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Prey selection, size, and breakage differences in *Turbo undulatus* opercula found within Pacific Gull (*Larus pacificus*) middens compared to Aboriginal middens and natural beach deposits, southeast Australia

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ABSTRACT

Qualitative discrimination criteria are employed commonly to distinguish cultural shell middens from natural shell deposits. Quantitative discrimination criteria remain less developed beyond an assumption that natural shell beds tend to contain a wider range of shell sizes compared to cultural shell middens. This study further tests this assumption and provides the first comparative quantitative analysis of shell sizes from cultural middens, bird middens, and beach shell beds. Size distributions of opercula of the marine gastropod *Turbo undulatus* within two modern Pacific Gull (*Larus pacificus*) middens are compared with two Aboriginal middens (early and late Holocene) and two modern beach deposits from southeast Australia. Results reveal statistically significant differences between bird middens and other types of shell deposits, and that opercula size distributions are useful to distinguish Aboriginal middens from bird middens but not from beach deposits. Supplementary qualitative analysis of taphonomic alteration of opercula reveal similar opercula breakage patterns in human and bird middens, and further support previously recognised criteria to distinguished beach deposits (water rolling and bioerosion) and human middens (burning). Although Pacific Gulls are geographically restricted to southern Australia, the known capacity of gulls (*Larus* spp.) in other coastal contexts around the world to accumulate shell deposits indicates the broader methodological relevance of our study.

1. Introduction

Shell middens are a ubiquitous archaeological site type and it has even been argued that shellfish gathering has been important in the cognitive development of modern humans (Álvarez et al., 2011; Claassen, 1998; Marean, 2010; Parkington, 2010; Waselkov, 1987; cf. Cortés-Sánchez et al., 2011). An enduring identification issue for cultural shell middens is differentiation from natural shell deposits such as those created by birds or storm surges (Claassen, 1998:70–7; Erlandson and Moss, 2001). While research reveals that cultural shell middens can often be distinguished from natural beach deposits based on the inclusion of artefacts (e.g. stone artefacts), bone, charcoal, and burnt shells and the exclusion of water-rolled shells (e.g. Attenbrow, 1992; Bailey, 1977; Gill, 1954; see also Henderson et al., 2002), many shell deposits do not contain such obvious signifiers. Claassen (1998:71) notes that 'birds may well be the most significant concentrators of marine bivalves and gastropods after humans'. In particular, at least eight species of gulls (*Larus* spp.) found in various coastal contexts around the world such as Australia, Europe, Africa, Eastern Asia, and North and South America, are known to accumulate shell deposits at drop-zone anvil sites used to smash open marine shells to extract flesh (e.g. Bahamondes and Castilla, 1986; Burger and Gochfeld, 1996; Barash et al., 1975; Ingolfsson and Estrella, 1978; Oldham, 1930; Teichert and Seventy, 1947; Ward, 1991). Yet, little research has been undertaken on bird shell middens and how these differ qualitatively and quantitatively from artefactless cultural shell middens (Bailey, 1994; Jones and Allen, 1978; Steele and Klein, 2008; Stone, 1989). This latter issue raises the question of how artefactless shell deposits are deemed as either cultural or natural (e.g. Nair and Sherwood, 2007). In many cases, artefactless shell middens are small deposits reflecting ephemeral encampments (e.g. Meehan, 1982). As criteria to distinguish natural shell deposits from artefactless shell middens are poorly developed, considerable potential exists for misidentification of cultural shell middens as natural shell deposits and vice versa. This potential misidentification issue has important implications for our capacity to accurately identify sites associated with low-level shellfishing activities (Erlandson and Moss, 2001:422).

Adequate discrimination criteria to allow differentiation of middens of Aboriginal origin from natural shell deposits such as bird middens and storm surge beach deposits are required within Australian archaeology. Despite considerable research into developing discrimination criteria, few studies include comparative quantitative assessments.

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While analysis of size differences in shells has been undertaken between an Aboriginal midden and storm surge deposit (Carter et al., 1999) and an Aboriginal midden and a bird midden (Jones and Allen, 1978), no controlled analysis has compared size differences for a single shell species between all three types of shell deposit. In this study we quantify the size distribution of *Turbo undulatus* opercula populations in two middens attributed to the Pacific Gull (*Larus pacificus*) and compare these with two beach deposits and two Aboriginal middens from southeast Australia (Fig. 1). We then apply a series of statistical tests to determine the degree to which shell size selectivity can discriminate between each of the three types of deposit. These metrical differentiation criteria are augmented with non-metrical insights into taphonomic differences between the three site types based on *T. undulatus* opercula breakage, weathering, and burning patterns.

