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Methods of investigation

Introduction

This chapter outlines the methods used to address data recovery and analytical issues. Excavation strategies and methods are outlined and sampling issues discussed. Analytical procedures adopted for the major classes of recovered materials are also presented. Detailed justification of the use of these methods is presented in Ulm (2004a:55–74).

Excavation strategy

Excavations targeted a range of sites located throughout the study area in order to develop a basic understanding of coastal land-use and construct a regional chronology upon which to examine continuities and disjunctions within and between individual site sequences (Table 3.1). Access to sites was constrained by land tenure and the remoteness of some parts of the study region. Sites were selected for excavation to represent both the most common site types encountered in the study region (large linear shell middens and smaller middens), as well as rarer site types (such as mounded shell middens and stone quarries). Excavated sites are located in a range of environmental contexts representing the diversity of landscapes in the study region. Only sites which exhibited material suitable for ^{14}C dating were selected in order to contribute to the regional chronology.

Detailed intra-site pedestrian transect surveys were used to characterise the surface distribution of cultural materials. Visibility was frequently limited to eroded sections on creek banks or crab burrow spoil and otherwise disturbed areas on the surface, owing to vegetation and leaf litter coverage and the subsurface location of many *in situ* deposits. Owing to resource limitations, excavations were generally located on or adjacent to the densest and/or deepest

exposures of cultural material observed, or in the case of large sites, at several of these locations. A key problem with this strategy is the assumption that visible concentrations of cultural material are an accurate indicator of intra-site diversity and not simply a product of differential visibility. The linear form of many sites investigated and large-scale exposure along eroding creek banks mitigated this problem to some degree at most sites, although it was shown in some excavations that apparent concentrations of material in the eroding section were not encountered in adjacent excavated deposits (see discussion of Squares A–B, Pancake Creek Site Complex, Chapter 8). Detailed excavation and analysis of small (often adjacent) 50cm × 50cm sampling units maximised data recovery within resource constraints while minimising damage to the archaeological record.

Table 3.1 Summary of excavated sites (arranged north to south).

SITE	SITE TYPE	YEAR EXCAVATED	SITE AREA (m ²)	AREA EXCAVATED (m ²)	SIEVE SIZE (mm)	EARLIEST DATE (cal BP)
Seven Mile Creek Mound	mounded midden	2000	200	1	3	3904
Mort Creek Site Complex	midden	1998	2500	1.75	3	3310
Pancake Creek Site Complex	linear midden	1998	22500	2	3	667
Ironbark Site Complex	quarry/midden	1998	150000	4.75	3	1519
Eurimbula Creek 1	midden	1999	10	1	3	171
Eurimbula Creek 2	midden	1999	10	0.25	3	modern
Eurimbula Site 1	linear midden	1999	100000	4.25	3	3205
Tom's Creek Site Complex	midden	1999	50000	1.5	3	966

Excavation methods

A key concern of this study was to employ a consistent data recovery strategy to establish comparable datasets from a range of stratified sites in the region. At all sites excavation was limited to small test pits, with excavations conducted as single or adjoining 50cm × 50cm squares. Where several adjacent 50cm × 50cm grid squares were excavated, squares were labelled alphabetically (A, B, C etc) in a clockwise direction from the northeast square. The southeast corner of each 50cm × 50cm grid square was used as the reference point for horizontal (*x* and *y*) coordinates of plotted objects. All squares were excavated by trowel in shallow arbitrary excavation units (XUs or spits) within stratigraphic units. Excavation procedures generally followed the model outlined by Johnson (1979). All sites were excavated until cultural material ceased to be recovered. Five elevations (four corners and centre-point) were recorded at the beginning and end of each excavation unit, using a local datum, autotest level and stadia rod. Plan view photographs were taken at the completion of each excavation unit. Section drawings and photographs were made of all sides of every pit after cleaning at the end of the excavation. Specific artefacts, ecofacts and features within excavation units were also photographed *in situ*. In addition, photographs were regularly taken to record the excavations in progress and the general site context. Artefacts and ecofacts encountered *in situ* during excavation, generally above 30mm in maximum dimension, were plotted three-dimensionally at their central points and removed as individual finds. This strategy was applied to stone artefacts, charcoal concentrations, large bone elements, articulated bivalves and other cultural material encountered towards the base of cultural deposits to enhance resolution for spatial analysis. The volume of all sediment removed was measured using a graduated bucket and weighed on a tared spring balance to the nearest 0.1kg.

