USE OF THESIS

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ABORIGINAL SHELL MIDDENS IN THE COASTAL LANDSCAPE OF NEW SOUTH WALES

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Thesis submitted for the degree of Doctor of Philosophy in the Department of Prehistory and Anthropology, Australian National University

April 1982
Except where otherwise stated in the text this thesis is entirely the product of my own research

Marjorie Sullivan
This thesis is concerned with the nature and distribution of prehistoric Aboriginal shell middens in the coastal zone of New South Wales. As such it is a study in landscape archaeology in which the relationships between the contents and locations of shell middens and the physical environments of coastal New South Wales are considered.

Shell middens are investigated within a framework of landscape units in which the New South Wales coastline is divided into four regions, based on geological structure. Eight hundred shell middens recorded over the entire length of the coastline have been used to analyse patterns of content, dimensions, locational variables and distribution with respect to these landscape units. From the results of this analysis it is argued that there are strong relationships between shell middens and the landscapes in which they occur, and that the coastal landscape has to a considerable extent influenced coastal prehistory.

Because this overview of sites takes no account of different temporal patterns, nor of the degree of site destruction through time, more detailed studies are included to examine these aspects. In addition for the far south coast, where no detailed archaeological investigation had been carried out previously, a shell midden was excavated. The results of this excavation relate to a number of issues raised within the general overview. These include the relationship between sites in the far south of the coastal zone and those further north, and the change in shell species which is commonly recorded in sites belonging to the recent prehistory of southern New South Wales.

The conclusions of the study are wide ranging. There is a strong relationship between shell middens and coastal landscapes. In terms of both landscape and archaeology there is a broad division of the coastal zone into a northern and a southern section. Shell midden sites in the north are characteristically estuarine and beach middens, with estuarine sites showing a marked use by their occupants also of terrestrial food resources. Sites in the south are characteristically
rocky shoreline middens reflecting an economy heavily dependent on shellfish and fish. Estuarine sites in the south, like those to the north, also commonly show a marked use of terrestrial resources.

Sites on the far south coast are also shown to be similar to those from slightly further north including the Sydney region. These similarities encompass their nature, contents, broad chronology and specific locational factors.
ACKNOWLEDGEMENTS

In many ways this is the most difficult part of any thesis to write, and it is the section to which most of those who read the thesis (and many who will not) will turn first, largely to see if I have really recognised and appreciated the help I have been given. Much of this I certainly do recognise, and I particularly hope I have not overlooked anyone who is unforgiving.

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CHAPTER 1

INTRODUCTION: A LANDSCAPE APPROACH TO COASTAL ARCHAEOLOGY.

THE AIM OF THE STUDY

Shell midden sites are by far the most common archaeological deposits in the coastal zone, and along the New South Wales coastline (Fig. 1-1) there are large numbers of such sites exhibiting a wide range of different characteristics. The broad aim of the study is to test whether there are relationships between coastal shell middens and the characteristics of the landscape in which they are set, and if so to define and explain these relationships. This is therefore a study of landscape archaeology in coastal New South Wales.

The term landscape archaeology is used here to express the concurrent study of archaeological sites and the landscapes in which they occur, on the assumption that the physical landscape will have had a determining effect on both the distribution and the nature of the sites (see Vita-Finzi 1978). Some degree of correlation has previously been shown to exist between the nature and locations of shell middens in southern coastal New South Wales and the landforms on which they have accumulated (Sullivan 1976). One aim of this study is to explore further the relationships suggested by that survey and also to extend the investigation to other parts of the coastal zone.

An Approach Using Spatial Analysis

Studies of landscape archaeology or geoarchaeology (as defined by Shackley 1975, Davidson and Shackley 1976 and Hassan 1978, 1979) involve theories and methods derived from the earth sciences, as well as those of archaeology, to answer archaeological questions. Such studies are concerned with archaeological sites in their settings, and combine aspects of both environmental and spatial archaeology (Butzer
Fig. 1-1. Location of the study area
While geographic techniques of spatial analysis have proved valuable in other studies of the distribution of archaeological sites (Hodder and Orton 1976), their usefulness in this case is limited by both the geographic setting of the study area and the nature of the data used. The general distribution of shell middens is one of very large sites interspersed among smaller middens, and is reminiscent of central place hierarchies (Christaller 1933). Central place theory however is not appropriate to apply in considering the distribution of these sites since the assumptions on which it is based are not applicable to hunter-gatherer communities in a real landscape, and particularly not to one specific site type such as shell middens. Spatial models such as those of von Thunen (1826), Losch (1940) and Chisholm (1968), which are based on a pattern of distribution of rural settlements are similarly inappropriate. All these models derived from the distribution of agricultural settlements, and all are based on the concept of geographic uniformity (distribution within a featureless plain), and the assumption that locational decisions are based on market economics.

Such techniques have been used effectively in considering patterns of archaeological site location, for instance by Irwin (1973), but in that case the sites under consideration were contemporaneous trading villages. The location of hunter-gatherer sites however is likely to be affected largely by the proximity of resources, not market considerations; these resources are strongly influenced by the nature of the landscape which itself varies.

There are also several reasons why the data used in this study are not an appropriate basis on which to undertake statistically-based spatial analyses. Point pattern analytical techniques such as simple Poisson probability distribution or nearest neighbour analysis, have been used successfully to analyse distributions of contemporaneous archaeological sites in Britain (Newcomb 1970, Hodder 1977), and also of working areas within sites (Whallon 1973, 1974). These techniques can be applied most successfully where sites which are contemporaneous are distributed over an area without firm boundaries (see Newcomb 1971). For a number of reasons (expanded below) these conditions do not apply to this study area; the shape of the area, the lack of comprehensive data on spatial distributions of middens, and the lack
of chronological control.

The study area consists of a long strip of land bounded by the coastline and the upland ranges. Its boundaries are fixed firmly, especially on the seaward margin. Moreover sites beyond the limits of the coastal zone may well be important for interpreting patterns of land use at any time in the past. Such sites have been excluded from the analysis by the nature and terms of this study.

Except for a few areas, very little intensive systematic survey has been carried out to provide the necessary quality of spatial data upon which such techniques might be applied. Many sites have been destroyed by natural and human agencies, and even thorough surveys will not necessarily lead to a complete picture of former site locations.

It is likely that most shell middens now visible on the landsurface date from the relatively recent prehistoric past, and excavations have shown that shell in all but very large, densely packed open sites does not tend to survive for more than a few thousand years. The sites whose locations are mapped in the National Parks and Wildlife Service site register, and which were used in this study, are likely therefore to be mainly of recent prehistoric age, probably less than 1,000 years old. Even this narrow time span however does not allow assumptions to be made concerning the contemporaneity of their occupation. Short of a major systematic programme of dating the commencement and cessation of use of these sites, there is no foreseeable solution to this problem. Spatial analysis of sites is only worthwhile if it provides information on human behaviour, and little can be gained in this aspect by analysing patterns of site locations if it is not possible to establish temporal patterns.

It therefore became apparent in the initial stages of planning this project that the use of techniques of spatial analysis was likely to be inappropriate. For this reason a broadly-based landscape approach to the archaeology of coastal New South Wales was chosen - one in which midden sites were considered in their landscape setting.
A Landscape Archaeology Approach

This study does not set out to test theoretical models of hunter/gatherer behaviour, such as those proposed by Lee and De Vore (1968), Jochim (1976) or Wood (1978). Theories such as these however are important in developing concepts of patterns of prehistoric landscape use. Jochim (1976:74) borrowed heavily from spatial geography in generating his gravity-based model to predict that hunter/gatherer sites will be located closer to less mobile and more dense resources than to others. Such concepts are involved in any study concerned with describing the nature and distribution of a group of sites in this instance shell middens, in a varied coastal landscape.

While concerned with the distributions of sites in a landscape, this study does not involve modelling relationships between sites, but rather the relationships between sites and environments. In its conception therefore, this project is a study in environmental archaeology as expounded by Butzer (1971:Chapter1). It is concerned with the prehistoric geography of people and land, and can be described (Butzer 1971:10) as "environmental reconstruction as applied to an understanding of the ecological setting to prehistory" for coastal New South Wales.

ORGANISATION OF THE THESIS

This chapter is an introduction, not a literature review. Reviewing the literature on shell middens would be a major undertaking, since shell middens (which as archaeological deposits are made up entirely of the products of human activity) have been the subject of a very large number of archaeological studies. The existing literature however is generally not directly relevant to the present study.

Most archaeological studies on shell middens have been directed towards specific aspects such as sampling methodology (e.g. Treganza and Cook 1948, Cook and Treganza 1948, Heizer and Cook 1956), and this literature has been reviewed thoroughly by Barz (1977). Other specific aspects of concern have been the analyses of shell middens to reconstruct diet in terms of total food value (e.g. Cook 1946, Bailey...
1975, Meehan 1977), cultural behaviour (e.g. McIvor 1974, 1982, Bowdler 1970, 1979), or issues of seasonality of resource use (e.g. Rowland 1977, Luebbers 1978, Mellars and Wilkinson 1980).

In this study, shell middens have been considered as sites of a particular type which were likely to reflect directly both the way in which prehistoric people used the resources of the landscape in which they are set, and the way in which the physical environment in turn set limits on the nature of such use, and on the locations of sites within it. Not only are they archaeologically very visible, their contents reflect the use of resources from the surrounding landscape, often over considerable periods of time. With their generally compact structure, and the durability of the dominant component (shell) they have tended to survive both longer and in better condition than other archaeological deposits along the coast.

The study is organised in five parts, some of which contain more than one chapter, and the structure of the thesis is as follows:

* Part I, Chapter 2, is a description of the coastal landscape of New South Wales. This chapter sets a background against which the nature and distribution of coastal archaeological sites can be considered. The chapter outlines the physical setting of the coastal zone, with particular reference to factors affecting archaeological sites. The coastline is divided into four zones on the basis of geological structure, and landscape features are considered within each zone. Emphasis is also placed on marine ecology within each of three broad coastal landscapes; rocky shoreline, estuarine and beach.

* Part II, Chapters 3 and 4, is a general statistical analysis of shell midden sites and their landscape settings, and an explanation of the patterns defined. Aspects of shell middens which are considered in this analysis are the nature, structure and contents of the sites, and locational factors such as distance from water, position in the landscape, and aspect. Because the quality of the data is very variable, this analysis is of a general nature, aiming to identify trends or patterns, not to quantify these. The results of the analyses are a series of empirical statements derived from cross-correlating site and locational variables; archaeological explanations are sought for the patterns identified.
The nature and distributions of sites are considered for the entire coastal zone, and within each of the four coastal regions. It is recognised that the broad patterns identified are derived from the archaeological landscape which now exists, and this provides no indication of changes through time or the rate of survival of sites.

* Part III, Chapter 5, concentrates on relating aspects of the patterns identified in Part II to particular sites and landscapes. This chapter points out the need for more investigation of factors identified from the statistical analyses. The chapter is divided into three parts, north coast sites, south coast sites and offshore islands. Within the two northern regions of the coastal zone particular sites which typify the patterns established in Part II are considered in more detail. Aspects of the changes through time and the ethnohistorical information available for the area are compared with the results of the overview from Part II.

For the south coast the archaeological information is very uneven. Detailed studies have been carried out in the Sydney region and in the northern part of the south coastal area, but not for the far south coast. These detailed studies are reviewed briefly. Subsistence models derived from ethnohistorical and archaeological data are considered in the light of more general evidence from the overview in Part II. Additional detailed work on the far south coast is followed up in Part IV.

For offshore islands very little is known. The analysis of broad patterns therefore does not contribute to explanations of their prehistory. The few detailed studies which exist however have been followed up to elucidate island prehistory and to raise additional questions concerning the relationship between mainland and island sites.

* Part IV, Chapters 6, 7 and 8, is concerned with detailed studies on the far south coast within a framework of landscape archaeology. Chapter 6 is a very short chapter introducing the two more detailed studies which follow, and raising one major problem of cultural change in south coastal sites, namely the recent prehistoric dominance of edible mussel in midden shellfish assemblages. Similarities and differences between sites in the far south of the coast and those from better studied areas to the north are discussed.
In Chapter 7 the results of a survey of two estuarine shorelines in southern New South Wales are presented. They are relevant to a consideration of survival of sites through time, and to aspects of site management. Chapter 8 is an excavation report, describing the analysis and archaeological implications of the investigation of one of the sites recorded in the survey described in Chapter 7. Aspects of cultural change and the relationships with sites further to the north are also considered.

* Part V, Chapter 9, concludes the thesis. Information from more detailed investigations is related to that obtained from a general overview, and aspects of cultural change are summarised and discussed. In addition it outlines three lines of future research which have been identified from this study.
CHAPTER 2

NEW SOUTH WALES COASTAL ENVIRONMENTS

Rifting during the Cretaceous Period (60-80 million years ago) associated with the formation of the Tasman Sea and the accompanying uplift of the eastern uplands created the southeastern Australian continental margin (Hayes and Ringis 1973). Past and present coastal landforms are a result of processes acting since that time, especially sealevel fluctuations, coastal erosion and wave and wind sedimentation.

Sealevel changes have occurred throughout the Quaternary as a result of episodic glaciations, but there is good evidence that along the coast of New South Wales sealevel has stood at or just slightly above its present position only twice during this time (Marshall and Thom 1976), and that a continuing overall very slow rise in sealevel results from the slow subsidence of the continental margin of southeastern Australia which has occurred throughout the Cenozoic Era (Roy and Thom 1975, Thom and Roy n.d.). This slow subsidence is likely to account for the removal of any depositional landform features such as dunes and barriers which may have existed prior to the high sealevel stand of about 120,000 to 140,000 years ago (Thom and Chappell 1975, Marshall and Thom 1976), as all depositional landforms along this coastline have formed since that time.

In a recent study of coastal lands of Australia (CSIRO 1980, Galloway 1981) Galloway measured the length of the Australian coastline as 33,000km, and that of New South Wales as 1,800km (using a divider intercept of 0.7km) by arbitrarily measuring around only those coastlines of estuaries and lagoons with mouths wider than 1km. He defined the coastal zone as an area of land around the coastline 3km wide, or to the landward margin of coastal dunes and estuarine sediments, if these extend inland further than 3km. In New South Wales this zone embraces approximately 6,000 sq.km, and encompasses a diversity of landscapes, including beach complexes, dune systems,
estuarine embayments, major river floodplains and rocky shorelines. This coastal zone is basically the area of the present study.

In this chapter a description of the New South Wales coastal zone is given. One aim of the study is to relate archaeological sites and site locations to landscape, so an independent system of describing the coastal zone has been used. This description is based on the geological structure of the New South Wales coastal zone, and landform complexes are described in terms of the underlying structural units. Emphasis has been given however to landforms or landscapes as they would have affected prehistoric land use, particularly food gathering activities, so the association between landforms and coastal ecosystems has also been covered in some detail.

STRUCTURAL REGIONS OF THE COASTLINE

There is considerable variation in coastal landforms along the New South Wales coastal zone, which may be correlated broadly with the underlying geological structure. In structural terms the New South Wales coastline extends from Cape Byron in the north to Mallacoota Inlet in the south (Fig. 2-1), and follows the trend of the structural lineament of the rifting and alignment of the eastern uplands. There are four structural regions in eastern New South Wales which determine the configuration of erosional landforms along the coastline. These regions are: the Clarence-Moreton Basin, the New England Fold Belt, the Sydney-Bowen Basin (referred to hereafter as the Sydney Basin) and the Molong-South Coast Anticlinorial Zone of the Lachlan Fold Belt (referred to hereafter as the Molong-South Coast region) (see the 1:500,000 Geol. 1 Sheet of New South Wales). The following detailed description of each of these regions has been derived from geological sheets at various scales, and from field observations.

The northernmost structural region, the Clarence-Moreton Basin is a broad synclinal basin capped predominantly by Cretaceous sandstones at its centre with underlying Jurassic and Devonian sandstones exposed on its southern rim. In the north flows of Tertiary basalt cover a considerable proportion of the sedimentary sequences, but some Devonian sandstones are exposed in the northern coastal area. The Basin is truncated at the coastline immediately north of Brooms Head, but inland extends south as far as the latitude of Woolgoolga.
Fig. 2.1 Structural regions of the New South Wales coastline and places named in the text.
Structural lineaments, which are not well developed, trend approximately north-south, giving rise to weakly structured flat-lying coastal rock platforms mainly on sandstones.

