Quaternary International xxx (2016) 1–4

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

# Current methodological issues in archaeomalacological studies

Current research into the origins of coastal economies show that aquatic environments and the resources they contain have played a significant role in human evolution since at least 160 ka, and even more so throughout periods of later cultural development worldwide (Erlandson and Fitzpatrick, 2006; Marean et al., 2007; Cortés-Sánchez et al., 2011; Jerardino, 2016b). Although the study of shell-bearing sites dates to almost the beginnings of world archaeology (Waselkov, 1987; Claassen, 1998), over the last several decades, and in particular with the currently fast-growing interest in these types of deposits, there has been an increased demand for improved methodologies in order to make sense of the considerable array of evidence derived from such research and to facilitate intra- and inter-assemblage comparisons on a quantitative basis. Since shells often form the dominant archaeological component of ubiquitous shell-bearing sites around the world's coasts and waterways, Archaeomalacology has developed as a sub-disciplinary area dedicated to study these remains in all their multiple facets (i.e., spatial distribution, retrieval, characterization, documentation, quantification and preservation) (Waselkov, 1987; Claassen, 1998). This special issue thus brings together updated and relevant case studies focusing on important methodological aspects in contemporary archaeomalacological research. These case studies reflect a broad geographical range (northern and southern Africa, Australia, North, Central and South America and Europe) along the shorelines of several large oceans (Mediterranean Sea, the northern and southern extensions of the Pacific and Atlantic Oceans) and the restricted riverine and relict freshwater lake systems of southern Australia and the United States. An array of different perspectives and analytical approaches are applied to scrutinise archaeological sequences of different time depths (Pleistocene and Holocene), and in some case studies presented here, the use of modern ecological and experimental data as an important component of the research is also evaluated. These efforts not only contribute towards enhancing our ability to reconstruct the human past (i.e., subsistence, foraging behaviour, technology, palaeoenvironment, site formation and taphonomy) but also provide tools to enable effective management of our cultural heritage around the world.

Dictated by conceptual models and those specific questions that guide individual research programs, methodological issues arise as a consequence of the need to strengthen and maximize the reliability of archaeological interpretations. In other words, how we arrive at an understanding of past scenarios and how we continue to improve upon data acquisition and interpretation is central to methodological concerns. More specifically, methodological approaches and protocols have been developed to understand not only what archaeological residues can tell us about past behaviours and environmental conditions, but also how these remains arrived at archaeological sites and what happened to them during and after the accumulation of the deposit. Potential biases and undetected variability at all these levels are central to archaeological methods, whether these are applied in the field while sampling, during laboratory analyses or final data processing and interpretation. Archaeomalacological studies have not been exempt from such matters, particularly as these types of methodological concerns are integral components in the reconstruction of past aquatic adaptations (Waselkov, 1987; Stein, 1992; Claassen, 1998; Thomas, 2015a, b; Jerardino, 2016a).

The papers assembled in this special issue explore some of the many methodological challenges intrinsic to the study of shell-bearing sites, and their case studies aim to illustrate the current progress in overcoming such challenges in order to reach a deeper understanding of ancient human lifestyles. Given the existing variability in the many traits that characterize the worlds' aquatic systems (environmental, ecological, geomorphological, biogeographic, demographic, technological and socio-cultural), the findings and methodological approaches presented here are necessarily context dependant. Nevertheless, the general principles and approaches presented in these case studies can be locally adopted and refined as appropriate, and as such are applicable to a variety of contexts across continents.

Approaches to surveying have been integral to the development of archaeomalacological studies. For example, Larsen et al. use three-dimensional digital records generated via Terrestrial Laser Scanning and systematic radiocarbon dating to survey and analyse mounded shell-matrix sites. As a result, they are able to establish useful information on site formation histories and to present a local chronology for the observed patterning in the size and shape of such sites across the landscape. Sampling of these and other shell-bearing sites is a challenge that can be assisted with the implementation of these new technologies in terms of targeting some areas over others when commencing excavations. However, as Campbell points out in the context of European archaeology, explicit criteria for the appropriate excavation and documentation of shell remains are complicated issues and need to consider several variables such as method of recovery, statistical considerations for determining minimum and maximum sample size, types of sites, composition and chronology, among the most important. In addition to these critical elements, stratigraphic integrity also needs to be scrutinized when sampling, as chronologies and provenience of the studied material have to be determined with

http://dx.doi.org/10.1016/j.quaint.2016.05.015

confidence in order to establish reliable reconstructions of the past. In this regard, the study presented by Koppel et al. shows that inexpensive amino acid racemisation dating can be successfully applied to identify vertical displacement of shell material, especially in cases where visual inspection of stratigraphic profiles proves to be opaque and/or extensive radiocarbon dating costs are prohibitive.