Excavated sediments were gently dry-sieved onsite through 3mm mesh to reduce sample mass while minimising damage to fragile elements such as fish bone. Sieving stations were set-up on tarpaulins covering the ground surface to prevent contamination of underlying sediments. All sieve residues were retained and bagged in the field. Grain-size analysis, pH readings and Munsell

Soil Color® Chart tests were each completed in the field for all XUs. Sediment samples (c.200g) were taken for each XU from the material that passed through the 3mm sieve. Each excavation crew kept a daily general log as well as detailed notes of each XU. All excavated materials were transported to the laboratory facilities at the Aboriginal and Torres Strait Islander Studies Unit, University of Queensland, Brisbane. This generic set of excavation methods was modified and/or augmented according to specific site conditions. Deviations are noted in specific site chapters.

Radiocarbon dating and calibration

This study establishes an independent absolute chronology based on a large series of radiocarbon dates. At the commencement of the project, 12 radiocarbon determinations from two sites had been obtained from the study area. At least four of these date the formation of a natural chenier deposit on Rodds Peninsula. The dating program aimed to determine the initiation, periodicity and termination of site occupations. A further 68 radiocarbon dates were obtained for this project, comprising 53 dates on archaeological deposits, 10 dates on environmental samples and five dates on live-collected shell specimens. Since marine shell is the primary form of cultural material represented in the archaeological record of coastal landscapes of the area it provided an ideal medium for dating.

All conventional radiocarbon determinations and sample preparation for accelerator mass spectrometry (AMS) determinations (including CO₂ production) were undertaken by the University of Waikato Radiocarbon Dating Laboratory to reduce the effects of interlaboratory variation in sample preparation and counting procedures. AMS dating was conducted by the Rafter Radiocarbon Laboratory of the New Zealand Institute of Geological and Nuclear Sciences (IGNS). Charcoal samples were washed in hot 10% HCl to remove possible contaminants. Shell samples were cleaned and washed in an ultrasonic bath before acid-etching (2M HCl) for 100 seconds to minimise the possibility of contamination through isotopic exchange between the sample and its environment. All aragonite shell samples (i.e. *A. trapezia*) were either subjected to XRD analysis (up to Wk-8328) or feigl staining (from Wk-8553 onwards) (Friedman 1959) to establish the absence of recrystallised CaCO₃ (calcite) in the shell structures. All conventional samples were converted to benzene through hydrolysis and ¹⁴C activity measured by liquid scintillation counting (LSC) (Higham and Hogg 1997). For AMS samples, CO₂ was converted to graphite before introduction to the mass spectrometer. Radiocarbon ages are reported as conventional radiocarbon ages (Stuiver and Polach 1977). That is, they are corrected for isotopic fractionation but not corrected for marine reservoir effect or any other factor (cf. Kelly 1982; Thom et al. 1981). The conventional radiocarbon ages include a laboratory error multiplier of 1.22 (Higham and Hogg 1997).

Marine and estuarine reservoir effects

Global studies have demonstrated major variations in radiocarbon dates obtained from contemporaneous samples living in marine and estuarine environments (Reimer and Reimer 2000). These differences arise primarily from variations in the carbon reservoirs in which these organisms grow. Marine and estuarine reservoir differences are a major issue in the investigation and dating of coastal archaeological deposits where failure to take these factors into account can result in dating errors of up to several hundred years. Although general correction values have been proposed for various regions (e.g. Reimer and Reimer 2000), in areas where no local studies have been undertaken, reliance on generic regional correction values can reduce confidence in the accuracy of individual radiocarbon dates obtained on marine and estuarine samples. As part of this study, five marine shells live-collected between AD 1904 and AD 1929 and 12 shell/charcoal

paired samples from archaeological contexts were radiocarbon dated to determine local marine and estuarine reservoir offset values. This research found considerable variation in estuarine reservoir effects between individual estuaries. Estuary-specific correction factors are proposed for each estuary to account for local factors. Full details are presented in Chapter 4.