The New England Fold Belt is an arc of uniform width comprising highly differentiated dipping rocks, and a narrow outlier along the coast between Woolgoolga and Brooms Head. This structural region extends approximately to the southern headland of Port Stephens, around Anna Bay. The southern boundary is difficult to define clearly as the area is thickly mantled with sand and little rock outcrop occurs along a long stretch of the coast. Structural lineaments are well developed and complex, with a dominant northeast to southwest trend, and these have a major control on erosional landforming processes. Outcropping Devonian and Permian sandstones are common along the coastline with some Permian acidic igneous rocks and occasional Tertiary gravels. The sedimentary rocks are generally steeply dipping, reflecting the folded and faulted nature of the region.

The Sydney-Bowen Basin is a broad geosynclinal basin which has filled gradually with near-shore marine or terrestrial sediments, and is predominantly capped with Triassic sandstones and shales. The Basin extends from Port Stephens in the north to Wasp Head in the south and over the wide central part, between Broken Bay and Wollongong, these rocks are generally virtually flat-lying, while on the rim of the Basin to the north and south underlying Permian rocks are exposed and there is a gentle dip towards the Basin centre. Structural lineaments are poorly developed and trend slightly east of north to west of south. Thus local bedrock jointing is the main control on erosional landforms through most of the area. Near the centre of the geosyncline the outline of Botany Bay is structurally imposed by the warping. On the southern rim of the Basin local faulting has influenced the outline of Lake Illawarra, and local folding has produced Jervis Bay and strongly determined the form of the surrounding landscape.

The Mylong-South Coast Anticlinorial Zone of the Lachlan Fold Belt is a narrowly contained north-south aligned belt comprising mainly a complex of Ordovician shales and Devonian sandstones and igneous intrusive rocks. The broad Fold Belt which forms a north-northwest to south-southeast trending upland zone shows strong structural lineaments intersecting the coastline at a low angle. Flows
of Tertiary volcanics and emplaced coarse igneous rocks are commonly exposed along the coastline, as are sandstones and shales. Cappings of Tertiary gravels and silcretes also occur in this region and thus coastal outcrops vary considerably in their form and nature.

PRESENT COASTAL LANDFORMS

The coastal landscape of New South Wales is dominated by depositional landforms. These include barriers, dunes, beaches and floodplains. Other landforms, such as estuaries and bays are partly depositional and partly erosional in origin, while erosional features of rocky shorelines make up a small proportion of the coastal landscape.

These landforms are described here in some detail, as landform types, not within the framework of structural units. Particular emphasis however is given to a consideration of the relationship between landscapes and shellfish ecology, and to the relationships between landforms and archaeological site occurrences.

Barriers

Depositional landforms comprising mainly sandy barriers and associated dunes make up a large proportion of the coastal landscape. These landforms developed mainly as a result of sea level changes and consequent changes in the depositional environment. Such landforms have been studied intensively and there is a considerable body of literature describing their form and development (e.g. Thom 1965, 1974, Hails 1968, Langford-Smith and Thom 1969, Thom, Hails and Martin 1969, Shepherd 1974, Thom, Polach and Bowman 1978, Thom and Roy n.d., Thom et al 1981a and b, Roy and Thom 1981).

Most of the coastal embayments of southeastern Australia have been partly filled by, or partly or completely enclosed by sand barriers in the last 120,000 to 140,000 years. North of the Hunter River, i.e. in the Clarence-Moreton Basin and New England Fold Belt regions, two separate barrier systems can be identified. The Landward Inner Barrier formed during the last interglacial 120,000 to 140,000 years ago (Marshall and Thom 1976) and the Outer Barrier is Holocene...
in age. South of the Hunter River in the Sydney Basin and Molong-South Coast region only Holocene barriers have been identified (Thom and Roy n.d.) although narrow bands of sediments of last interglacial origin occur beneath recent sands close to the present coastline.

In general the Inner Barrier system comprises a series of ridges which, through the removal and remobilisation of sand over time are now of low relief, and are commonly separated by swampy swales. These Inner Barrier sands have generally undergone a considerable degree of soil formation, mainly podzolisation, and strongly bleached A horizons over yellow to brown B horizons are common. Outer Barrier beach ridges are mostly higher, with 3 to 6 metres of local relief, and the swales are not swampy. Outer Barrier deposits may lie shorewards of the Inner Barrier sands or may be superimposed on them, giving rise to a complex series of landforms. Sands of the Outer Barrier deposits are generally pale yellow to pale brown, and do not show the high degree of bleaching or profile differentiation common to the Inner Barrier deposits. Most barriers studied in detail however, have been shown to have reached their present form during the Holocene (Thom et al 1981a). Of six areas studied in detail by Thom and his colleagues, four had achieved most of their barrier width by 4,000 years ago, and the other two since then. Hence during the time of human occupation there have been major changes in these landforms. These changes have been described by Thom et al (1981a) as more in the nature of "...local...changes in rates of progradation, superimposed on a broad regional trend."

Bay barriers have been classified and described by Thom, Polach and Bowman (1978), who distinguish three types composed of marine sand facies: prograded, stationary and receded barriers, and a fourth type composed of aeolian sand: the episodic transgressive dune barrier. Their classification and associated stratigraphic profiles are shown in Fig. 2-2.

1. **Prograded bay barriers** have built seawards as a series of beachridges. Transgressive sand which moved onshore ahead of the rising sealevel prior to 6,000 years ago is overlain by a regressive sand wedge comprising multiple beachridges. Generally only one barrier is present, e.g. at the Fens Embayment, Woy Woy, Moruya, Wonboyn (Fig. 2-3), but in three localities (Nambucca Heads, Stuarts Point and
<table>
<thead>
<tr>
<th>TYPE</th>
<th>MORPHOLOGY</th>
<th>STRATIGRAPHY</th>
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<tr>
<td>1a PROGRACED BARRIER</td>
<td>Beach ridges</td>
<td></td>
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<tr>
<td>1b PROGRACED BARRIER</td>
<td>Two barriers</td>
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<td>2a STATIONARY BARRIER</td>
<td>Low foredune</td>
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<tr>
<td>2b STATIONARY BARRIER</td>
<td>High foredune</td>
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<td>2c STATIONARY BARRIER</td>
<td>Tombolo-like</td>
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<td>3 RECEDED BARRIER</td>
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<tr>
<td>4a EPISOIC TRANSgressive</td>
<td>Parabolic dunes</td>
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<td>4b EPISOIC TRANSgressive</td>
<td>Long-walled transgressive,</td>
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Fig. 2-2. Types of Holocene bay barrier (from Thom Polach and Bowman 1978)
Fig. 2.3 Localities named in the text
Narooma) twin barriers occur where the two Holocene barriers are separated by shallow water subject to strong tidal and river currents.

2. **Stationary bay barriers** comprise a single ridge which has not migrated seaward or landward since the sea reached its present level. The ridge is commonly backed by a sandy flat and shallow lagoon. Stationary mid-bay or bayhead barriers with a low hummocky vegetated foredune are common on the New South Wales coast, e.g. at Coffs Harbour, Burrill Lake, Durras Lake, Merrimbula. A large complex stationary barrier occurs at Tabourie, made up of a high partly stabilised foredune. Similar tombolo-like stationary barriers are also found linking bedrock "islands" at Barrenjoey and Gurrarong.

3. **Receded barriers** are rare in Australia and are characterised by outcrops of lagoonal or tidal flat clays or freshwater peats exposed as the barriers have migrated landward. Examples occur at Crescent Head, Fingal Bay, Dee Why and Bermagui.

4. **Episodic transgressive dunes** form barriers when they block drainage and enclose coastal lagoons. These features are best developed in south or southeast facing embayments. Two sub-types are distinguished on the basis of dune morphology: parabolic dunes as at Eurunderee and long-walled transgressive dunes as at Bhrwerre.

Thom (1978) suggested that barrier development has been episodic, with a high proportion of marine sand deposition occurring around the time that sealevel reached its present position about 6,000 to 5,700 years ago. Two or three other phases of accretion have occurred since that time, particularly during the 6,000 to 3,000 years B.P. "stillstand" phase during which sealevel oscillations were negligible (Thom and Chappell 1975).

As depositional features barriers have undergone enormous changes since sealevel began to rise after the end of the last glaciation. These changes will have affected their forms and locations over the time of Aboriginal occupation of the coastline, as well as the nature and location of associated swamps and other sources of water. Because of the changes which have occurred, archaeological sites on barrier deposits will in many instances have been destroyed. This is specially true of older, i.e. mid-Holocene, barriers.
Dunes

Coastal dunes occur on all types of barrier, especially towards the north of embayments where beachridge orientation has permitted maximum exposure to southerly and southeasterly winds. Two commonly occurring types of dune system are described by Thom and Roy (n.d.): transgressive dunes and free-moving dunes.

1. Transgressive dunes include both parabolic dunes and the long-walled advancing fronts of migrating sand sheets which have been driven in the direction of the effective wind over pre-existing stable surfaces. These dunes may be fixed by vegetation or be currently mobile. They commonly reach heights of 35m, and the largest transgressive ridges, near Myall Lakes, are up to 100m above sealevel.

2. Free-moving dunes are mobile secondary dunes formed on an active sand sheet. These dunes change their alignment with changes in local or seasonal winds.

Both types of dune may occur on any barrier system. Some are now fixed by vegetation while others are re-activated or newly active. Thom (1978) noted that phases of dune activity are poorly dated and appear to be very variable, however two major periods of transgressive dune activity can be recognised. The earlier period relates to transgressive dune encroachment ahead of the rising sealevel, mainly between 6,000 and 10,000 years ago. During this period sealevel off the southeastern Australian coast rose about 30m at 10-15mm per year (Thom and Chappell 1975) triggering sand mobilisation across the exposed shelf. Embayments in which such dunes occur are characteristically exposed to southerly winds, and are near the eastern ends of bedrock promontories which probably acted as sediment traps during times of lower sealevel. A second period of dune activity occurred during the sealevel stillstand after 3,000 years B.P. when barrier surfaces were reworked by aeolian processes (Thom, Polach and Bowman 1978). Exposed southerly facing bays were most commonly affected by this phase of activity.

As is the case for barriers, dunes are mobile and dynamic, and the rate of survival of archaeological sites in dune systems will be determined by the processes of sand movement over time. Dune systems
were important in determining the locations of sources of fresh water, and in other considerations of archaeological site locations.

Beaches

Beaches form on bay barriers in response to wave action, sediment supply and offshore slope profile (see e.g. Bird 1972). The southeastern Australian coast is dominated by a moderate to high energy east coast swell (Davies 1964) which influences the form of waves and the direction of wave action. Short (1978a, b) has developed a six-stage model for beach form based on accretionary and erosional stages of beach development, and has shown that given no removal of sediment from the system that beach stage can be predicted on the basis of deepwater swells, breaker wave power and offshore slope.

On an annual basis about 70% of swell waves reaching the New South Wales coast are from the southeast (Short 1978a). The coast is oriented east-southeast causing the predominant southeasterly swell to run up the coastline slightly refracted. Dominant high deepwater waves are controlled by tropical cyclones and offshore low pressure zones during summer, with variable wave intensities but a predominantly southeasterly swell during winter in response to more distant storm disturbances across a considerable ocean fetch (Lawson and Abernethy 1975, Short 1978b).

In general decreasing breaker wave power leads to onshore bar migration, beach accretion and reflective surfzone conditions. Increasing wave power generates beach erosion, bar-channel formation and dissipative surfzone conditions (Short 1978a). Beach stage is thus a response to these conditions, and on an annual basis for any beach there will be a modal stage which reflects the orientation of the bay to modal wave action. Hence over a long time beach form and condition is predictable and broadly stable.

In terms of prehistoric food gathering long sandy beaches were an important source of the bivalve shellfish, pipi (Plebidonax deltoidea). Like dune dynamics, the processes of beach progradation and erosion are very important to site survival, and the activities of storm waves along beaches have been shown to be very important to a consideration of marine re-working of shell middens (Hughes and
Sullivan 1974).

Deltaic Floodplains

In the two northern structural regions of New South Wales and in the Shoalhaven Valley of the Sydney Basin, the coastal plains are dominated by large river systems such as the Richmond, Clarence and Macleay, which Hails (1968) noted do not form offshore deltas, but instead occupy the area between the ancient bedrock coastline and the coastal barriers. He used the term deltaic floodplain for the lowermost reaches of these systems, and noted that they are characterised by relict meander belts, levees, point bars and flood basins (sumps). Thom and Rov (n.d.) comment that these areas are dominated by terrestrial processes and distinguish five different environments within deltaic floodplains.

1. **River channel environments**, where flood flow is the major depositional agent, include point bars of gravel and sand and the beds of rivers and distributary channels.

2. **Floodplain environments** consist of terrestrial muds (silts+clays) and sand on levees and crevasse splays and muds in sump basins.

3. **Delta front environments** where shelly muds and sands are deposited in estuaries behind bars at the mouths of distributaries, or behind levees. Flood sediments are reworked by tidal currents and locally generated waves.

4. **Freshwater swamp and lake environments** where organic muds and peats accumulate in backplain areas.

5. **Dunes and aeolian sand sheet environments** where locally sand is mobilised from point bars or older marine deposits.

Particular biological communities are specifically related to each of these environments, and each was important as a source of particular shellfish or other aquatic resources in prehistoric times. Deltaic floodplains are dynamic landform complexes, and the particular
locations of archaeological sites and their likelihood of survival over time are closely related to changes within the floodplain.

Estuaries

Estuaries are important features of the New South Wales coastline, and their forms vary considerably as do their biotic components. Pritchard (1967) defined an estuary as "...a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage." Thom and Roy (n.d.) distinguish and describe four types of estuary: floodplain estuaries, bedrock controlled ria-like or bay estuaries, estuarine lakes or lagoons and interbarrier channel estuaries, and their distribution along the coastline reflects differences in structure and lithology and the consequent size of coastal rivers.

1. Floodplain estuaries are the lowermost tidal zones or delta front environments of rivers and are characterised by terrestrial sediments deposited from the rivers, except where marine sands form shoals at the mouths. Their bed sediments are commonly fine sands or muds (silts+clays), and shellfish communities adapted to these conditions are common on their beds or where mangroves provide a firm substrate along the banks.

These estuaries are characteristic of the Clarence-Moreton Basin and New England Fold Belt, and include the lower reaches of the deltaic floodplains of the Tweed, Richmond, Clarence, Macleay, Manning and Hunter Rivers, as well as the Shoalhaven River within the Sydney Basin.

2. Bedrock controlled estuaries are of two types:

2a. Ria-like estuaries which occur where steep narrowly incised bedrock valleys have been drowned by rising sea level. The shorelines are generally rugged and rocky and the mouths are located between rocky headlands. Such estuaries are generally deep, with terrestrial sediments deposited along their beds.
Tidal currents and fluvial discharge are the dominant hydrodynamic processes, with the effect of ocean waves attenuated within three kilometres of the open sea. Within such estuaries the upper reaches commonly support shellfish on the beds or attached to mangroves along the banks, while closer to the mouths low wave energy marine rock platform communities are common on rocky outcrops and tidal mudflat shellfish are found in local embayments.

These estuaries are characteristic of the central part of the Sydney Basin and include Broken Bay, Sydney Harbour and the Georges River and Port Hacking estuaries, as well as the Clyde River estuary, Wagonga Inlet and Wallegra Lake in the Molong-South Coast region.

2b. Bay estuaries which are broader basin shaped drowned valleys, developed as a result of structural control of the valley form. The combined effects of wide bay mouths, rocky shorelines and low discharge streams result in embayments in which ocean waves and tidal currents are the dominant influences, and marine sands form the bed sediments. Sandy bays, muddy basins, tidal flats and rocky headlands occur around the shorelines of such embayments, resulting in the local availability of shellfish communities characteristic of each of these environments.

Botany Bay and Jervis Bay within the Sydney Basin are of this form, as is Twofold Bay in the Molong-South Coast region.

3. Estuarine lakes or lagoons are broad open water bodies generally elongated parallel to the coast and impounded behind coastal barriers. They are commonly situated in terrain of low relief where small valleys which coalesce near the coast are drowned. The coastward barriers may be kept open by a tidal inlet, but in the case of smaller lakes the barrier may be periodically closed. Salinities vary considerably depending on stream inflow and tidal exchange.