Another important methodological aspect within Archaeomalacology is mollusc species quantification, an aspect long debated within the broader zooarchaeological literature. Within Archaeomalacology, some quantification methods have been favoured over others depending on sample characteristics and on particular research questions (i.e., Mason et al., 1998; Claassen, 2000; Giovas, 2009; Glassow, 2000; Gutiérrez-Zugasti, 2011; Harris et al., 2015). For the sake of maximising data quality and comparability within and between sites, differential shell fragmentation and associated taphonomic factors need to be factored in as several of the main considerations behind the use of certain measures for calculating taxonomic abundance. This is clearly reflected in the study of Californian mussel umbones presented by Glassow, where identifiability and quantification of Non-Repetitive Elements, and the variable ability of laboratory personnel to recognise them, can have an important bearing on the calculation of Minimum Number of Individuals (MNI), valve length reconstruction and inferences regarding foraging behaviour. As has been recognised for some time, however, the differential fragmentation patterns of marine and freshwater mollusc species can affect species representation in archaeological assemblages (i.e., Claassen, 1998; Wolverton et al., 2009; Gutiérrez-Zugasti, 2011; Harris et al., 2015). In this regard, Popejoy et al. empirically demonstrate that shell strength and identifiability of freshwater mussels have a clear influence in archaeomalacological abundances, highlighting the need for evaluating variability in species taphonomy and representativeness before using such data to answer zooarchaeological and palaeozoological research questions. Going beyond how MNIs are calculated, Thomas and Mannino advocate persuasively that considerations of meat-yields of those main taxa recovered from shell deposits can significantly alter the reconstruction of shellfish procurement and relative contribution of different taxa to the diet, themes that are at the centre of many archaeomalacological studies (Waselkov, 1987; Claassen, 1998). They also show that site and assemblage-specific variables (i.e., type of shell matrix, shell preservation, rates of accumulation) ought to be taken into account not only when quantifying but during earlier research stages such as field sampling (see also Campbell; Glassow; Jerardino 2016b).

Another important methodological topic addressed within Archaeomalacological studies is how species-specific requirements, in terms of the biology, ecology and biogeography of molluscs, are used in palaeoenvironmental reconstructions (i.e., Waselkov, 1987; Claassen, 1998; Thomas, 2015a). Given the biases that human behaviour and site preservation can impose on archaeological shell assemblages, these reconstructions ought to be complemented by, or compared to, independent sources of palaeo-data. Langejans et al. do this by studying not only the molluscs species that were purposefully collected, but also those taken as by-catch (and therefore largely unselected by humans; see also Ainis et al., 2014, Glassow in this issue). Distinguishing between species that were intentionally collected and by-catch can make a huge difference when evaluating subsistence systems of ancient groups, particularly when dealing with less common archaeological contexts such as the late Pleistocene freshwater systems highlighted in Garvey's work. In this case, Garvey clearly highlights the need to reconsider ideas of specific taxa being economically viable or not as indicated ethnographically or based on shell size, indicating that a previously identified by-catch taxon was likely more economically important than formerly recognised. In addition to by-catch species, marine sediments can also became incorporated into archaeological sites through active but inadvertent human agency. As demonstrated by Jerardino, quantity and composition of marine sediments can inform on local Holocene sea-level history, and provide indirect evidence for the carrying devices used during coastal foraging and prey transport even in the absence of direct archaeological evidence of such technology.

Reconstructing palaeoclimate and marine coastal productivity have been central concerns for explaining prehistoric coastal subsistence and settlement patterns worldwide, and isotopic signatures on archaeological marine shells provide an important tool in this regard (e.g., Colonese, et al., 2012; Glassow et al., 2012). One example is the paper presented by Hausmann et al. that tests the suitability of Oxygen isotope analyses for reconstructing Sea Surface Temperatures (SST) on one of the most common molluscs found in the many shell middens of the Farasan Islands. Another example touching more specifically on palaeo-productivity is that by Santoro et al., who propose that changes through time in the radiocarbon reservoir effect ($\Delta R$) of marine shells can also track local changes and latitudinal variability in upwelling intensity. In a similar vein regarding local variability of upwelling phenomena, Flores' research in southern California is a welcomed note of caution, demonstrating that broad regional palaeoenvironmental reconstructions based on single locations often don't apply at a local level where human activities (i.e., foraging) actually took place. Without such a realization, reconstructions of the past are potentially biased, and alternative hypotheses for explaining the archaeological record are not taken into account as a result. Also in southern California, the work presented by Thakar et al. advocates for a greater integration of ecological data, particularly small-scale, when considering similar scenarios. As these authors show, previously unrecognized variation in California mussel growth rates across tidal gradients shapes resource availability and thus may well have influenced human foraging decisions in the past. Without such small-scale and modern-day ecological data, archaeological correlates for resource depression via intense exploitation could be easily and incorrectly invoked as opposed to investigating micro-habitat causes for the types of patterns being observed.

Shellfish procurement and resource intensification has been a central theme in archaeomalacological studies as well, and Zangrando et al. provide an example from the high latitudes of South America with its own and distinctive patterning. Based on observations from a site on the southern shores of Tierra del Fuego, they argue that, contrary to common expectations, shrinking mean sizes of mussels through the stratigraphic sequence can be more easily explained by particular transport and processing strategies rather than resource depression. Agent-based modelling (ABM) is a new addition to the available battery of analytical tools for enquiring into these research themes, and Morrison and Allen use it to explore via evolutionary ecology, how energetic return rates (dependant on body size) and age at reproductive maturity of collected shellfish, shape prey resilience to human harvest. They also use ABM to understand how prey spatial structure (dispersed or aggregated) has an effect on foraging efficiency and on prey susceptibility to resource depression.

The last decade has seen an efflorescence of isotopic studies on collected mollusc shells for the purpose of establishing SST and determining the season of harvest (see Flores and also Hausmann et al.; Thomas, 2015a). Nevertheless, few have queried the reliability of samples sizes of archaeological shells for seasonality