Radiocarbon age calibration

Radiocarbon ages are usually reported in ^{14}C years rather than calendar years. The primary difference between the two time-scales is caused by variability in the proportion of radioactive carbon in the biosphere through time and space. Conversion (or calibration) of radiocarbon dates from ^{14}C years to calendar years is possible by reference to records of known variability in radioactive carbon activity derived from dated tree-ring and coral-varve sequences. Such sequences, calculated from growth bands, enable direct comparisons to be made between radiocarbon dates and true calendar ages to derive a correction for a specific time period and region to convert ^{14}C years to calendar years.

Conventional radiocarbon ages were converted to calendar years using the CALIB (v4.3) computer program developed by the Quaternary Isotope Laboratory, University of Washington (Stuiver and Reimer 1993). Determinations based on charcoal were calibrated using the atmospheric decadal dataset of Stuiver et al. (1998a) with no laboratory error multiplier. Charcoal ages were reduced by 41 ± 14 years to correct for ^{14}C variation between northern and southern hemispheres (McCormac et al. 2002). Note that the incorporation of the southern hemisphere offset error assumes that each atmospheric conventional radiocarbon age derives from an independent secondary carbon reservoir (see Jones and Nicholls 2001 for discussion). Dates on marine samples (e.g. marine and estuarine shell) were calibrated using the marine calibration model dataset of Stuiver et al. (1998b) with a variable ΔR correction value defined for each estuary (see Chapter 4). The calibrated ages reported span the 2σ calibrated age-range. Samples too young for use of the calibration curves are reported as 'modern'. Where a calibrated intercept or age-range is reported as '0*', a 'negative' or 'modern' age BP is indicated owing to uncertainties introduced by nuclear testing. The dates presented on either side of the bracketed dates represent the 2σ calibrated age-range of the radiocarbon date using the calibration procedure outlined above. The date/s in the brackets represent the intercept/s of the radiocarbon age with the calibration curve. In parts of the calibration curve exhibiting short-term variation in atmospheric radioactive carbon activity, or where radiocarbon ages have large standard errors, it is common to have multiple intercepts (i.e. multiple calibrated ages for any given radiocarbon date) which are equally probable. Note that a new version of the CALIB (v.4.4) calibration program incorporating an option to use a southern hemisphere calibration curve for the last c.1,000 calendar years was released in late 2003. Radiocarbon dates presented in this study have not been recalibrated using this new dataset, although the new recommended southern hemisphere offset of 41 ± 14 years is employed. The small difference in calibrated ages does not significantly alter any data presented in this study.

Dating terminology

Following convention, calibrated radiocarbon dates are referred to in this study as years cal BP; for example, 2,340 cal BP. Specific uncalibrated (i.e. conventional) radiocarbon ages are reported with their accompanying error estimate and laboratory number; for example, $2,340\pm 55$ BP (Wk-5353). Where a precise date is unnecessary, a generalised date is used; for example, c.2,300 years ago (referring to the calendrical, or calibrated time-scale). Occasionally very generalised dates are cited to refer the reader to a general time interval; for example, c.3,000 BP (very roughly around 3,000 years ago; calibration is irrelevant in such cases).

Laboratory analyses

In the laboratory, all 3mm sieve residues were gently wet-sieved with freshwater and air-dried prior to analysis. Small finds were also wet-sieved, with the exception of charcoal and other fragile materials, which were cleaned using tweezers to remove adhering sediments. Excavated material was sorted into the following generic categories using tweezers: organic material (i.e. roots, leaf litter, seeds, scats, insect remains etc), shell (separated into marine bivalve, freshwater bivalve, marine gastropod and terrestrial gastropod), crustacean carapace, bone (separated into fish bone and non-fish bone), charcoal, stone artefacts, non-artefactual stone, pumice, pigment and coral. Material in each category was weighed to the nearest 0.1g on an A&D EK 1200 electronic balance for samples above 10g, while those below 10g were weighed on a Shimadzu AW120 electronic balance to the nearest 0.0001g. Detailed laboratory procedures for the major categories of recovered materials are presented below. This generic set of analytical methods was modified and/or augmented according to specific assemblage requirements. Deviations are noted in relevant chapters detailing the results from specific sites.