These lakes are generally shallow, depths rarely exceeding five metres, with beds of shelly or organic muds. Sandy sediments are deposited in the deltas of tributary streams and against the barriers, and these sediments may be redistributed by locally generated waves or by tidal currents. Muddy flats and beaches, sandy beaches and occasional rocky outcrops are the main micro-environments supporting associated characteristic shellfish suites.
Large estuarine lakes such as Port Stephens, Wallis, Myall, Tuggerah, and Illawarra Lakes and St. Georges Basin are typical of the southern part of the New England Fold Belt and the rim of the Sydney Basin. Smaller estuarine lakes such as Coila, Tuross, Mummuga, Wapengo and Kianga are typical of the Molong-South Coast region.

4. **Interbarrier channel estuaries** are small shallow tidal creeks elongated parallel to the coastline and draining back-barrier swamps or interbarrier depressions. They are frequently blocked by sand barriers, and the beds are generally sandy. Because of their small size and the restricted range of micro-environments, they support a limited range of aquatic plants and shellfish species.

These estuaries are associated particularly with the presence of an inner barrier deposit and thus occur in the Clarence-Moreton Basin and the New England Fold Belt. Examples are the lower Myall River and Wooli River. Similar but less well-developed features occur within the Holocene and recent dune sand of the Molong-South Coast region, where swampy depressions behind the foredunes are blocked by sand barriers e.g. near Tilba Tilba.

**Rocky Shorelines**

Erosional landforms along the coastline are less varied than depositional forms, but are also important in considering prehistoric land use. The diversity of rocky shoreline features is determined mainly by differences in lithology, which is itself a function of geologic structure. Rocky shorelines fall into two broad categories, those bounded by cliffs to the water's edge, and those with fringing shoreline reefs or rock platforms. Clearly the reefs and platforms are the major source areas for shellfish, and the diversity in the form of coastal rock platforms (a term used here to include reefs, ramps and boulder talus accumulations) has been considered further in an attempt to differentiate between the types.

Galloway and Bahr (1979) have shown that a statement of coastline length is entirely proportional to the map scale used, and the method of measuring the intercepts, and that no truly accurate statement of length is possible. Proportions however, measured in a similar way are more likely to be accurate, and length estimates for different
purposes require different degrees of accuracy. For the Australian coastline (including the major offshore islands) Galloway and Bahr (1979:246) arrived at estimates of 24,330km using an accuracy equivalent to a divider intercept of 100km, and 69,630km if the accuracy is equivalent to an intercept of 100 m. For most purposes where maps form part of the data, including this present study, an accuracy equivalent to their 100km intercept is adequate. Their exercise however highlighted the problem of comparing population density estimates (either of people or shell middens per length of coastline) derived from different studies or using different scales.

The length of coastline studied between Tweed Heads and Mallacoota Inlet was measured from 1:500,000 geological maps using a revolution counter. The estimated length of this coastline was 1885km, and this compares well with the estimate of 1800km (Galloway, pers. comm. 1980) using a 100km divider intercept. This length was broken down into the categories of rock type recorded on the site data sheets (see Chapter 3), and the lengths and proportion of coastline for the entire coast, and for each structural region are shown in Table 2-1.

**Rock Types**

In this categorisation several terms are used broadly to include rocks with similar weathering or breakdown characteristics in exposed outcrops.

**Sandstone** covers the range of arenaceous sedimentary rocks which occur along the coastline as massive jointed outcrops. These include quartzose sandstones, lithic sandstones, quartzitic sandstones, greywackes and tuffs.

In the Clarence-Moreton Basin these include a range of Devonian, Jurassic and Triassic sandstones, greywackes and tuffs. A number of different types of Devonian, Carboniferous, Permian and Triassic rocks are represented in the New England Fold Belt. Those in the Sydney Basin are mainly Permian and Triassic quartzose sandstones with some silty sandstones and occasional outcrops of poorly consolidated Cainozoic sandstones on the Basin rim. In the Molong-South Coast region Devonian quartzose sandstones are the dominant rocks of this type.
<table>
<thead>
<tr>
<th>Bedrock outcrop on coastline</th>
<th>Clarence-Moreton Basin</th>
<th>New England Fold Belt</th>
<th>Sydney Basin</th>
<th>Molong-South Coast</th>
<th>Total Coastline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length(km)</td>
<td>%</td>
<td>Length(km)</td>
<td>%</td>
<td>Length(km)</td>
</tr>
<tr>
<td>Sand</td>
<td>170 (83)</td>
<td>380 (71)</td>
<td>250 (34)</td>
<td>75 (18)</td>
<td>875 (46)</td>
</tr>
<tr>
<td>Sandstone</td>
<td>20 (10)</td>
<td>95 (18)</td>
<td>350 (47)</td>
<td>130 (32)</td>
<td>595 (32)</td>
</tr>
<tr>
<td>Shale</td>
<td>5 (2)</td>
<td>7 (1)</td>
<td>80 (11)</td>
<td>145 (36)</td>
<td>237 (13)</td>
</tr>
<tr>
<td>Coarse acidic</td>
<td>-</td>
<td>-</td>
<td>15 (3)</td>
<td>-</td>
<td>20 (5)</td>
</tr>
<tr>
<td>Coarse basic</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>25 (3)</td>
<td>15 (4)</td>
</tr>
<tr>
<td>Fine acidic</td>
<td>-</td>
<td>-</td>
<td>25 (5)</td>
<td>-</td>
<td>15 (4)</td>
</tr>
<tr>
<td>Fine basic</td>
<td>10 (5)</td>
<td>3 (&lt;1)</td>
<td>35 (5)</td>
<td>5 (1)</td>
<td>53 (3)</td>
</tr>
<tr>
<td>Metamorphic</td>
<td>-</td>
<td>-</td>
<td>10 (2)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>205 (11)</td>
<td>535 (29)</td>
<td>740 (39)</td>
<td>405 (21)</td>
<td>1885</td>
</tr>
</tbody>
</table>

**TABLE 2-1** Broad categories of rock outcrop along the coastlines
Shale includes argillaceous sedimentary rocks such as siltstones and phyllitic metasediments (including some Permian argillites with glacial erratic inclusions up to boulder size) as well as ordinary shale. All shatter readily or weather to smooth outcrops which do not maintain distinct joint patterns.

In the three northernmost regions there are shales, siltstones and phyllites of Devonian, Permian and Triassic age. Those in the Molong-South Coast region comprise siltstones and shales in Ordovician and Cambrian deposits.

Coarse acidic rocks are intrusive igneous rocks, mainly granites and adamellites, which form massive jointed outcrops, rounded exfoliated boulders and corestones. Permian and Tertiary granites occur in the New England region, and older granites and adamellites crop out along the coastline in the Molong-South Coast region.

Coarse basic rocks are intrusive igneous rocks and include mainly quartz monzonites with minor occurrences of essexite and gabbro. They are restricted to Mesozoic outcrops in the southern part of the Sydney Basin and in the Molong-South Coast region. In outcrop they are similar to those of more acidic rocks, but they tend to weather more deeply.

Fine acidic or extrusive igneous rocks are highly variable in character, and include flow banded and uniform rhyolites, and porphyritic and equigranular volcanics. They are mainly associated with folded zones and thus occur more abundantly in the New England Fold Belt and Molong-South Coast region. These rocks shatter into angular rubble as they weather, and commonly form steep cliff faces.

Fine basic or extrusive volcanic rocks are mainly basalts and latites and the outcrops may contain minor lenses of tuff. There are a range of these outcrops, including the Tertiary Lamington Volcanics in the Clarence-Moreton Basin, a number of Devonian and Tertiary basalt occurrences in the New England Fold Belt, Permian latites and basalts in the Sydney Basin and several Tertiary basalt outcrops in the Molong-South Coast region. Weathering tends to produce spheroidal boulders subject to major cracking and exfoliation, and the columnar jointing which occurs during cooling in massive outcrops is accentuated by weathering processes.
Metamorphic rocks are uncommon as coastal outcrops in New South Wales, comprising minor outcrops of serpentinite in the New England Fold Belt. Like fine acidic rocks, they tend to shatter into angular rubble as they weather, and commonly form steep cliff faces, but they weather more deeply than do the acidic volcanics.

**Platform Characteristics**

Because of their different weathering patterns these lithologic groups give rise to rock platforms with characteristic forms. Terms used in the classification of platform type reflect the typical jointing and breakdown patterns which give rise to categories of rock platform. In this study three types are recognised.

**Jointed** platforms include those in which joints, bedding plane cracks, exfoliation layer cracks or salt spray tafoni are maintained (Plate 2-1). They are typical of sandstone, coarse acidic igneous and coarse basic igneous rocks.

**Lumpy** platforms are associated with folded shales, volcanics or metamorphic rocks where differential weathering along bedding planes has removed material leading to the more cohesive residuals remaining as narrow raised bands in reef-like platforms (Plate 2-2). Such platforms do not maintain deep cracks, but are generally of a rough or uneven surface texture, with shallow smoothed crevices along eroded planes.

**Smooth** platforms are generally associated with flat-lying shales. Slaking and salt spray weathering have removed ridges or angular crests to give flattened or rounded surfaces without major cracks (Plate 2-3).

Rock platforms and reefs were very important source areas for collecting edible shellfish. Rock platform ecology is closely related to the form of the rocky shoreline, and hence this is important to a consideration of the resources available in prehistoric times. Site distribution is also related to platform morphology and the dynamics of wave action. Shell middens occur on the backs of many rock platforms, but in such locations they have rarely remained intact or may have been completely removed.
PLATE 2-1. JOINTED ROCK PLATFORMS ON SANDSTONE AND GRANITE.
PLATE 2-2. LUMPY ROCK PLATFORM ON ACIDIC VOLCANIC ROCK.

PLATE 2-3. SMOOTH ROCK PLATFORM DEVELOPED ON A SHALE BED WITHIN SANDSTONES.
COASTAL LANDFORMS RELATED TO STRUCTURAL REGIONS

In terms of coastal environments the two northern structural regions, the Clarence-Moreton Basin and the New England Fold Belt, can be regarded as one unit. They are characterised both by long sandy zeta-curved beaches commonly lying to the east of a series of dune barriers (see e.g. Thom 1965, Hails 1968, Langford-Smith and Thom 1969) and by floodplain estuaries. Rock platforms are minor landforms and their forms vary considerably. In the Clarence-Moreton Basin flat-lying sandstones give rise to jointed tabular platforms. Those on igneous rocks tend to be ramp-like and rounded through exfoliation weathering, while steeply dipping rocks especially in the New England Fold Belt are sharply truncated, generally forming small platforms sloping parallel to the bedding planes.

The Sydney Basin comprises generally short arcuate bayhead beaches, or longer asymmetrical (log-normal curved, J-curved, zeta-shaped) beaches, separated by rocky headlands commonly fringed with rock platforms. The form of the platforms is determined by rock type such that they are mainly broad and smooth on shale, or massive and jointed on sandstone. In terms of coastal landform assemblages this structural region can be divided into a central area and a rim. In the central area platforms are tabular on horizontally bedded rocks, but on the rim of the Basin where the rocks dip more steeply platforms on sandstone slope parallel to the bedding planes. Those on shale tend to form smooth but irregular lumpy reefs where differential erosion through slaking along the bedding planes has led to partial removal of the rock mass. In the central region also are major river valleys which formerly extended to a lower sealevel several kilometres offshore, and which are now drowned, and give rise to bedrock controlled estuaries. The rim of the basin, with no major rivers cut through bedrock, comprises small alluviated valleys and sandy beaches with intermittent rocky headlands.

The Molong-South Coast division is similar to the rim of the Sydney Basin, with dominant rocky headlands, and short sandy arcuate bayhead beaches. Rock platforms show considerable variety, with bedding plane angles controlling the slope of sandstone platforms and exfoliation weathering causing strongly jointed but rounded ramp-like platforms on igneous rocks. The shaley Ordovician sedimentary rocks
are generally tilted and form smooth lumpy platforms similar to those on the rim of the Sydney Basin. Flatter lying shales of the Cretaceous Wagonga Beds form extensive smooth flat platforms.

THE COASTAL ZONE AS A PREHISTORIC ENVIRONMENT

Food Resources

Differences in coastal landforms have a profound effect on local littoral ecosystems, and basically determine the differences in shellfish species found in different localities. Such differences in the local availability of shellfish should be reflected in Aboriginal economy as inferred from archaeological remains. It is the main purpose of this study to determine the ways in which prehistoric land use can be related to environments, and interpreted from such environmentally determined differences. Differences in beaches, platforms and estuaries will markedly affect local ecosystems, and in turn the food resources available from them.

Beaches.

The fact that for any one beach conditions are predictable given experience of wave height, wind and swell direction, has important implications for Aboriginal economy. Beach condition must have been even more predictable in pre-European New South Wales when sand supply had not been artificially modified. Over the recent few decades sand mining has disturbed the near-shore sand supply and back barrier sand deposits have been impounded by carparks and concrete walkways or fixed by urban settlements, with the result that beaches are now commonly unstable.

The chief beach shellfish resource exploited by Aborigines in New South Wales was the pipi (Plebidonax deltoides), and even now its occurrence can be accurately predicted on many beaches. Pipis are most prolific on beaches with a strong swell i.e. those facing south to southeast, where a freshwater inlet carries a supply of organic material from lagoons or back-barrier swamps (Luebbers 1978:47). There are many such beaches in New South Wales, and local Aboriginal
shellfish collectors are still familiar with, and comment on, the best pipi spots. For instance on Bherwerre Beach people from the Wreck Bay community who commonly collect pipis, mainly for bait, gradually shift their collection area along the beach from the eastern end to mid-bay as winter approaches. A group of Aboriginal men from a community near Kempsey who visited Julia Coleman's South West Rocks midden excavation site in November 1979 with Aboriginal Sites Officers Ray Kelly and Glen Morris of the New South Wales National Parks and Wildlife Service, noted that at that time of the year pipis should be well down (south) towards the mid-beach area, and returned an hour later with several buckets full of pipis. They commented that many other north coast beaches also had their predictable pipi-collecting spots.

In northern New South Wales pipis spawn mainly in winter (Callaghan 1980) and the shellfish beds settle in about September. While these beds tend to drift along the beaches with changes in season, pipis generally can be collected from most beaches throughout the year. This is especially the case for collectors who know the pattern of beach stage, and the location of pipi beds in relation to the migration of bars or the surfzone conditions - states with which coastal Aboriginal groups must have been very familiar.

**Rock Platforms**

Marine rock platform ecology is very well known and much has been written on marine rock platform organisms and ecosystems (e.g. Dakin 1952 and revised by Bennett and Pope 1976, Bennett 1974, McPherson and Gabriel 1962) but little attention has been paid to the differences between systems on different types of platform. For the south coast between Batemans Bay and Bermagui such a factor does seem to have been significant for prehistoric Aboriginal exploitation (Sullivan 1976, 1978) and further work has been focussed on this aspect in the present study (see Chapters 3 and 4).

**Rock Platform Shellfish.** A clear and well described (see above) zonation of molluscs occurs on intertidal rock platforms, and this varies only slightly along the entire New South Wales coastline as warm water species such as cone shells give way southwards, and shellfish such as mussels which are adapted to colder water increase. The major differences between rock platforms however relate to the
wave power to which the platform is subjected, and the extent of
sheltered niches on the platform. Species distribution is determined
primarily by the proportion of time for which each zone of the
platform is exposed to drying or is covered by water during tidal
shifts.

The rock platform organisms, especially shellfish, collected by
Aborigines were taken mainly from the littoral and infra-littoral
zones of the platforms (Besly and Meyer 1954, Dakin 1962). Those from
the lower-littoral and infra-littoral zones can generally be collected
only by diving into the water, while those from the upper-littoral and
mid-littoral zones are exposed for about half of each tidal cycle.

Shellfish which occur on platforms exposed to open sea swells are
generally the larger molluscs, many of which shelter in rock cracks or
pools, or amongst the beds of large seaweeds on the platform margins.
Those found on rock platforms in more sheltered areas within bays or
estuaries are generally smaller, with a more restricted range of
species represented. Shellfish which are common on the upper-littoral
to mid-littoral zones of most rock platforms and which are also
commonly observed in Aboriginal shell middens include gastropod
molluscs of the genera Austroplacida, Nerita, Bambicula, Ballantraea,
Montfortula, Murex, Drachis, Scutus, Cellana and Patellinae, a
number of Isochonochitonidae and the barnacle genera Tetraclita and
Cataphragmus. From the lower littoral zones, especially on platforms
exposed to sea swells or turbulence, the gastropod genera Mallotiis,
Turbo, Cabestana, Cellana and Patellinae, the bivalves Hytilus and
Trichomya, echinoderms such as the sea urchin Heliocidaris and the
barnacles Cataphragmus and Balanus are common. (Details of the
classification and nomenclature of these genera are given in Appendix
1).

