be recorded, and how to achieve useful and meaningful results.

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