Invertebrate remains

This category includes both marine and terrestrial shellfish remains as well as crustacean carapace. Shell was identified to the lowest taxonomic level possible using diagnostic features and a comprehensive shell reference collection specifically constructed for this project with the assistance of the Malacology Section, Queensland Museum (Appendix 5) and standard reference works (Coleman 1981; Lamprell and Healy 1998; Lamprell and Whitehead 1992; Wilson and Gillett 1979). Minimum number of individuals (MNI), number of identified specimens (NISP) and shell weight per taxon were used to characterise shellfish abundance. Intra-specific size measurements were undertaken on whole shells of principal taxa represented in excavated assemblages throughout the region — *A. trapezia* and *S. glomerata*. Fragmentation rates were calculated for *A. trapezia* (NISP/100g) to investigate site-specific differences in post-depositional processes. The diversity of recovered shellfish assemblages was examined using Simpson's index (see below). Finally, excavated *A. trapezia* assemblages from each site were subject to bivalve conjoin analyses to examine aspects of site integrity and depositional processes. Details of all of these analyses are presented below. Figures 3.1–3.2 show bivalve terminology. Figure 3.3 shows gastropod terminology.

Minimum number of individuals (MNI)

The MNI measure is the minimum number of individual shellfish necessary to account for the number of diagnostic elements identified in an assemblage. For symmetrical bivalves (e.g. *A. trapezia*, *D. deltoides*), the highest number of hinges of one side is taken as the MNI for that sampling unit. For asymmetrical bivalves (e.g. *S. glomerata*) shells were separated into upper (lids) and lower (bases) valves and the greater number taken as the MNI for that sampling unit. Spires of gastropods were used to calculate MNI. Although MNI calculations are often adopted to avoid the impact of fragmentation on NISP calculations (e.g. Mowat 1995:83), in highly fragmented assemblages, few diagnostic attributes amenable to MNI calculation may be represented, potentially rendering the MNI a severe underestimate of abundance.

Number of identified specimens (NISP)

The NISP measure is the number of shell fragments identified to a particular taxon. The major limitation of this method for application to shellfish is the level of identifiability of fragmented shell. As laboratory analysis proceeded it was found that virtually all shell in the 3mm sieve residue was identifiable to species as analyst experience increased and the comparative reference

collection became more comprehensive. Although NISP has been criticised for over-representing the abundance of taxa with distinctive sculpture attributes (e.g. Mowat 1995), it is useful for intra- and inter-site comparison of individual taxa within and between shell assemblages and for examining shell fragmentation rates (see below).