Rocky shorelines were also a rich source of fish, which were
exploited along with shellfish. These fish could be speared or hooked
from the platforms or from canoes (see chapter 8).
Estuaries and Deltaic Floodplains

There is considerable variety within estuarine environments. The term "estuarine" has been used here to include the similar set of environments within deltaic floodplains. Wave activity, salinity, bed and bank sediment, substrata and water depth are factors which influence estuarine ecology, and in this study considerable emphasis has been given to estuarine environments as they influence potential sources of food.

Environments within and between estuaries vary widely and one notable variation is in salinity. While the salt content of seawater is around 35gm/l (or parts per thousand), the salt concentration within estuaries along the New South Wales coastline commonly varies from less than one part per thousand near the head to 35-40 parts per thousand at the mouth (Owen 1978a:102).

Bed sediments also vary within and between estuaries. The upper reaches normally have muddy bottoms as a result of comparatively slow water movement, and salinities of 5-18 parts per thousand. The middle reaches have sandy to muddy bottoms consequent upon faster water movement resulting from tidal action, and salinities between 18 and 25 parts per thousand. The lower reaches have sandy mud to sand bottoms, fast or turbulent water movement mainly due to tidal action, and salinities up to 40 parts per thousand.

True estuarine organisms are found in these three environments and generally do not compete successfully with marine organisms in the open sea (Owen 1978a:102). Day (1967:401) suggested that an estuary with slowly weathering rock and wooded banks will have clear water and vigorous plant growth which will in turn encourage a wide range of fauna; hence estuaries are rich biotic environments.

Estuaries in southern New South Wales yielded about 75 species of fish in a study carried out by the Australian Museum (Owen 1978a:103) as well as characteristic shellfish suites. It is perhaps significant that the richest estuaries in terms of faunal yields in this study are also those around which the most numerous and largest archaeological sites have been recorded. Tuross Lake, Wagonga Inlet and Wallaga Lake all yielded numerous fish species and showed generally diverse biological communities, and are all estuaries where large shell
middens are concentrated. Similarly on the north coast estuaries known as rich fishing areas such as those of the Richmond, Clarence and Macleay Rivers, are also areas with numerous large shell midden deposits.

**Estuarine shellfish.** In general estuaries on the New South Wales coast produce about twenty common species of edible shellfish, seven of which are most frequently represented in shell middens. These most commonly occurring and generally most easily collected shellfish species are: the Sydney cockle (*Anadara trapezia*), Hercules club whelk or mud whelk (*Pyrazus ebeninus*) and small mud whelk (*Velaomantus australis*) which occur as bottom dwellers in the muddy head reaches, and the dredge oyster or mud oyster (*Ostrea angasi*) found in the more sandy middle reaches. The rock oyster (*Crassostrea commercialis*) is found throughout many estuaries attached to firm substrata such as rocky shorelines and mangrove roots, and nearer to the mouth the edible mussel (*Mytilus planulatus*) and hairy mussel (*Trichomya hirsutus*) are frequently found. In addition to these more common shellfish, specimens of the small mussel (*Brachiodontes rostratus*) also occur in shell middens in colder areas to the south.

Rock platform species typical of sheltered coastal environments, especially the smaller gastropods, are also common near the mouths of most open estuaries. These generally include the striped top shell *Austrocochlea constricta*, the small tent shell *Bembicium nanum*, the nerite *Nerita stramentosa*, limpets *Cellana tranosera* and *Patellana patelloides* and the mulberry shelled oyster borer *Morula marginata* or another common predator, the cartrut shellfish *Dicathais orbita*. Shells of these species occur in most estuarine shell midden deposits in areas where rocks are exposed along the shoreline.

Ecological and physiological information provided by marine biologists can enable patterns and conditions of shellfish availability to be determined. Callaghan (1980:74-95 and 111-140) collected a considerable amount of data on the shellfish represented in the lower Macleay Valley middens and these data also provide a basis for consideration of the likely patterns of exploitation of shellfish by Aborigines.
Allan (1947), Hutchings and Rainer (1979) and Hutchings and Recher (1974) noted that about fifteen bivalve species are commonly found on tidal flats near estuary mouths or in sheltered bays in New South Wales. Of these the Sydney cockle, rock oyster and mud oyster are most common. While all these bivalves show a limited range in tolerance of both salinity and substratum, the edible mussel and rock oyster can tolerate considerable variations in their environment.

The ecological genetics of the Sydney cockle *Anadara trapezia* is well known (Dixon 1975), as are their responses to changes in the external environment. Cockle mortality is strongly associated with salinity and temperature effects. Cockles tolerate best salinities of 35 parts per thousand or slightly lower. They prefer protected water and gentle wave action, and hence thrive in beds of the sea grasses *Zostera* and *Posidonia* on sandy to muddy flats, especially in estuarine embayments such as Gunamatta Bay, St. Georges Basin and Wagonga Inlet. When water temperature and salinity drop together cockle mortality is high (Dixon 1975). These conditions occur most commonly with major river flooding. For the rivers of the north coast of New South Wales, where overflow floods occur at intervals slightly greater than 1.5 years (Callaghan 1980), cockle populations have been observed to fluctuate over a period of one to five years, depending on the magnitude and frequency of river floods (Callaghan 1980, Dixon 1975). It is probably significant that the most regularly observed thriving cockle beds are in embayments fed only by minor streams, such as at Gunamatta Bay, St. Georges Basin and Wagonga Inlet. Cockle beds in north coast rivers would always have been subject to sudden severe mortality associated with floods. Cockles triple their weight between one and two years and double it between two and three years. Meat weight in a mature cockle is about 4 gm, and this weight is about 20% less in winter than in summer.

Dixon (1975) compared changes in cockle and rock oyster *Crassostrea commercialis* morphology with changes in latitude (and thus water temperature) and salinity, and showed that cockles display little morphological variation. This lack of variation is associated with a limited tolerance of environmental change. The more tolerant rock oyster shows considerably more variability in its morphology, mainly associated with differences in its external environment.
Rock oysters can tolerate salinities between 7.5 and 35 parts per thousand, and thrives at a salinity of about 17.5 parts per thousand. These oysters can tolerate more water turbulence and turbidity than either *Ostrea* oysters or cockles due to the presence in the body structure of a promyal chamber which effectively buffers the water reaching the filtering structures (Thomson 1954). They thus occur throughout the tidal and salinity ranges of estuaries from their baymouths upstream to their tidal limits.

Rock oysters spawn most commonly in spring and in August. The oyster is at its peak weight at an age of 3-4 years when it weighs some 55-60 gm of which the meat weight is about 20% (Thomson 1979, Callaghan 1980). An average oyster at three years thus weighs about 50 gm, of which 10 gm is meat weight. These oysters triple their weight between one and two years, and double it between two and three years.

Both oysters and cockles are at their prime meat weight and edibility immediately before spawning. As noted above *Anadara* spawn annually in summer, however *Crassostrea* spawn much less regularly or predictably.

Rock oysters are also well adapted to survive because of their spawning behaviour. Individual oysters produce very large numbers of eggs which are dispersed widely by tidal currents before the additional dispersion of the offspring during the free-swimming larval stage. The large number of eggs produced and the wide dispersal - frequently well beyond the immediate estuary or bay in which the parent community is established - ensures a rapid re-colonisation of rock oysters following any depletion of the oyster beds.

The mis-named mud oyster *Ostrea angasi* on the other hand is a species much less adapted to survive as a community (Thomson 1954). This oyster is incubatory, retaining its eggs until they are on the point of hatching into free-swimming larvae. Two factors which diminish the ability of mud oyster communities to regenerate rapidly follow from this. Firstly the number of eggs produced (and stored) by individual oysters is far smaller than those released by a single rock oyster, and secondly the stage of wide dispersal of the eggs by tidal currents is eliminated from the life cycle. There is a short free-swimming larval stage during which spat are dispersed, followed by a stage of attachment to a firm substratum. During the growth phase
however the oyster detaches itself from the firm base and again becomes free-moving. At this stage the oyster must fall onto a firm sandy to muddy sand base. If the oyster in fact becomes buried in mud it dies. Although in other respects the mud oyster exhibits a similar range of tolerances of environmental changes to the rock oyster, these two differences of a much lower level of dispersal and a lower tolerance of turbidity render mud oyster communities locally much more susceptible to extinction than rock oyster communities.

The edible mussel *Mytilus planulatus*, which occurs on both open marine rock platforms and within estuaries, is worthy of special attention. It is a shellfish species which appears commonly in midden deposits along the southern half of the coastline and which became economically very important in more recent periods (see Chapters 4, 5 and 9). Owen (1978b) noted that this mussel is a subspecies of the commonly cultivated edible mussel of Europe (*Mytilus edulis*), but shells of the Australian species are found in midden deposits which date well back into prehistory, e.g. at Bass Point in layers older than 1,000 years (Bowdler 1970), at Bowen Island at least 1,000 years B.P. (Blackwell 1980) and at Pambula Lake at about 3,000 years B.P. (Chapter 8), so the species has been present and exploited in New South Wales coastal waters for at least several thousand years.

Edible mussel biology is similar to that of the rock oyster. There is a short free-swimming phase followed by settlement and attachment to a suitable base, but unlike oysters the mussel retains the ability to re-attach itself to a new base (Owen 1978b). Like the rock oyster also, the mussel can tolerate wide variations in salinity, from four to sixty parts per thousand. They adapt to this wide range of salt conditions by closing the valves and ceasing to feed when salt concentration drops below four parts per thousand (Hum 1970). While edible mussels from areas prone to extended periods of low salinity are thus relatively stunted in growth, their range of potential habitats is large.

Commercial edible mussel culture is very dependent on unpolluted water (Owen 1978b) reflecting the fact that mussels are well adapted to survive in a range of environmental conditions, and tend to isolate and accumulate biological and mineral contaminants as part of this adaptive mechanism. Mussels are tolerant of water temperature changes as high as 27 Centigrade degrees (Hum 1970:28), as well as a high
range of turbulence and turbidity, and are thus found in a wide range of coastal environments between Wallis Lake at the northern edge of the Sydney Basin and the sub-Antarctic islands.

The biology of the hairy mussel (*Trichomya hirsutus*) is generally similar to that of the edible mussel. This species however is not adapted to extreme cold, and does not occur south of Tasmania. In southern New South Wales the ranges of the two mussels overlap, and beds of the two species commonly occur together.

The Hercules club whelk or mud whelk (*Pyrazus ebeninus*) is also generally present on estuarine mudflats and occurs in most estuarine shell middens. These shellfish, which inhabit soft sandy to muddy intertidal flats (Besly and Meyer 1954), are found on most muddy estuarine shorelines from Queensland to Tasmania (McPherson and Gabriel 1962). These whelks can tolerate a range of salinity and turbidity but prefer calm water. They abound in areas with mangroves, and are most prolific during warmer seasons (Dakin 1962). The small mud whelk *Velacumantis australis* is found in similar environments and has a similar range of tolerance to external environmental factors (McPherson and Gabriel 1962, Dakin 1962).

Of the small gastropods O'Gower and Meyer noted (1965 and 1971) that in the Sydney region striped top shells occur on rock platforms throughout the year, but are least available in summer. They are smallest with lowest meat weights however in cooler seasons. The smaller tent shell is also available throughout the year and is similarly smallest in cooler seasons. Nerites are most common during spring and early summer when they are at their largest size. In contrast the ubiquitously occurring limpets tend to increase in both shell and body size in cooler seasons. The predatory oyster borers and cartrut shellfish are present throughout the year, and like the limpets tend to be largest during the cooler seasons.

Shellfish Ecology and Subsistence

All types of coastal landscape can produce edible shellfish. In considering the availability of shellfish as food sources it is relevant to consider factors of habitat, population dynamics and seasonality.
The common beach shellfish, pipi, is available throughout the year in northern New South Wales, but is largest in winter just before spawning. Owen (pers. comm.) noted that pipis were available in somewhat limited quantities throughout the year in southern New South Wales, but were very small, indicating over-predation in areas where they are collected for bait during school holidays. It is likely that also in prehistoric times more prolific pipi populations in the north were less vulnerable to predation than smaller populations in the south. Some shellfish are available on rock platforms throughout the year, although there are seasonal changes in sizes and availability of particular species. The smaller gastropods which are present in very large numbers appear to maintain populations despite predation or damage by severe storms, although some very disturbed rock platforms near Sydney show an increase in the numbers of rock oysters and a depletion of gastropods (Besly and Meyer 1954).

Populations of the larger gastropods and bivalves of the lower littoral zones vary seasonally. Poiner (1971, 1976) noted general differences in shellfish availability throughout the year, however small numbers of all species can be collected at any time. Personal observations and those of regular divers (Stockton pers. comm.) indicate that in the warmer waters off the New South Wales coast, large gastropods such as the triton (Cabeatana spengleri) which migrate away from the platforms during winter of southern Victoria and Tasmania (McPherson and Gabriel 1962:161), remain in cracks on the platform edges throughout the year and could be collected by diving.

Some rock platform species however are vulnerable to predation and other environmental changes, and their populations could be altered considerably (Owen 1978a:115). These include the edible and hairy mussels and abalones (Haliotis spp.).

Shellfish are similarly available in lagoons and estuaries. Although rock oysters are generally largest in late winter, and cockles and whelks largest in summer, all are readily available throughout the year. Mud oysters are particularly vulnerable to environmental change, and mussels do not recover well from population depletion, while rock oysters are well adapted to re-colonising firm substrata in open estuaries and deltaic floodplains.
It is likely that in prehistoric times limpets, oyster borers and rock oysters were collected most commonly in winter, and large gastropods, nerites, cockles and mud whelks in summer. In New South Wales however the presence in or absence of particular shellfish species from a midden deposit is not a clear indication of seasonal use of the site. Certainly shellfish collecting would have been possible throughout the year in all coastal landscapes.

THE MOVEMENT OF PEOPLE

The nexus between geological structure, sealevel change and the development of coastal landforms almost certainly influenced not only coastal resources but also patterns of movement along the coastline. Eastern Australia, and especially coastal New South Wales, is dominated by the presence on the eastern margin of the continent of the eastern uplands, a belt of block faulted and folded sedimentary rocks, which forms both a major drainage divide within the continent, and a major barrier to human movement. This upland trend mainly north-south, and its position relative to the north-northwesterly trending coastline consequently varies from north to south.

In the north the upland range lies some 50km inland of the coastline, while in the south the foothills of the upland lie within 10km of the shoreline. As well as forming both a drainage divide and a barrier, these uplands are also a major water catchment source. Orographic rainfall from airmasses moving across the continent from the west occurs on the upland ranges. In addition frictional orographic rain associated with southeasterly airstreams crossing the coastline is also concentrated on the eastern slopes of this range, so the upland is a major source of water flowing from upland headwater channels across the coastal plains to the ocean.

The coastal plain in the Clarence-Moreton and New England regions is wide enough to allow major drainage networks to consolidate, and rivers reaching the coast are commonly 3th order (Horton 1945, modified by Strahler 1964) channels draining considerable catchment areas (19,800 sq.km in the case of the Clarence, and 11,500 sq.km for the Macleay River). In contrast, to the south organised drainage networks which may have existed at times of lower sealevels are truncated on the narrow plains, and channel networks rarely reach 6th
order, and commonly drain considerably smaller upland areas than those to the north. As a consequence river systems in the north are large, with the trunk channels broad, and annual discharges of the order of several thousands of millions of cubic metres. Those in the south are narrower and frequently carry only a few hundred million cu.m. For example, for the Clarence at Grafton the annual discharge is 4,000 million cu.m, and for the Moruya River at Moruya it is less than 300 million cu.m. Even the Shoalhaven, the largest river on the south coast, carries an annual discharge of less than 900 million cu.m (Australian Water Resources Council 1976). The movement of people along the coast as well as the availability of resources would have been consequent on these differences. Valleys to the north are broad and alluviated, with wide sandy floodplains and evidence of channel migration and overbank deposition. In the south valleys are narrower, and sandy overbank deposits are restricted to a narrow band near river mouths.