2. Cultural versus natural shell deposits in Australian archaeology

In 1954, geologist Edmund Gill published a foundational paper with criteria to discriminate between Aboriginal 'kitchen middens' and natural 'raised beach' deposits (Gill, 1954). The list of criteria reflected Gill's experience with the coastline of Victoria in southeast Australia and his dual skills in geology and archaeology. He noted that in contrast to middens, natural beach deposits feature water-laid deposits, non-edible species, shells at all stages of growth ('not just the edible sizes'), water-worn shells, and no evidence of fire (charcoal), terrestrial animals (bones), and artefacts (flint implements) (Gill, 1954:252–253). Over the years, a range of archaeologists have refined Gill's criteria (e.g. Attenbrow, 1992; Bailey, 1977; Coutts, 1966), including the presence of foraminifera to identify marine-deposited shell beds (Carter et al., 1999; Gill et al., 1991; Lilley et al., 1999; McNiven, 1996; Rosendahl et al., 2007). In terms of shell size, researchers concur that Aboriginal middens tend to feature a bias towards larger shells due to prey selection towards larger ('edible' or 'economic') specimens whereas natural beach (usually storm surge) deposits feature a wider range of growth sizes, with a high proportion of small ('non-edible' or 'non-economic') specimens (e.g. Attenbrow, 1992:19–20; Bowdler, 1983:137; Coutts, 1966:343; Gill, 1954:251–252; Hughes and Sullivan, 1974; O'Connor and Sullivan, 1994:22, 24; see also Henderson et al., 2002:202; Waselkov, 1987:139). Yet as Rowland (1994) rightly notes, the distinction between larger (edible/economic) and smaller (non-edible/non-economic) shells is rarely defined and quantitative thresholds (e.g. 10 mm — McDonald, 1992:58; 15 mm — Attenbrow, 1992:15; McNiven et al., 2015) tend to focus on calorific profitability rather than taste and medicinal values, or indeed aesthetic and symbolic values. Similarly, Carter et al. (1999) provide the only study that quantitatively demonstrates that middens and natural beach deposits are dominated by larger and smaller-sized shells respectively (see also Henderson et al., 2002; O'Connor and Sullivan, 1994; Rosendahl et al., 2007).

Birds can also create accumulations of faunal remains that superficially look like Aboriginal middens. Examples include shell, bone, and crustacean exoskeleton deposits created by marine birds (Horton, 1978; Dortch, 1991; Dortch et al., 1984; Jones and Allen, 1978; McNiven, 1990; Sim, 1991), bone accumulations from the regurgitated

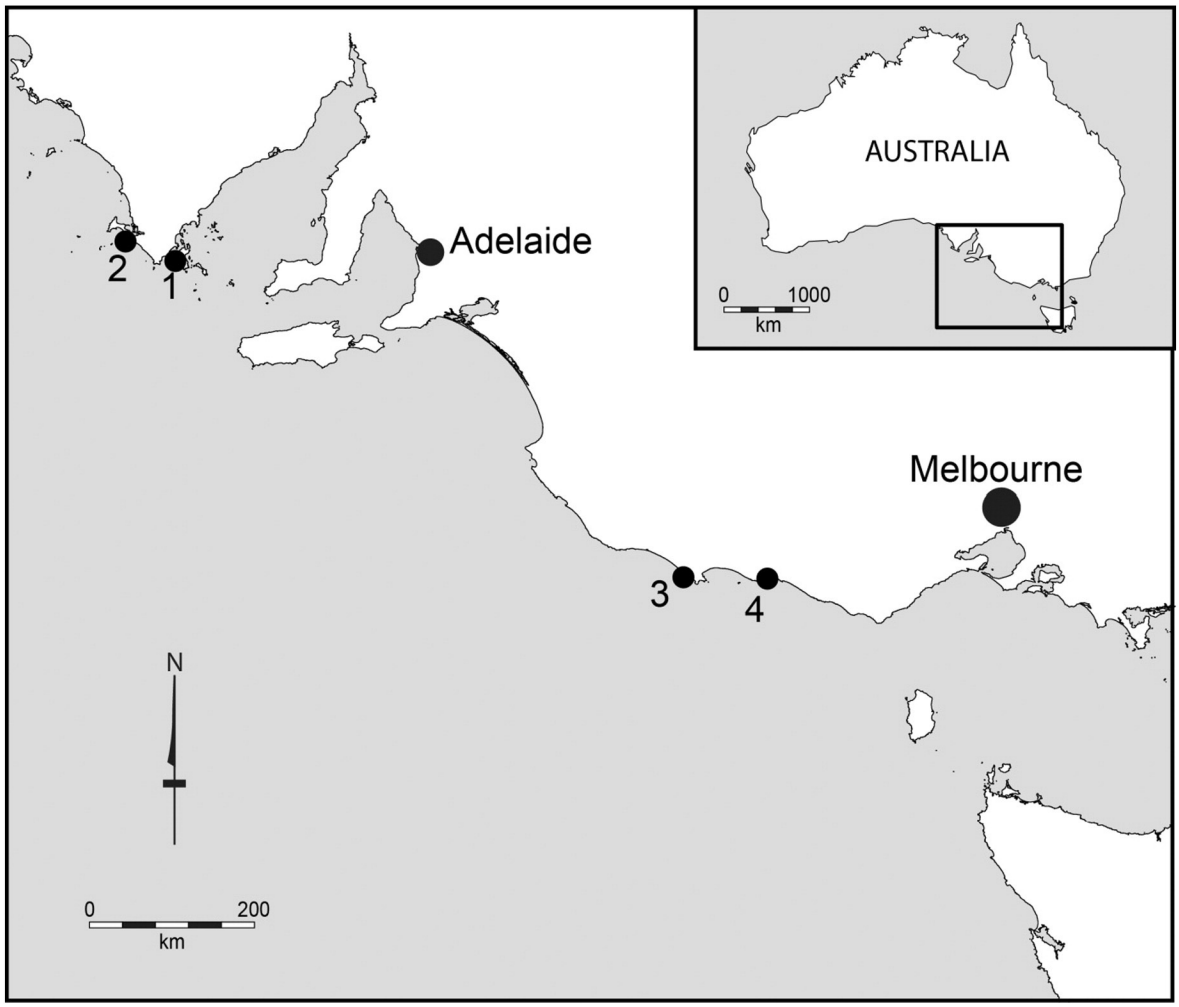

Fig. 1. Map showing shell sample locations. 1. Un-named beach, 2. Point Avoid and Golden Island Lookout, 3. Cape Duquesne, 4. Breakwater Island, Thunder Point, and Point Ritchie.