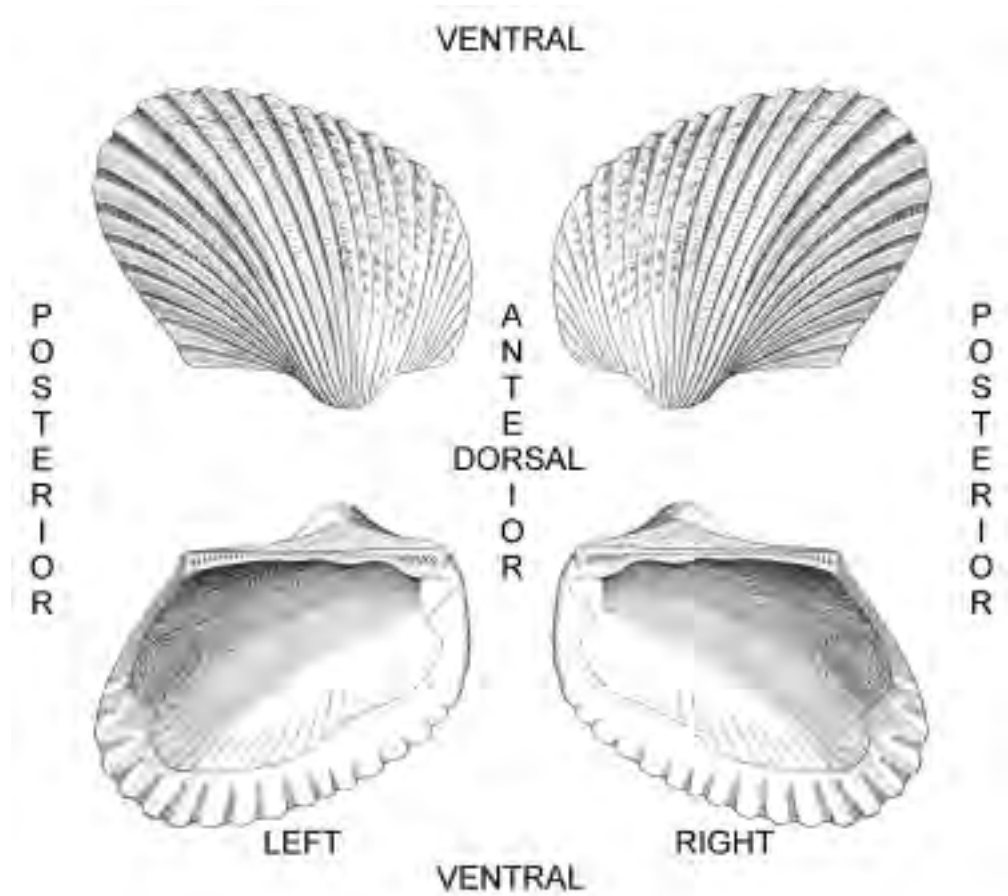


Figure 3.1 Bivalve terminology (after Claassen 1998:21; Hedley 1904).

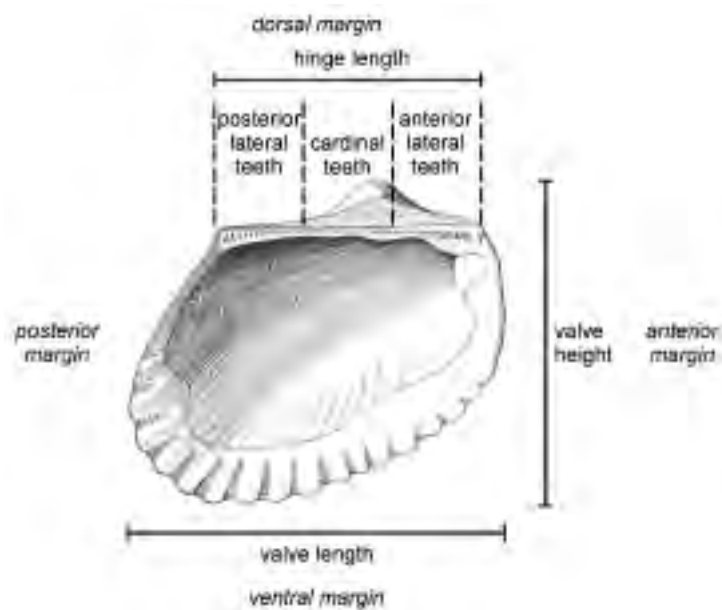


Figure 3.2 Bivalve terminology and measured attributes (after Claassen 1998:21; Hedley 1904).