Differences in access routes along the coast reflect channel form and discharge. The deltaic floodplain reaches of the wide northern rivers are difficult to cross, and this must have been even more the case in prehistoric times before the floodplains filled with sediments. For prehistoric people such crossings must have necessitated the constant use of water craft and these were noted by explorers and ethnohistorians such as Oxley (1820) and Hodgkinson (1845). At the present time such rivers as the Macleay, Clarence, and Richmond are bridged by major engineering structures, yet it is normal to find the Princes Highway, the main coastal highway in New South Wales, closed for several days each year due to flooding in these rivers. It is worth noting in fact that the rivers, and their sizes have captured the imaginations of Europeans. Grafton is the administrative centre of the Northern Rivers Shire and approaching the Clarence Valley on the Princes Highway or from the New England tablelands, one is confronted by signs welcoming travellers to Big River Country. It is interesting that these signs, although probably not placed by geologists, mark the boundary of the Clarence-Noroton Basin against the encircling arc of the New England Fold Belt.

Not so dramatic are the bridges, river crossings, flood hazards or the alluvial valley fill deposits in the south. Similarly it is difficult to imagine that any rivers south of Newcastle, except
perhaps the Shoalhaven, caused more than a few moments hesitation for anyone able to swim, even when carrying floodwaters anywhere more than a few kilometres back from the coastline. South of Newcastle rivers would not have represented significant barriers to human movement, while north of Newcastle it is unlikely that river crossings were undertaken lightly and probably not without watercraft.

Patterns of resource exploitation probably varied widely between groups commonly using watercraft to traverse wide rivers and those bound by the absence or infrequent use of watercraft to travel by foot along the banks. People using craft on rivers might be expected to have travelled further along the banks and to have left remnants of their camps in upstream reaches or distributed more widely around the banks, than people travelling by foot.

The degree to which these postulated differences in the movement of people in the different regions is reflected in the archaeological record is discussed in the concluding chapter.
CHAPTER 3

ANALYSIS OF THE NATURE AND LOCATION
OF COASTAL SHELL MIDDENS.

AIM OF THE ANALYSIS

In a previous study I had demonstrated that on a relatively short stretch of about 120km along the New South Wales south coast there were definite relationships between the nature and distribution of shell middens and their setting in the landscape (Sullivan 1976, 1978). Factors which were identified as apparently having been important in determining site locations were the type of rock platforms from which shellfish were collected, the presence of sand on which to camp, the availability of shelter from prevailing winds and proximity of drinking water.

Within this survey area it was found that the most favoured site location was on a foredune next to a rock platform, and commonly on the northern side of the adjacent headland (Sullivan 1976:68). Such locations in fact represent a logical compromise between access to readily available shellfish, to water which is often derived from drainage off the headland, sand to sit on and shelter from the prevailing winds. The sheltered beaches in front of such site locations were ideal landing spots for canoes used to exploit the fish resources off the platforms.

A major aim of this study was to test whether similar relationships existed along other parts of the New South Wales coastline, with a similar physiography, and whether there were differences between the structural regions. In Chapter 2 it was shown that the coastal zone can be divided broadly into two main sections; a sand dominated depositional coastline in the north, and a bedrock dominated mixed coastline in the south. It might be expected that the patterns of site contents and distribution identified in the previous study would apply generally to the southern section, but that different patterns may be identified in the north.
To examine the relationships between the nature and distribution of sites and their environmental settings, a statistical approach was developed. Information about the nature and contents of large numbers of shell midden sites, and their setting in the physical landscape, was recorded systematically to allow comparisons to be made within and between coastal areas.

METHODS USED

The Data Base

In order to organise shell midden sites within regionally distinct landscapes and identify such relationships, it was necessary to use a method of distinguishing between landscape types which was independent of archaeological criteria. The structural geological division of the New South Wales coastline described in Chapter 2 was used as the basis for this landscape classification.

Shell middens occur in a number of forms and in varying degrees of complexity of structure and content. In this study, in order to recognise patterns of site occurrence which may reflect prehistoric behaviour patterns, shell midden deposits have been grouped into categories which describe their extent and modes of occurrence, if not their complexities of structure and content.

The recording method used was designed as a data file for use with a computer (in this instance the Australian National University Dec-10 system), which would allow rapid simple statistical manipulations in order to generalise the information from which specific information about prehistoric behaviour patterns along the New South Wales coastline could be derived (Sullivan 1980:143-5). Briefly, attributes of shell midden deposits which were derived almost entirely from field survey observations and which were recorded in this data file include geographic location, dimensions, gross contents, position within the landscape and factors describing the physical settings of the sites.

Since the late Eighteenth Century the New South Wales coastline has been subjected to enormous changes as the result of population growth and associated rural, industrial and urban development. Near
the three major cities, Sydney, Newcastle and Wollongong, housing and industrial development have had a major effect on the coastal zone, in that they have both altered its form and removed or obscured much of the evidence of former Aboriginal occupation, including coastal shell middens. Urban sprawl, the growth of coastal towns, the generally arbitrary development of strips of coastal foreshore land for housing development and sand mining have all had a major effect in obliterating Aboriginal sites along the coastline. In addition natural processes leading to the destruction or obscuring of sites have occurred. These include the effects of wave action (Hughes and Sullivan 1974) or fluvial erosion, deflation and burial by windblown sand and loss of distinctive shell layers through solution processes (Hughes 1977). Because of the existence of large areas of disturbed coastline it was not possible to systematically sample lengths of coastline and obtain a reliable stratified sample of sites from which general patterns could be extrapolated.

I therefore chose to work with the largest possible number of sites for which information was available, or could be collected, in order to obtain an overview of the total recorded population of coastal midden sites. The New South Wales National Parks and Wildlife Service (NPWS), and its predecessor the New South Wales Fauna Protection Panel, have had systems for recording information about Aboriginal archaeological sites for some decades, but since 1969 when the original National Parks and Wildlife Act placed the responsibility for the protection of such sites on the Director of the NPWS, a systematic register of archaeological sites has been maintained by that Service. This register contains information on a large number of sites which have now been disturbed, destroyed by development or other factors, as well as a record of extant and visible sites. Information in the register has been collected through both systematic surveying (e.g. Campbell 1972, Starling 1974, Sullivan 1978) and fortuitous recording, and there is considerable variation in the quality of the information recorded. Site descriptions varied from "a midden on the left hand side of the Princes Highway" to the thorough description of excavated sites, which included accurate location, description of the physical setting, a summary of site contents and a chronology of site accumulation. For a large proportion of sites there was a good general description and the quality of the information was considered adequate for the purposes of this study.
Fieldwork to Supplement the Data Base

Fieldwork was undertaken as follows:

1. Where detailed records were lacking but locational information was good, the use of the register enabled rapid re-location of the sites in the field to supplement the information previously available through personal observations (see also Sullivan 1980). A number of previously unrecorded sites were also located and described.

2. Such fieldwork involving locations along the entire coastline, also enabled me to gain an appreciation of the archaeology and landscape of each of the four structural regions. This was especially important for the two northern regions where I had had little previous fieldwork experience.

3. A number of archaeological consultancies which I undertook between 1978 and 1980, added to this fieldwork experience, and provided opportunities for a more detailed investigation of specific tracts of the coastline.

4. Along some stretches of the coastline, especially in the south of the State, where no systematic surveys had been carried out and where very few or no sites had been recorded, I carried out short survey traverses to ensure that there were no major areas along the coastal strip from which site information was lacking. Fig. 3-1 shows the main sources for the information used in this study.

The Recording Method

The variable quality of the data available did not warrant the application of sophisticated statistical methods. I therefore decided at the outset of the study to use the computer-based statistical programme SPSS (Nie et al. 1975), which would allow simple statistical procedures to be carried out and which enabled missing data to be excluded from any specific calculation. This meant that sites did not have to be discarded from other computations if information on some aspect of their contents or location were not available.
Fig. 3.1 Sources of systematic survey information
A method was developed to record details of site type, contents and locational variables, which was simple to use in field situations, and which presented the data in a form suitable to be entered into the computer. A single two-sided recording sheet was designed, based on a standard 70 character computer-input data-punching form, such that each site description occupied two lines on the record sheets. The sheet used is shown in Fig. 3-2. Sites were not recorded in a systematic geographic sequence, so that any sites located fortuitously or by systematic surveys at later stages could be included in the data set. The list of sites was later sorted into a north-south sequence (see below). The total list of sites used in the analyses is given in Appendix 1.

Based on the results of the previous survey of sites along part of the south coast (see above), I chose a number of variables which seemed relevant to the locational analysis, and which were generally available from the NPWS site register or from field observations of the sites. These variables are described below, and in Appendix 2.

A coding system was used to avoid full verbal descriptions of each variable recorded. SPSS allows the manipulation of both numerical and alphabetic descriptors, and in this study numerical characters were used only where they referred to an actual numerical value. All qualitative or non-parametric descriptions were recorded using alphabetical characters. In the computer output from SPSS calculations there is an optional printed description of the coding system used. An example of this printout is shown in Fig. 3-3, and details of the options provided are given in Appendix 2.

In each case the coding system was based on an abbreviation of the normal descriptive terms specified as options, and these abbreviations were readily committed to memory so that it was possible in most instances to complete the recording sheets without reference to the coding system, and to interpret the meanings of the coded sheets at a glance. The format of the recording sheet (Fig. 3-2) divided variables into site descriptions and landscape descriptions, the details of which are given in Appendix 2.
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Fig 3-2. Two sides of the record sheet used to list field data.
Fig. 3-3.
Computer listing of site variables
Site Descriptions

The descriptions below follow the order in which information was recorded on the data sheets: site locational information; factors describing the nature, contents, conditions and dimensions of the site; information on the physical setting of the sites.

Site Locational Data (Columns 1-27)

Site Number is a unique four figure identifying-number used to enter data on the sheets. The number was repeated on the second line of the record, enabling rapid computer-sorting to amalgamate the two lines of record once the data set was complete.

Region. For each site the structural region of the coastline within which it was located was recorded (Chapter 2). This was later used to generate four subfiles of data, each containing information for the sites within one region.

Grid Reference is a six figure grid reference to locate the sites on 1:250,000 topographic maps. Eleven maps cover the coastal zone and these were each identified by two alphabetic characters.

Latitude and Longitude were recorded in degrees, minutes and seconds. The value of this information is that at the completion of data recording, the sites were sorted by the computer in a numerical sequence from north to south based on latitude. Longitude was used to provide a west to east sequence where two or more latitude values were the same.

Nature and Contents (Columns 31-68)

The options for site descriptions are listed in Appendix 2, and relate to the nature and contents of the deposits.

Site Type lists the types of site recorded; stratified or deflated open middens, buried occupation deposits, shelter or cave midden deposits, surface scatters of shell or worked stone, surface campsites, buried worked stone and quarry sites. A definition of these site types is given in Appendix 2.
Art refers to the presence or absence of rock art or ochre associated with the shell deposits.

Reworking is the degree to which re-deposition of the midden contents has occurred as the result of wave activity, slopewash or other processes. Reworking was identified by noting characteristics described by Hughes and Sullivan (1974), such as layers of shell grit or very small shells, beach or slope gravel inclusions and the presence of pumice. This information was gathered to assess the condition or state of existing archaeological sites in coastal New South Wales, and changes in landscape which have occurred.

Preservation. A "preservation rating" was assigned to each site on the basis of its observed degree of disturbance. Good preservation meant that more than about 75% of the observable deposit appeared to be undisturbed (except perhaps by wave reworking along its seaward margin), and to be located in situ. Fair implied that 25% to 75% of the deposit remained largely undisturbed and poor implied that less than about 25% of the observable deposit appeared to remain in situ. Deflation by wind and undercutting by flowing water or wave action appeared to be the main natural agents of disturbance, although human interference was also commonly a clear factor in site disturbance.

Rating was a significance value assigned to each site. As there is an interest on the part of archaeological resource managers in the relative importance of archaeological sites, a subjective attempt was made to rate the midden deposits. The concepts involved in assigning a rating were based on the archaeological research value of the site, and included consideration of the state of preservation, the stability of the landscape unit in which it is set, and the general "richness" and diversity of the deposit. Large undisturbed deposits with a variety of contained materials were rated most highly. In addition unique or very unusual deposits were rated to be of high value. Scoring such values for archaeological sites and deposits has been investigated and applied recently by Groube (1978) for sites in Dorset, U.K. His method takes into account the physical characteristics of the site, its location in the modern landscape and its potential archaeological significance - similar factors to those considered but not scored in this study. For hunter-gatherer sites, however, the method used by Groube needs to be modified considerably
and more work is necessary to render his classification applicable to a range of sites of a similar type (such as shell middens) in the Australian context.

Rating values in this study are based on a three-level classification. In management terms it is suggested that sites rated A have high research value and should be preserved if at all possible, while those rated B have research value and should be permitted to be destroyed only if it is essential, and then only if thorough archaeological investigation or "salvage" of the site is carried out beforehand. Sites rated C are of relatively low archaeological value.

Aspect was recorded for sites with a constrained outlook or for elongated deposits, as a bearing in degrees. It had been noted (Sullivan 1976, 1978) that along part of the south coast sites tended to be located in positions which offered shelter from the prevailing southeasterly wind, and in this study it was intended to test how widely this factor applied.

Dimensions. Length, width and depth were recorded for each site, as well as area and volume which could be useful for comparing overall dimensions of sites. Since the range of sizes of middens is considerable, and as precise and accurate measurements of site dimensions are not normally available from field survey observations, a system of recording was used which allowed for a large range of values and which took into account the limits of precision.

An index notation was chosen, using a two-figure value for each characteristic. The first figure is the decile value in cm, sq.cm or cu.cm, the second figure is the power of 10 to which this is raised to express the measured value. Values of 99 were used for all sites in which the volume equalled or exceeded 9,000,000,000cu.cm, i.e. 9,000cu.m.

Shell. Up to three types of shellfish suites could be listed in decreasing order of occurrence within each deposit: rock platform, beach and estuarine shellfish. No attempt was made in this listing of sites to record individual species.

Bone was recorded as mammal, bird, fish and mixed or undifferentiated if it had been observed in the site. A separate note was kept for sites where human burials had been recorded, because of
Aboriginal sensitivity to such information being publicised.

Stone, particularly as the raw material for artefacts, was noted, with up to three types listed for each site. As for shellfish, stone was recorded in decreasing order of observed occurrence. Noticeable stone which had been used as hearth material, or other manuports in the sites was also recorded.

**Implements.** The presence or absence of implements or artefacts were noted, and if typologically distinctive pieces such as backed blades were recorded in a site these were also noted. The categories Pre-Bondaian, Bondaiian, Post-Bondaian and undifferentiated were allocated as approximate indications of cultural context. It became apparent however in recording this information from site forms in the NPWS register, and from field observations, that only two of these were meaningful in manipulating this range of information, Bondaiian if backed blades were present, and undifferentiated.

**Matrix.** The finely divided shell and organic matter, and the inorganic sediment which make up the "non-archaeological" component of shell midden deposits is normally referred to as the matrix of the deposit (see e.g. Hughes 1980). Such material may accumulate, at least in part, as the result of human activity on the site, and the nature and composition of the matrix were noted in the recording system.

**Dating.** In instances where chronological information was available in the form of radiocarbon dates for the site, this was noted in the record.

**Locality Descriptions (Record Sheet 2)**

The site number was repeated on the back of the recording sheets to ensure that the locality descriptions could be related to the site specific data. Locational information recorded was mainly that which had appeared to correlate with site distribution in the previous study on the south coast (Sullivan 1976, 1978), or which otherwise appeared likely to have influenced site distribution.

**Landform.** The landform on which the site is located, and the nature of the immediate substrate of the site and the general substrate or local "bedrock" were noted.
Slope in degrees of the surface on which the site rested was measured, or estimated from the landform where all previous evidence of the site had been obliterated.

Position. If a site were sheltered by a headland or dune, this landform was recorded. The direction of the site relative to that landform was also noted.

Floods. This is a description of the position of the site in the landscape relative to disturbance by river flooding or tidal wash. Sites were recorded as being within the normal bankfull or tidal zone, reached by major floods or storm waves, or beyond the reach of floods or wave action.

Water Source. The distance in metres from the site to the nearest source of drinkable water was noted, as well as the nature of the water source.

Rock type, the area of the platform exposed at low tide, the surface slope of the platform and its form, as described in Chapter 2, were recorded. These details were recorded only if rock platforms were present in the immediate vicinity.

Species in terms of general shellfish suites, the relative size and the availability or abundance of shellfish currently present in an area within 100m of the site were noted.

Quarries (stone sources) referred specifically to the immediate presence of a utilised source of stone adjacent to the midden deposit.

Although the photographic record (film) was listed with the remainder of the site recording, this was not used in any of the analyses.

A completed site record sheet, for sites on the Tweed Heads and Maclean map sheets in the Clarence-Moreton and New England regions, is presented as an example in Fig. 3-4.

ANALYSES

Only simple statistical procedures were applied to the variables recorded. The results described in this chapter are based on the use of the SPSS procedures FREQUENCIES, CROSSTABS and SCATTERGRAMS (Nie et
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**Fig. 3-4. A completed site record form for part of the north coast**
al. 1975:558-60), using four subfiles for sites in the four structural regions previously defined. FREQUENCIES provides frequency tables and descriptive statistics for all variables specified, CROSSTABS produces cross-tabulations for any nominated pairs of variables, and this procedure was used a number of times to test relationships between numbers and volumes of shell middens and various locational variables. SCATTERGRAM produces bivariate plots for any two specified variables, with a Pearson correlation coefficient (R), intercept and slope coefficients. At a later stage the REGRESSION procedure was also used to perform simple regression analyses between selected variables, indicated as relevant by CROSSTABS and SCATTERGRAMS. The results of the simple FREQUENCIES, CROSSTABS and SCATTERGRAMS procedures are discussed in this chapter, and the archaeological implications of the results are explained in Chapter 4.

OUTLINE OF THE RESULTS OF THE ANALYSES

Factors which broadly described the composition of coastal shell middens are listed in Tables 3-1 to 3-7, and they provide an overall impression of the characteristics of the middens. Site locational data are summarised in Table 3-8 and Figs. 3-5 to 3-8, and these characterise the patterns of site distribution.

Site Type

Along the entire coastline 801 sites were recorded, 68 in the Clarence-Moreton region, 194 in the New England region, 309 in the Sydney Basin and 230 in the Molong-South Coast region as shown in Table 3-1.

Stratified open middens exposed at the ground surface are the most common site type recorded, making up 91% of all the sites in the Clarence-Moreton and New England regions, 63% in the Sydney Basin (where 33% of the midden sites recorded were in rock shelters) and 86% of the sites in the Molong-South Coast region (where 4% of the sites were in shelters).
In a few instances stone sources or surface scatters of stone artefacts were recorded as sites immediately adjacent to shell middens (see below), but buried occupation deposits and deflated sites in approximately equal numbers made up most of the other 4-10% of the sites. Buried occupation deposits generally occur on accumulating sandy landforms, and were all recorded from dunes or beachridges, except for one site buried by alluvium on a deltaic floodplain in the New England Fold Belt region.

Deflated middens similarly occur in areas of wind-eroded sand on dunes and beachridges, with one group of sites recorded from broad rock platforms in the Molong-South Coast region, where they have been undercut by wave action.

**Rock Art and Shell Middens**

Shell middens are not normally associated with painted or engraved art, or with traces of artistic activity such as ochre apparent in the deposits (less than 1% of sites), except in the Sydney Basin and a few sites in the Molong-South Coast region where about half the shell middens in rock shelters occur in decorated shelters. Attenbrow (1981:169) found in the Mangrove Creek catchment, that about 33% of the rock shelters shown to have occupation deposit also had rock art in them, and this is probably typical of the proportion of both decorated and occupied shelters in the Sydney Basin sandstones. Haphazard recording of sites, unlike systematic surveying, is likely to give an overestimate of the proportion of decorated shelters. Certainly it is apparent from areas which I have re-surveyed where sites have been recorded by bushwalkers (e.g. in Morton National Park) that untrained observers more commonly notice rock art than they do occupation deposits, including shell deposits, in shelters.

**Redeposition and Preservation**

Preservation of shell middens was judged as good to fair for 80% of those remaining in the Clarence-Moreton and New England Fold Belt regions, and 85% in the Sydney Basin and Molong-South Coast regions. Poor preservation is generally associated with small shell deposits or disturbed and deflated scatters of shells. Many of the deposits
however were at least partly redeposited or reworked by wave, tide or wash processes (Hughes and Sullivan 1974). About 45% of the middens recorded in each region are partly reworked while about 5% are totally redeposited. This is consistent with the observation that between 25 and 50% of the sites in each region are situated within the zone normally affected by storm waves, approximately 3-7m above normal high tide levels, or are situated near the margins of floodplains within reach of high floods. The state of preservation of many such redeposited accumulations however is good.

Rating of Sites

From Table 3-2 it can be seen that in the two northernmost regions there is a low proportion of sites rated A and a high proportion rated C. This is in part a reflection of the high degree of site destruction, since when data were being recorded sites known to have been destroyed by sand mining were rated C. Destroyed sites were nevertheless a low proportion of the total numbers of sites in the two northern regions, and ratings also reflect the general conditions of preservation and hence archaeological value of the sites.

It is worth noting that archaeological resources, in terms of sites likely to warrant further investigation, are richer in the two southern regions, both proportionally and in terms of absolute numbers of sites.

Mounding of Deposits

Mounded forms are unusual for middens comprising mainly rock platform or beach species of shellfish, but are common for estuarine shellfish species middens (Table 3-3) regardless of whether such deposits occur on the estuarine shorelines, on sandy backing slopes or on the slopes of headlands or valley sides adjacent to the estuary. The largest shell midden deposits along the New South Wales coast are mounds of estuarine species of shells. Such deposits include the elongated mounds of Clybucca (Connah 1975) and Stuarts Point (Connah 1976, Sullivan and Hughes 1978), and the circular mounds at Ballina (Bailey 1975), Wombah (McBryde 1974), Sussex Inlet (Sullivan 1977), Wagonga Inlet and Pambula Lake (Sullivan 1981).
### TABLE 3-1
Types of shell midden in each region

<table>
<thead>
<tr>
<th>Type of Deposit</th>
<th>Clarence-Moreton</th>
<th>New England</th>
<th>Sydney Basin</th>
<th>Molong-South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>%</td>
<td>No</td>
<td>%</td>
</tr>
<tr>
<td>Stratified open midden</td>
<td>62</td>
<td>91</td>
<td>176</td>
<td>91</td>
</tr>
<tr>
<td>Deflated open midden</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Shelter Deposit</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Buried occupation layer</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Surface scatter</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Surface worked stone</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Quarry</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

### TABLE 3-2
Subjective rating of recorded sites, showing number (and percentage) of sites with each rating

<table>
<thead>
<tr>
<th>Region</th>
<th>A No</th>
<th>A %</th>
<th>B No</th>
<th>B %</th>
<th>C No</th>
<th>C %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarence-Moreton</td>
<td>1</td>
<td>(1)</td>
<td>27</td>
<td>(40)</td>
<td>40</td>
<td>(59)</td>
</tr>
<tr>
<td>New England</td>
<td>4</td>
<td>(2)</td>
<td>83</td>
<td>(43)</td>
<td>107</td>
<td>(55)</td>
</tr>
<tr>
<td>Sydney Basin</td>
<td>20</td>
<td>(6)</td>
<td>166</td>
<td>(54)</td>
<td>123</td>
<td>(40)</td>
</tr>
<tr>
<td>Molong-South Coast</td>
<td>12</td>
<td>(5)</td>
<td>129</td>
<td>(56)</td>
<td>89</td>
<td>(39)</td>
</tr>
</tbody>
</table>

### TABLE 3-3
Percentage of sites with dominant shellfish suites as indicated, which occurred as mounded deposits

<table>
<thead>
<tr>
<th>Region</th>
<th>Beach</th>
<th>Estuarine</th>
<th>Rock Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarence-Moreton</td>
<td>0</td>
<td>57</td>
<td>0</td>
</tr>
<tr>
<td>New England</td>
<td>3</td>
<td>39</td>
<td>0</td>
</tr>
<tr>
<td>Sydney Basin</td>
<td>9</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Molong-South Coast</td>
<td>0</td>
<td>34</td>
<td>2</td>
</tr>
</tbody>
</table>
Smaller middens containing primarily estuarine shellfish genera are also common, and there appears to be no correlation with particular shellfish species, since all the common edible estuarine shellfish (Ostrea angasi, Crassostrea commercialis, Anadara trapezia, Pyrazus ebeninus) can normally be observed to occur in midden deposits of this form.

Site Aspect and Position Relative to Shelter

For all sites within the coastal zone showing distinct orientation, the directions towards which they face are shown in Fig. 3-5. Site aspect has been shown separately for the four regions, and it is apparent that there is a trend towards the southern part of the coastline for sites to be sheltered by headlands and to face towards the north and east. This phenomenon is discussed in more detail in Chapter 4.

In the Clarence-Moreton region sites in sheltered locations tend to be on the western sides of dunes. In the other three regions sites which are sheltered by dunes lie on the northerly to westerly sides of such landforms.

Dimensions of Shell Middens

The dimensions of the sites recorded vary considerably. Middens range in size from surface shell scatters 1m X 1m in area to very large stratified deposits in excess of 150,000 cu. m. and covering areas of about 200,000 sq. m (see Chapter 7).

Volume is the dimension which best enables middens to be compared. Larger volumes of midden present have been taken to infer greater use or a "preference" for particular areas, specific locations and certain shellfish species, and hence this dimension has been used in a number of crosstabulation calculations to assess the effect of particular variables on site locations.

In Fig. 3-6 the range of volumes of sites in each region is shown. In most of the subsequent calculations and comparisons these have been grouped into volume classes (as shown in Fig. 3-6 and Table 3-4). There is apparently a pronounced mode in each region for sites
Fig. 3-5. Aspects of shell middens.
Fig. 3-6. Volumes of shell middens in each region. Volume class shown (3).
### TABLE 3-4
Number of sites in each volume class

<table>
<thead>
<tr>
<th>Volume class</th>
<th>Clarence-Moreton</th>
<th>New England</th>
<th>Sydney Basin</th>
<th>Molong-South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>%</td>
<td>No</td>
<td>%</td>
</tr>
<tr>
<td>0.01-10</td>
<td>12</td>
<td>(18)</td>
<td>18</td>
<td>(9)</td>
</tr>
<tr>
<td>10-1,000</td>
<td>35</td>
<td>(51)</td>
<td>108</td>
<td>(56)</td>
</tr>
<tr>
<td>1,000-10,000+</td>
<td>21</td>
<td>(31)</td>
<td>68</td>
<td>(35)</td>
</tr>
<tr>
<td>Total Sites</td>
<td>68</td>
<td></td>
<td>194</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 3-5
Percentage of sites for which data were available, with various categories of bone recorded

<table>
<thead>
<tr>
<th>Bone category</th>
<th>Clarence-Moreton</th>
<th>New England</th>
<th>Sydney Basin</th>
<th>Molong-South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammal only</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Bird only</td>
<td>-</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Fish only</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Mixed or undifferentiated</td>
<td>10</td>
<td>24</td>
<td>33</td>
<td>25</td>
</tr>
<tr>
<td>None noted</td>
<td>82</td>
<td>65</td>
<td>59</td>
<td>64</td>
</tr>
</tbody>
</table>

### TABLE 3-6
Percentage of sites for which data were available, with each stone type recorded

<table>
<thead>
<tr>
<th>Stone type</th>
<th>Clarence-Moreton</th>
<th>New England Fold Belt</th>
<th>Sydney Basin</th>
<th>Molong-South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine acidic igneous</td>
<td>9</td>
<td>11</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Hornfels</td>
<td>5</td>
<td>7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Quartz</td>
<td>5</td>
<td>4</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>Sandstone</td>
<td>5</td>
<td>5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chert</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>Silcrete</td>
<td>3</td>
<td>3</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>Other (total)</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Unknown</td>
<td>23</td>
<td>25</td>
<td>39</td>
<td>32</td>
</tr>
<tr>
<td>None</td>
<td>39</td>
<td>36</td>
<td>22</td>
<td>21</td>
</tr>
</tbody>
</table>
in the volume range 100-3,000 cu.m, and a second smaller mode for very large sites, in excess of 10,000 cu.m. As will be argued in Chapter 4 however, these modes are more apparent that real and can be better explained as resulting from observer bias.

Shell Species in Middens

In the two northernmost structural regions rock platform species are least well represented in the midden deposits while in the two southern regions these shellfish suites dominate. Estuarine species however are consistently represented in 42% to 56% of the sites in each of the four regions (Fig. 3-7).

Bone in Deposits

Bone is not readily observed in shell middens in superficial surface examination, especially not by untrained observers. Where middens had been destroyed there was no way of retrieving this information if it was missing from the original site record. In less than 20% of middens in the Clarence-Moreton region, and at most about 40% of middens recorded from any region, was bone noted as present. Table 3-5 shows the proportions of middens with fish, bird, mammal and either mixed or undifferentiated bone recorded. Bone is almost invariably recovered from excavated shell middens however, and the low proportion of deposits noted as containing bone is probably mainly a reflection of the difficulty in distinguishing bone from shell in a normal compact midden deposit dominated by shell and characterised by fractured shells and dark organically stained sediments. Both of these effectively mask small or fragmented bones, especially if they are present only in low proportions.

Human burials (in some cases representing more than one individual) were noted in several shell middens along the entire length of the coastline, usually observed when they eroded from deflating deposits or were disturbed by construction activities. There were four in the Clarence-Moreton region, nine in the New England Fold Belt, eight in the Sydney Basin and nine in the Molong-South Coast region, where they included two cremated and crushed individuals. In most instances the burials appear to be of relatively recent origin,
Fig. 3-7. Shellfish suites in the sites

P = Platform species
B = Beach species
E = Estuarine species
probably from within the last 200 years. The absence of older burials from all but a few excavated sites probably reflects deterioration of the older bone through time. An additional factor is that sandy landforms such as dunes which have formed in the recent prehistoric past are also those which are currently most affected by erosion. Both male and female adults and children have been found in midden burials, and it appears likely that middens were easily dug into but remained relatively undisturbed, and were thus excellent burial sites.

**Stone as a Raw Material**

Stone, particularly the raw material used for stone artefacts was recorded on the data sheets when it had been noted in the site. As was the case for bone however, for shell middens which had been largely destroyed this evidence was commonly not available, unless such details had been included on the original record. These instances of middens which no longer exist represent the relatively high proportions of "unknown" or "not distinguished" categories for stone in Table 3-6. Where part or all of the midden deposit remained information missing from the initial records was derived by supplementary field observations.

**Diagnostic Artefacts**

As noted above, these data were not useful in the form of the original recording. Sites which were assumed to be Pre-Bondaian or Post-Bondaian by the original recorders may not have been so. As the only diagnostic artefacts generally recognised from sites are Bondaian, the distinction between Bondaian and undifferentiated artefacts is the only meaningful distinction in this part of the record.

Sites on whichbondi points or other backed pieces or geometric microliths had been recorded were noted as Bondaian sites. The high proportion of these in the Sydney Basin (12%), as shown in Table 3-7, reflected the relatively large number of sites in that region where surface collections or excavations had been carried out. Chronological control was poor, since the proportion of dated sites from each region was low (2% in the Molong-South Coast region to 12% in the
### TABLE 3-7

Percentage of sites with each category of artefact type recorded

<table>
<thead>
<tr>
<th>Artefact types</th>
<th>Clarence-Moreton</th>
<th>New England</th>
<th>Sydney Basin</th>
<th>Molong-South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prebondaian</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Bondaian</td>
<td>4</td>
<td>2</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Postbondaian</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Not distinguished</td>
<td>55</td>
<td>60</td>
<td>64</td>
<td>77</td>
</tr>
<tr>
<td>None</td>
<td>39</td>
<td>36</td>
<td>22</td>
<td>21</td>
</tr>
</tbody>
</table>

### TABLE 3-8

Percentage of shell middens recorded on each landform type

<table>
<thead>
<tr>
<th>Landforms</th>
<th>General Stability of location</th>
<th>Clarence-Moreton</th>
<th>New England</th>
<th>Sydney Basin</th>
<th>Molong-South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>EROSIONAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hillslope, crest slope or toe of headland, cliff top, escarpment</td>
<td>stable</td>
<td>7</td>
<td>11</td>
<td>51</td>
<td>36</td>
</tr>
<tr>
<td>Back of rock platform</td>
<td>unstable</td>
<td>-</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>DEPOSITIONAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inner barrier, backdune, beachridge, sandsheet</td>
<td>stable/ unstable</td>
<td>51</td>
<td>37</td>
<td>17</td>
<td>16</td>
</tr>
<tr>
<td>Beach, fordune</td>
<td>unstable</td>
<td>15</td>
<td>31</td>
<td>24</td>
<td>20</td>
</tr>
<tr>
<td>Floodplain</td>
<td>stable/ unstable</td>
<td>25</td>
<td>5</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Current or former estuarine shoreline</td>
<td>stable</td>
<td>1</td>
<td>21</td>
<td>5</td>
<td>21</td>
</tr>
</tbody>
</table>
Clarence-Moreton Basin) and at this broad level of survey the chronological information did not enable a better determination of artefact sequences to be established.