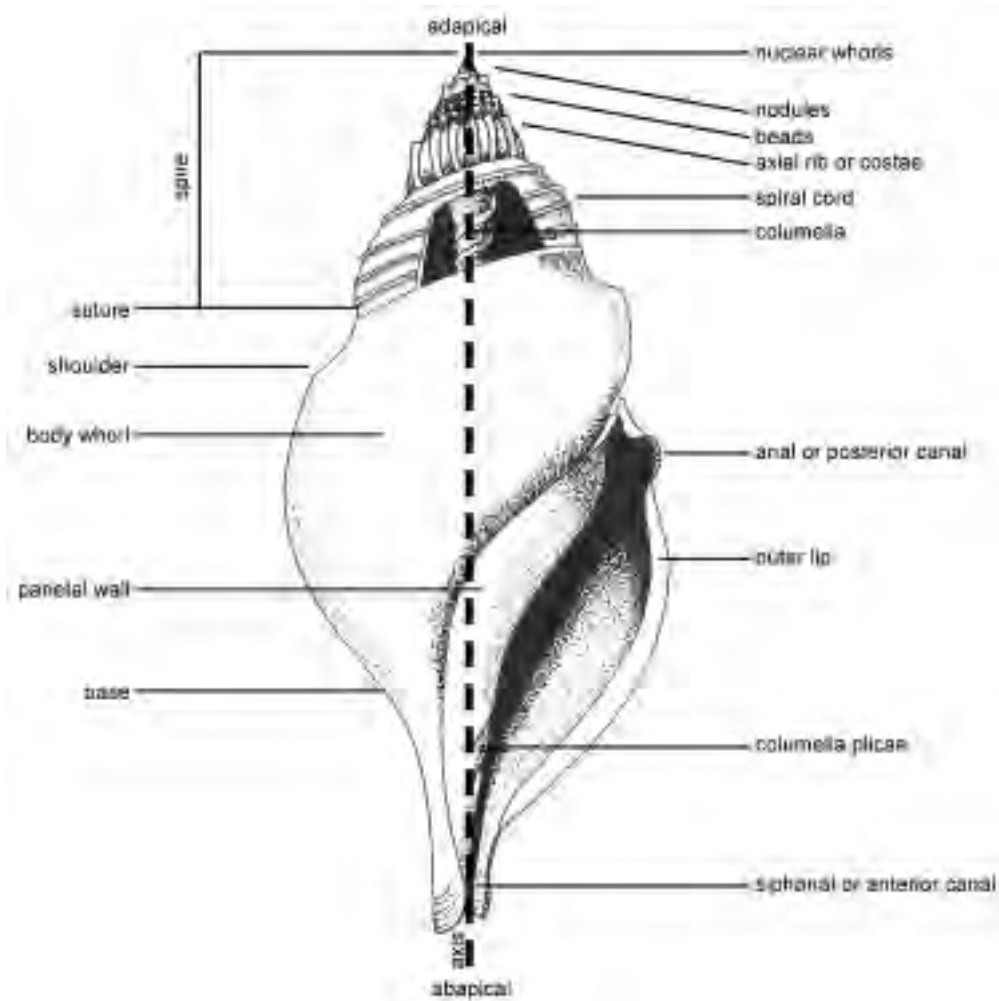


Figure 3.3 Gastropod terminology (after Andrews 1971:42; Claassen 1998:19).

Species diversity and similarity measures

In this study, the diversity of recovered shellfish assemblages was examined using two methods: the Shannon-Weaver Function (H') and Simpson's Index of Diversity ($1-D$) (Krebs 1989; Reitz and Wing 1999; Simpson 1949).

Shannon-Weaver Function:

$$H' = \sum_{i=1}^s (p_i)(\text{Log } p_i) \quad [3.1]$$

where:

H' = information content of the sample

p_i = the relative abundance of the i th taxon within the sample

$\text{Log } p_i$ = the logarithm of p_i (to base e in this study)

s = the number of taxonomic categories

High Shannon-Weaver Function values are associated with higher numbers of taxa exhibiting higher degrees of evenness in abundance across taxa. Disproportionate representation of

individuals in only a few of the same taxonomic categories will lead to lower values (Reitz and Wing 1999:105).

Simpson's Index of Diversity:

$$1-D = 1 - \sum_{i=1}^s (p_i)^2 \quad [3.2]$$

where:

D = Simpson's Index

p_i = the proportion of individuals of species i in the assemblage

s = the total number of species

This index expresses the probability that two individuals selected at random from a community will belong to different species.

Similarity coefficients between mollusc assemblages within and between sites and from different time periods were calculated using the percentage similarity measure (Reitz and Wing 1999:107-9; Krebs 1989:304):

$$PS = \sum \text{minimum}(p_{1i}, p_{2i}) \quad [3.3]$$

where:

P = percentage similarity between samples 1 and 2

p_{1i} = percentage of species i in community 1

p_{2i} = percentage of species i in community 2

Bivalve conjoin analyses

An innovative method of identifying conjoins in assemblages of bivalves was developed to examine aspects of site integrity and depositional processes in the region. Articulated live-collected and excavated specimens of *A. trapezia* were used to derive reliable criteria for identifying unarticulated valve-pairs. These criteria were used as the basis of a systematic bivalve conjoin analysis method which successfully identified valve-pairs among the unarticulated *A. trapezia* valves excavated from the Seven Mile Creek Mound. A subsequent blind test confirmed the reliability of the method. Full details are presented in Chapter 5. Valve-pairing methods were applied to all excavated assemblages in the region containing whole *A. trapezia* valves.