It is worth noting however, that stone artefacts were recorded from 60-65% of sites in the two northern regions, and from about 80% of the sites in the two southern regions.

Matrix of Deposits

The inorganic matrix of almost all the sites recorded is sand. This is consistently the case in 97-100% of sites in each region. The minor exceptions are sites where alluvial sediments or slopewash gravels make up the bulk of the inorganic sediment.

Landscape Variables in Site Locations

Shell midden sites were recorded from a wide range of coastal landforms, and these are listed in Table 3-8. This classification includes a description of the general stability of the landform groups, and it is apparent that 70-90% of the sites in the two northern regions and 40-45% in the two southern regions are on potentially unstable landforms, and are threatened either by deflation of sand deposits or by wave action on the backs of rock platforms.

Regardless of the general landforms on which they occur, most sites rest immediately on sand or fine-grained alluvial sediments. In the two northern regions 97-100% of the sites are on sand or, much less commonly, or fine alluvium. In the Sydney Basin 32% of the sites recorded rest directly on sandstone, mainly in rock shelters, as do 8% of the sites in the Molong-South Coast region, with the remainder chiefly on sand or fine alluvium.

Fresh Water

Sites are generally located close to fresh water, the source of which is mainly permanent or intermittent creeks. Swamps are the other common source of water, and 30-40% of sites in the two northern regions are located near swamps, and 5-10% of sites in the Sydney
Fig. 3-8. Relationship between numbers of sites and distance from water
Basin and Molong-South Coast regions.

In each region more than 70% of the sites recorded are within 150m of a source of fresh to slightly brackish water, 80-90% are located within 200m of water (see Fig. 3-8), and there is a rapid decline in the number of sites located further from water. This trend is most pronounced in the north, and towards the south a slightly larger proportion of the sites is located further from water. In general sites more than about 500m from drinking water are large deposits consisting almost entirely of shell.

**Rock Platforms and Locally Available Shellfish**

In all regions shellfish suites now available locally are those which occur in the adjacent middens, although in some cases fewer species can now be observed locally than are present in the middens. This is especially noticeable in areas of commercial rock oyster cultivation, where these shellfish have colonised all suitable local habitats destroying the normal platform ecosystems.

In the case of the association of sites with rock platforms, there are differences between the four regions. There is an increase southwards in the proportion of sites containing rock platform shell species, 24% in the Clarence-Moreton region, 49% in the New England region, 66% in the Sydney Basin and 74% in the Molong-South Coast region. Sites in the two southern regions are mainly closely associated with rock platforms, while those in the Clarence-Moreton region are most commonly not associated with platforms. In general shell midden sites are larger or more numerous near jointed rock platforms, and this relationship is discussed further in Chapter 4.

**DISCUSSION**

It is apparent from the variables noted that a number of factors indicate variation between regions or a trend along the length of the coastline, and some of these relationships will be investigated further in the following chapters. In particular the implications of these patterns, and some possible explanations of the relationships noted, are examined and elaborated in Chapter 4.
variables considered it is apparent that in terms of site observations and locational factors there is a broad division of the coastline into a northern section, comprising the Clarence-Moreton and New England regions, and a southern section made up of the Sydney Basin and Molong-South Coast regions. The similarities and differences between patterns in site locations within and between these two broad zones are also discussed in Chapter 4.
CHAPTER 4

SPECIFIC GENERALISATIONS, OR EXPLAINING
THE RESULTS OF THE STATISTICAL ANALYSES.

When the nature and distribution of some 800 shell middens from the entire coastal zone of New South Wales were compared, regional patterns were identified, as outlined in Chapter 3. These regional variations in the archaeological expression of one major type of prehistoric land use can be related to landscape variability between the four main structural regions into which the coastline was divided. Relationships between the form, location and contents of the middens and the landscapes in which they occur were described in Chapter 3.

In this chapter explanations are proposed for the patterns identified in the previous chapter, explanations which relate differences in the nature and distribution of sites to landscape variability. The variables considered are discussed in a similar order to that in which they were recorded in the field and discussed in Chapter 3; firstly those dealing with the nature and content of the midden deposits and secondly factors of site location.

NATURE AND CONTENT OF SHELL MIDDEN DEPOSITS

Site Type

Most coastal shell middens are stratified open deposits or stratified deposits in rock shelters (Table 3-1), although sites of this type, particularly open sites, may be largely deflated or partly buried by more recently deposited windblown sand. Surface scatters of shell were recorded where no apparent depth of deposit occurred but where the shell showed no evidence of having been deflated onto the surface. Surface exposures of worked stone, and quarries or stone sources were considered in the analyses only when they were immediately associated with, or formed an extension of, the middens.
When the nature and distribution of shell middens is considered, there is a major break in the pattern recorded along the length of the coastal zone, a break which divides the coastline into a northern and a southern section. In the northern section, comprising the two northernmost structural regions, there is a high proportion of stratified open shell midden deposits (91% of the sites in each region), which reflects the dominance of large depositional coastal plains with few areas of rock outcrop. This depositional landscape gives rise to a coastline dominated by long sandy beaches and deltaic floodplains, and most of the sites in these two regions are shell middens containing beach or estuarine shellfish species (see below).

The southern section is made up of the Sydney Basin and Molong-South Coast regions. The narrower Sydney Basin coastal zone is made up of a complex range of landform assemblages, and this is reflected in the more complex distribution of site types. Only 66% of the shell middens in this region are open sites, and the remaining 33% occur as deposits in rock shelters. It is probable that a very large number of open sites in areas developed for agriculture and for residential use, with associated commercial and industrial activities early in the history of European settlement, have been destroyed without record. Lime burning early in the history of the New South Wales colony (Chapter 7, Pearson 1981), and destruction during clearing and subsequent land development undoubtedly removed evidence of a very large number of such sites. While lime burning activities involved the destruction of rock shelter sites (Collins 1802:555) as well as open sites, land clearing and development probably affected a larger proportion of open sites.

While the appreciable numbers of rock shelter sites are therefore proportionally over-represented in the sites remaining, they are a real phenomenon of this region in particular. This is a direct reflection of the geological makeup of the Sydney Basin, with flat-lying sandstones readily undergoing cavernous weathering along bedding planes and joint lines to form shelters and overhangs which were sites of repeated occupation in prehistoric times (Hughes 1977, Attenbrow 1981).

In the Molong-South Coast region 91% of the sites are also open sites, but these show more variation in form and content than do sites on the uniform sandy shorelines of the northern part of the coastline.
The geological complexity of the narrow, mainly erosional coastal zone in this area is reflected in the wide variety of site types. Some 4% only of the shell middens are rock shelter deposits, corresponding to the low proportion of flat-lying jointed sandstone bedrock prone to the development of shelters and overhangs (see Table 2-1).

Climate

The main difference in the climate along the coastal zone is in average temperature. Despite the long distance of the coastline, and the consequent changes in latitude, the coastal climate is essentially uniform, and this is a function of moist air and maritime effects. Although not great (see Table 4-1), the differences mean that in the Clarence-Moreton region the average annual temperature range is about 9°C, and in the Molong-South Coast region it is about 7°C. In all four regions the coastal zone is backed by a hinterland of uplands in which frosts are common, but on the south coast the zone of regular winter frosts is closer to the coast than it is in the north. Frosts are uncommon on the coast, with frost-free days annually ranging from 355 in the south to more than 360 in the north. The subtropical climate in the north thus gives way to a temperate climate in the south, in each case tempered by a maritime effect. In terms of human comfort (Auliciems and Kalma 1981:20), the entire coastline is acceptably comfortable, with conditions in the two northern regions closely approaching optimal conditions for human comfort.

Rainfall variation is slight, with a more pronounced summer rainfall in the north, and a more even annual distribution of rainfall in the south. Winds are generally stronger and colder in the south of the area, and water temperatures are colder towards the south by about 5°C (Table 4-1). This difference is slight in terms of resource availability, with the colder water favouring the growth of the mussel _Mytilus planulatus_ and the warmer water favouring the pipi _Plebidonax deltoïdes_. The colder and stronger winds to the south appear to have influenced the aspects of sites in the south of the coast more than those in the north (see below).
Site Preservation and Reworking

It is significant that the number of sites rated A or B (as defined in Chapter 3) for each of two northern regions is lower at around 40% than for the two southern regions at 60%. This is partially a reflection of the effects of sandmining and associated development on the sandy beach dune complexes which predominate in the north of the coastal zone. It is also a function of the stability of the landforms on which the sites occur (Table 3-8). In the two northern regions 70-90% of the sites recorded are on potentially unstable aeolian and alluvial depositional landforms, a direct correlation with the high proportion (70-80% by length) of sandy coastline in these regions. In contrast on the narrower coastal zone in the south, with relatively little length of coastline dominated by wide depositional floodplains and barrier or dune sequences, about 60% of the sites are on stable bedrock landsurfaces. There can be no doubt that in the past, sites on unstable landforms are more likely to have been destroyed by erosional processes than those on bedrock, and it is likely that site preservation in the northern section of the coastline has been low relative to the rate of survival of sites in the south.

Reworking of sites however is more common in the two southern regions. Reworking by wave action of sites adjacent to headlands increases in effect southwards along the coastline, reflecting stronger wave activity. In the Clarence-Moreton region most of the sites on the W to NW sides of headlands are partially reworked, as are most of the sites on the N, NE and SW of headlands in the New England region. There is an increase in the range of aspects of sites subject to reworking in the south, and in both the Sydney Basin and Molong-South Coast regions sites are commonly reworked, regardless of the direction in which they face.

Midden Volumes

There appeared to be a number of volume modes for middens in each region. Close inspection of the volume class histogram (Fig. 3-6) however suggests that the apparent modes (or more strictly "peaks") in that graph are the result of bias in observation, since all are skewed
TABLE 4-1
Climatic Data for Coastal Areas

<table>
<thead>
<tr>
<th>Region:</th>
<th>Clarence-More on</th>
<th>New England</th>
<th>Sydney Basin</th>
<th>Molong-South Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Station:</td>
<td>Kempsey</td>
<td>Newcastle</td>
<td>Moruya</td>
</tr>
<tr>
<td></td>
<td>Ballina</td>
<td></td>
<td>Jervis Bay</td>
<td>Green Cape</td>
</tr>
<tr>
<td>Mean annual maximum</td>
<td>26</td>
<td>24</td>
<td>23</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>19</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Mean annual minimum</td>
<td>15</td>
<td>15</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Rainfall (mm)</td>
<td>1660</td>
<td>1100</td>
<td>1050</td>
<td>1200</td>
</tr>
<tr>
<td>Mean annual</td>
<td>summer</td>
<td>summer</td>
<td>winter</td>
<td>even</td>
</tr>
<tr>
<td>Dominant season</td>
<td>(pronounced)</td>
<td>(slight)</td>
<td>(slight)</td>
<td></td>
</tr>
<tr>
<td>Dominant wind direction</td>
<td>NW-NE</td>
<td>NW-NE</td>
<td>S-NE</td>
<td>S-NE</td>
</tr>
<tr>
<td>Average water</td>
<td>24</td>
<td>22</td>
<td>21.5</td>
<td>19</td>
</tr>
<tr>
<td>temperature (°C)</td>
<td></td>
<td></td>
<td>18.5</td>
<td>18</td>
</tr>
<tr>
<td>Number of frost free days</td>
<td>&gt;360</td>
<td>360</td>
<td>355</td>
<td>355</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>360</td>
<td>358</td>
</tr>
</tbody>
</table>

Sources: Australian Bureau of Meteorology, 1968; McBryde, 1974; Kalma and McAlpine, 1978; Callaghan, 1980.
towards the lower values in each class grouping. Midden volumes in this study were calculated from length, width and depth values, and it seems likely that in generalising in the three dimensions used to calculate volumes the observers have skewed the values towards the unit value of each volume class.

This is likely to have occurred as demonstrated by the following example:

A shell midden may have the real dimensions of length 95m, width 90m and depth 90cm. The volume of such a deposit is in fact about 7,700cu.m. The site recorder is likely to have rounded off these figures and noted them down as length 100m, width 100m and depth 1m. The volume would then be calculated as being 10,000cu.m.

Observer bias of this type would account for the apparent absence of sites in the volume ranges 7-10, 70-100 and 700-1,000cu.m. If such bias is taken into account, there is a fairly even distribution of midden volumes, with a tendency towards a mode in the 200-300cu.m volume, or 100-200cu.m in the Molong-South Coast region. There are also proportionally more sites larger than 1,000cu.m in the two northern regions than in the two southern regions. Similarly there is apparently a real secondary mode in the 2,000-3,000cu.m volumes.

The peak in the volume class equal to or larger than 10,000cu.m is real, since middens in this group were all of dimensions which produced a volume of at least 10,000cu.m, and many were considerably larger than that.

The dimensions on which these volume calculations were based were either taken from previous records or were recorded by me. Several observers were involved, and the records are those held by the New South Wales NPWS in its archaeological sites register. It is worth noting from this exercise that site dimensions such as these in any sites register are likely to be generalised, and that studies dependent on knowing precise volumes or areas would require accurate field recording to be carried out by the researcher concerned.

Midden volumes were grouped into a set of 3 (or occasionally 6) classes (as shown in Fig. 3-6 and Table 4-3) which separated these likely modes. Comparisons using midden volumes were carried out using these classed data, since the use of smaller groupings would be spurious.
Site Distribution

The spatial distributions of groups of these sites were examined in areas where comprehensive survey data were available, to determine the relationships between sites of different sizes. These were two well-surveyed areas, near Narooma on the south coast and near Evans Head in the north. In order to determine the general pattern of distribution of sites in each of these areas the linear distances between the sites were simply measured from the maps. In the Narooma example the largest sites (over 10,000cu.m) are spaced at approximately 4km intervals, those in the volume class 100-300cu.m are found at distances of about 2km from each other and from the larger sites, and sites smaller than 100cu.m occur at less than 1km intervals from both the larger site categories. Few undisturbed and well surveyed areas are known from the north coast, but in the Evans Head area, where site densities appeared to be high, the middens were more widely spaced than in the south. At Evans Head the largest sites (more than 10,000cu.m) were about 7km apart, and the smaller sites 250m to 1km apart.

These distributions appear to be typical of other areas along the coast where sufficient numbers of sites have been recorded to identify patterns of distribution. There are other areas where thorough surveys have been carried out (Lake Macquarie, Beecroft and Bherwarre Peninsulas, Tuross, Pambula), generally as the result of management planning or environmental impact assessments for proposed developments. The density of shell midden sites along the coast as recorded from those areas varies from 1 to 5 sites per kilometre, or 1 site per sq.km to 1 site per 10 sq.km (using distance measurements specified in Chapter 2). Although differences can be recognised, these possibly relate more to site destruction as the result of European land use than to initial differences in site locations. In general site densities are higher in areas with more diverse environments, and tend also to be higher in (less disturbed) areas on the south coast compared with the generally more disturbed landscapes in the north.
Shellfish Type

In the two northern regions most of the shell middens are dominated by either beach or estuarine species, whereas in the two southern regions rock platform shell species predominate (Fig. 3-7). This difference can be explained in terms of the very different landscapes in which these shell middens are set.

In the northernmost Clarence-Moreton region there are relatively few rock platforms, and the landscape is dominated by long sandy beaches and large deltaic floodplains. The coastal reaches of the New England Fold Belt are very similar to those of the Clarence-Moreton region to the north, with a larger number of small rock platforms, very few large rock platforms, and extensive beaches and deltaic floodplains. Beach species of shellfish present in midden deposits dominate only in the Clarence-Moreton but are also represented in more than 50% of the sites in the New England region. In both these regions rock platform shellfish species are dominant in only a minority of sites.