Vertebrate remains

All bone recovered from analysed squares was initially examined by Deborah Vale (2002, 2004). Vale separated fish remains from the bone assemblage and undertook basic characterisation studies of the fish bone assemblage including: body part representation, vertebral sizing, identification rate, number of fragments, NISP and MNI. MNI was calculated for each excavation unit, which may overestimate the MNI for the site as a whole. Fish NISP is calculated on the basis of the number of specimens identified to family or species only (Vale and Gargett 2002). Fish taxa were identified using a comparative reference collection assembled for northern New South Wales and southern Queensland and adapted for the central Queensland coast (for example, the tiger flathead, *Platycephalus indicus*, uncommon in New South Wales, was included). Owing to the limitations of the reference collection, however, Vale made taxonomic identifications to the family level only, with the exception of the bream, *Acanthopagrus australis*, which was identified on the basis of distinctive diagnostic cranial elements. Preliminary identification of non-fish remains was undertaken by Stephen Van Dyck (Mammals and Birds Section, Queensland Museum). No further analysis of this non-fish material was conducted.

Stone artefacts

Artefactual stone exhibits a range of technological and descriptive diagnostic attributes consistent with deliberate modification, transport and/or use. Technological attributes include the presence of a bulb of percussion, platform and/or point of force application. In the absence of unambiguous signs of modification or use, stone objects were classified as artefacts if they were of exotic petrological origin. Raw materials were identified by Stephen Cotter (Cooperative Research Centre for Landscape Evolution and Mineral Exploration, University of Canberra), utilising a comprehensive reference collection compiled for the region. Artefactual stone was categorised as either core, flake, broken flake, flaked piece, manuport or other. The size of each artefact was characterised to the nearest 0.1mm by measurements of the maximum length (longest longitudinal axis), width (longest lateral axis) and thickness (maximum height between ventral and dorsal surfaces) using vernier calipers. Limited use-wear and residue studies have been conducted on parts of the stone artefact assemblage. Methods employed in these studies are outlined in the relevant chapters.

Non-artefactual stone

Non-artefactual stone is lithic material native to the sedimentary context of the site with no obvious signs of modification, transport and/or use. The non-artefactual stone was weighed, but no further analysis of this material was conducted.

Charcoal

Charcoal is the carbonised remains of organic material. Samples of charcoal from most sites were subject to radiocarbon isotope analysis. The charcoal was weighed, but no further analysis of this material was conducted.

Organic material

Organic material refers to plant remains other than charcoal including roots, leaves, seeds, twigs, wood, scats, insect casings. The organic material was weighed, but no further analysis of this material was conducted.

Age-depth curves and analytical units

Analytical units for synthesising results are based on defining chronostratigraphic units for each excavated 50cm × 50cm square. Individual excavation units were assigned to 500 year intervals between 0–5,500 BP. For several sites this process is straightforward with all deposits assigned to a single 500 year interval (Seven Mile Creek Mound, Eurimbula Creek 1, Eurimbula Creek 2). For other sites, age-depth models were established based on linear regressions through available data points. Where dates are not available from a square radiocarbon determinations are extrapolated from adjacent squares where there are no obvious discontinuities in depth, sediments and stratigraphy between the units.

Summary

The generic field and laboratory methods used to investigate the archaeological record of the southern Curtis Coast are outlined in this chapter. In addition to employing well-established standard archaeological techniques, this study also employs detailed analyses of local marine and estuarine reservoir effects on radiocarbon dates to improve the accuracy of radiocarbon determinations and develops a procedure for identifying bivalve conjoins in excavated shellfish

assemblages in order to investigate aspects of site integrity. These technical studies are discussed in detail in the following chapters.