In the two northernmost structural regions rock platform shellfish are least well represented in the midden deposits while in the two southern regions these shellfish suites dominate. In the two southern regions beach species are present in only about 10% of all the deposits. Although this may reflect either a selection away from beach species or a climatic control which makes pipi readily available throughout the year only in the warm waters in the north, it is likely also to be directly associated with the high proportions of the length of the coastline in each of the two northern regions comprising sandy deposits (83% and 71% respectively - Table 2-1). Estuarine species however occur consistently in 42% to 56% of the sites in each of the four regions and this is apparently independent of the total areas of estuary in each region. Very large estuaries or deltaic floodplains occur primarily in the Clarence-Moreton and New England regions, whereas estuarine shell middens are also found on the shorelines of smaller backdune swamps and drowned ria-like or bay-mouth estuaries in the two southern regions.

In the two southern regions rock platform species dominate the shellfish types observed in the middens. The pattern of occurrence is very similar for these two regions, with rock platform species making
up either the major or secondary component in about 80% of the sites.

The change in this pattern of shellfish types in the middens occurs north of Newcastle where the landform expression of the Sydney Basin region occurs. Geomorphologically, on the immediate coastline the boundary between the New England Fold Belt and the Sydney Basin is not clear. Along Stockton Bight north of Newcastle a zone of vast sand accumulation which has built up over at least the last 6,000 years has obscured the rocky foreshore zone and has imposed a "north coast" landform type on the northern edge of the Sydney Basin (Chapter 2). Immediately north of this sandy area several closely spaced rock platforms occur, reminiscent much more of the Sydney Basin landforms than of those typical of the New England Fold Belt landscape. The boundary zone is therefore diffuse, extending over a shoreline distance of some 20 km between Port Stephens and Newcastle, with no single clear line to mark the break.

In the southern two regions the landscapes comprise numerous rocky headlands each generally extending to an intertidal platform, small bayhead beaches and crenulated drowned river mouth estuaries. Long sandy beaches and deltaic floodplains are rare, and coastal scenes in these southern regions more commonly feature rough waves breaking over rocky platforms than rolling breakers moving smoothly onto sandy beaches as in the north (Plates 4-1 and 4-2). These wave-washed, open-sea platforms provide an ideal habitat for gastropods, particularly where cracks or overhangs in the sublittoral reaches exist as niches for the largest such species.

Relatively little difference occurs in the minor shellfish component observed in midden deposits in the four major regions. It is possible that the minor shellfish component was not the particular resource being sought, but rather that these were gathered in addition during time spent on the coast, and consequently incorporated into the deposits. A complementary explanation is that a broadly common pattern of coastal exploitation persisted along the entire coastline, and shellfish of ubiquitous suites of small gastropods such as the top shells and nerites of the upper mid-littoral zones of virtually all rock platforms were collected similarly by all coastal shellfish gatherers.
PLATE 4-1. TYPICAL COASTAL SCENES ON THE NORTH COAST WITH LONG BEACHES, SPARSE ROCKY HEADLANDS AND DELTAIC FLOODPLAINS.
PLATE 4-2. TYPICAL COASTAL SCENES ON THE SOUTH COAST WITH ROCKY HEADLANDS AND WIDE WAVE-WASHED ROCK PLATFORMS.
When all sites are analysed, platform, estuarine and beach shellfish suites occur in that order in the sites. While this is a real reflection of the present remaining midden deposits it may also be a reflection of a lower rate of destruction of sites on the southern part of the coastline. If this is the case however, it is unlikely that in the two northern regions sites containing rock platform species (and hence more likely to have been near headlands) should have been selectively destroyed in preference to sites in dunes or along estuarine shores. Rather a contrary pattern of survival would be expected, with sites on rocky landforms such as headlands being selectively preserved rather than those on unstable sandy landforms. It is more likely that the sites presently surviving in fact reflect the proportion and range of sites which were certainly more numerous in the past (see e.g. Chapter 7, Sullivan 1981) and may be regarded as a "surviving representative sample" of the total number of shell midden deposits which have existed throughout the time of human occupation of the coastline.

**Shell Types and Other Contents**

In general shell middens which consist primarily of rock platform species contain both stone and bone more commonly than do sites with primarily estuarine species or beach species (pipi) shellfish (Table 4-2). It is possible that for grass-covered mounded estuarine shellfish sites, stone and bone are not observed as readily during field survey as they are on more open beach and platform species middens. Pipi middens, especially those in the northern section of the coastline similarly contain little bone, and it is likely that many of these middens do not represent occupation sites, but rather single meal events or dinner-time camps. Coleman (1978) interpreted the Macguires Crossing pipi midden site in this way, and it is likely that this site is typical of many such pipi middens. (See Chapter 5 for further discussion of pipi middens.)
**TABLE 4-2**
Proportion of Each Midden Type Containing Stone and Bone

<table>
<thead>
<tr>
<th>Region</th>
<th>BEACH</th>
<th></th>
<th>Estuarine</th>
<th></th>
<th>Rock Platform</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% with stone</td>
<td>% with bone</td>
<td>% with both stone and bone</td>
<td>% with stone</td>
<td>% with bone</td>
<td>% with both stone and bone</td>
</tr>
<tr>
<td>Clarence-Hobart</td>
<td>66</td>
<td>8</td>
<td>3</td>
<td>44</td>
<td>35</td>
<td>20</td>
</tr>
<tr>
<td>New England</td>
<td>64</td>
<td>29</td>
<td>15</td>
<td>55</td>
<td>37</td>
<td>35</td>
</tr>
<tr>
<td>Sydney Basin</td>
<td>90</td>
<td>27</td>
<td>19</td>
<td>52</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>Molong-South Coast</td>
<td>0*</td>
<td>0*</td>
<td>0*</td>
<td>60</td>
<td>29</td>
<td>25</td>
</tr>
<tr>
<td>Total shell middens</td>
<td>66</td>
<td>21</td>
<td>12</td>
<td>55</td>
<td>32</td>
<td>26</td>
</tr>
</tbody>
</table>

* Category contains less than 10 sites.
Midden Volumes and Other Contents

In general the largest shell middens are also those with the greatest variety of contents, and they usually contain bone and stone as well as shell (see Table 4-3). While it is difficult to generalise from very small numbers of sites (fewer than 10 in any category), there is nevertheless a trend apparent in Table 4-3 which indicates that the least complex sites in terms of contents are those in the medium size range 10 to 100 cu.m. The smallest sites (less than 1 cu.m) are generally more complex in their contents, commonly having both shell and at least one type of stone present, and the largest sites (more than 1,000 cu.m) generally have more than one stone type represented as well as bone. It appears from this content information that very small middens do not necessarily represent a single activity, which might be expected at a dinner-time camp, but commonly reflect the exploitation of vertebrate animals and contain evidence of stone artefact use as well as shellfish consumption. Such sites may in fact be campsites or occupation sites which were simply used for only a short stay.

In the southern section of the coastline there was a site volume mode in the range 10-30 cu.m, that is class 4 of Table 4-3. This group of sites is the least complex class in terms of site contents in each region, and it presumably represents a group of campsites used by Aboriginal groups foraging from a larger and more complex "base camp" some distance away. It is possible that these middens reflect repeated daytime use of campsites from which parties returned to the base camp. It is also possible that they are transit camps or the campsites of small parties, and that larger numbers of people used the larger and more complex sites at times of groups gathering on the coast.

Local Aboriginal stories suggest for instance that Murramarang Point, Bingie Bingie Point and the headlands above Summercloud Bay and the Tomaga River mouth were the locations of large gatherings at certain times (Jack Campbell, Ted Thomas, George Brown pers. comm.). Other large complex sites may have had a similar function.
### Table 4-3

Proportions of Sites in Each Volume Class with Stone and Bone Recorded as Present in the Deposits

<table>
<thead>
<tr>
<th>Volume Class</th>
<th>Midden Volume (cu m)</th>
<th>CLARENCE-MORETON</th>
<th>NEW ENGLAND</th>
<th>SYDNEY BASIN</th>
<th>MOLONG-SOUTH COAST</th>
<th>TOTAL SHELL MIDDENS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% with stone</td>
<td>% with bone</td>
<td>% with stone</td>
<td>% with bone</td>
<td>% with stone</td>
<td>% with bone</td>
</tr>
<tr>
<td>1</td>
<td>&lt;0.009</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0.1-0.9</td>
<td>66*</td>
<td>0*</td>
<td>33*</td>
<td>100*</td>
<td>95*</td>
</tr>
<tr>
<td>3</td>
<td>1-9</td>
<td>57*</td>
<td>0*</td>
<td>90</td>
<td>61</td>
<td>33</td>
</tr>
<tr>
<td>4</td>
<td>10-99</td>
<td>39</td>
<td>7</td>
<td>43</td>
<td>60</td>
<td>33</td>
</tr>
<tr>
<td>5</td>
<td>100-999</td>
<td>59</td>
<td>10</td>
<td>62</td>
<td>79</td>
<td>48</td>
</tr>
<tr>
<td>6</td>
<td>&gt;1,000</td>
<td>71</td>
<td>43</td>
<td>76</td>
<td>84</td>
<td>45</td>
</tr>
</tbody>
</table>

* Category contains less than 10 sites. # mixed stone means more than one type of raw material
Stone Content of Shell Middens

Stone artefacts are not generally abundant in coastal shell middens compared with shell-free archaeological deposits from further inland. To compare stone densities between sites, consideration must be given to both the area excavated and the period of time over which the sites were used. To account for both these factors comparisons have been made using numbers of artefacts per sq.m of excavated surface per 100 years of accumulation. At excavated sites without shell midden deposits in coastal hinterland sites in the Mangrove Creek catchment and at Sassafras shelter 1, in excess of 40 artefacts were discarded per sq.m per 100 years (Attenbrow 1981, App.2:19, Hughes and Djohadze 1980:25), compared with those from shell midden deposits of less than 10 for Bass Point (Bowdler 1970:43), Currajong Shelter 2 (Lampert 1971a:38, Hughes and Djohadze 1980:21), Burrill Lake (Lampert 1971a:17) and Wombah (McBryde 1974:291), and about 20 for Pambula (Chapter 8).

The relative proportions of stone types present in shell middens provide interesting information on prehistoric resource use. Edge ground artefacts have been recovered from such excavated deposits so rarely that no general pattern can be established. For flaked stone assemblages however from the pattern recognised on the coast there is little indication that much raw material was moved very far from its natural source. Up to three types of stone were recorded for each deposit in the observed order of abundance (Table 3-3). In the two northern regions a variety of stone types is represented in sites, volcanics, hornfels, cherts, tuffs (sandstones) and quartz being common, with a predominance of fine-grained acidic volcanic rock. In the two southern regions quartz, silcrete and fine-grained acidic volcanic rock are widely represented, with little other material of overall importance.

A gradual change along the coast in the raw materials recorded in sites can be observed, which correlates broadly with locally available sources of fine-grained siliceous rocks suitable for flaking. Silcretes and porphyritic volcanic rocks are rare in sites in the north where there are no natural outcrops of these stone sources, and tuffs and hornfels are rare in sites in the south where they do not occur in outcrop. Hornfels and acid volcanics in the north give way
to silicified tuffs of Permian age found as pebbles in Triassic sandstones along the central coast, and "cherts" which crop out along the coast in the Newcastle-Merewether area. Further south silcrete dominates the siliceous assemblages, and this gives way in areas to porphyritic acid volcanics which occur as pebbles eroding from Permian or Triassic sandstones.

Stone Working Sites

Although shell middens are not generally very rich in stone artefacts, a feature frequently observed on relatively undisturbed coastal areas, especially in southern New South Wales is the presence of stone working areas some ten metres to several hundred metres inland or upslope of shell midden deposits, particularly those on the crests and slopes of headlands. These sites are separate and different from the major stone workshops identified at Schnapper Point (McBryde 1982) and Yaccaba Head (McCarthy 1947, Starling 1974).

Stone working at the sites associated with middens is attested to by the presence of flaked pieces, cores and associated flakes as well as blade cores and blades in several stages of reduction. Such sites have been recorded from a backdune area at Evans Head near Lismore (a few kilometres south of the Schnapper Point site), Seal Rocks north of Newcastle,killalea near Wollongong, Captains Beach and Summercloudbay on Bherwerre Peninsula, sites behind both Pretty Beach and Pebby Beach north of Batemans Bay, at Mosquito Bay, Sunpatch and Bawley Point south of Batemans Bay, on Grey Rocks, Bingie Bingie, Boogumgorridge and Potato Points near Tuross and at Kianga, Wapengo and Long Point north of Merrimbula (Fig. 2-3). It is a locational phenomenon generally encountered where the rock platform of the headland is rich in shellfish, and these sites possibly represent debris from stone working activities associated with a relatively longer or more intensive period of occupation of such areas than occurred near less productive coastal landforms. Too few examples of this type of site distribution were observed to draw general conclusions on the pattern of occurrence, but it seems likely that many such stone working sites have been disturbed by roadbuilding and other development, and they would have been considerably more numerous in the past.
Stone artefacts noted on many of these sites included backed blades, other geometric microliths and eloueras, as well as a number of blade cores and utilised or unmodified flakes. Silcrete and porphyritic acidic volcanic rocks were the most common stone types in the sites, generally with quartz, and it seems likely from the artefact associations observed and the predominance of silcretes (see e.g. Hughes, Sullivan and Lampert 1973) that the use of these stone working sites was especially common in Bondaiian times, and probably continued after that.

Similar rock types generally occur within the stone assemblages recovered locally from excavated sites and noted from the surface exposures of shell middens nearby. Both the range of artefacts noted and the relatively large numbers of pieces of worked stone in these areas compared with stone occurrences in the shell middens however, suggests that they are flaking floors or slightly deflated stone working areas. These stone working activities are likely to have been associated with hunting or the maintenance of wooden artefacts, rather than with shellfish collecting. These activities were possibly directed towards the exploitation of "inland" rather than marine resources and may well represent the location of men's camping sites while women gathered shellfish on the adjacent rock platforms.

Matrix of Deposits

The matrix of archaeological deposits in open sites is overwhelmingly sand, with only a few sites in any region having a matrix of finer alluvium, fine estuarine sediments, or gravel. In the case of shelter sites the matrix is generally also sandy and is derived from roof-fall and/or colluvium washed in from the slopes around the shelters (see e.g. Hughes 1977, Hughes and Sullivan 1981). Shells may be sparsely dispersed through such a matrix, which is partly derived from the products of shell breakdown (Hughes 1977, Chapter 8) but it is virtually impossible to find examples of shell midden deposits which consist of shells without a sediment matrix. The largest midden deposits known in New South Wales, which occur discontinuously between Glybucca and Stuarts Point, are in fact those which appear on site observation to be those with the lowest proportion of contained sedimentary matrix of all midden sites.
observed.

Shell middens are therefore sites of sediment accumulation. It is likely that the highly organic rich deposits encouraged the growth of vegetation which acted to trap windblown sand (Hughes 1977:169). Occupation of rock shelters apparently accelerated the rate of roof-fall (Hughes 1977:113), and this occupation may have been commonly associated with burning or other disturbance on hillslopes above the shelters, with consequent increase in the amount of sediment transported down the slopes and trapped in the shelter deposits (Hughes and Sullivan 1979, 1981).

The Form of the Deposits

Open shell midden deposits which have not been disturbed by deflationary processes commonly occur as accumulations currently raised above the general ground surface. Others are in sand dune or floodplain depositional sequences where they are now buried by more recent sediment build-up (usually of windblown sand). The form of such buried sites indicates that they previously must have been raised accumulations on former surfaces. Such deposits are generally spread to a fairly even depth over part of the landscape, and commonly cover large sections of the slopes or crests of headlands, or form layers within or on beach dunes or high dunes mantling the slopes of promontories. The form of these deposits is essentially that of a "rectangular" layer, although this layer may be spread over a curved or irregular surface, and the superficial form of the deposit may assume that of a mound.

In some cases however shell deposits are built up as distinct mounds. These are generally circular in plan, although elongated mounds also occur. The proportions of the various dominant shellfish suites occurring as mounded midden deposits (Table 3-3) are worthy of comment. For the Clarence-Moreton region about 60% of the middens consisting primarily of estuarine shellfish are mounded while none of those comprising primarily beach or rock platform species is. In the New England Fold Belt region 40% of the estuarine shellfish middens are mounded, while only 3% of the dominantly beach species middens are mounded and none of those dominated by rock platform species occurs as a mound. In the Sydney Basin 10% each of estuarine and beach species
middens are mounded while only 4% of rock platform species middens show this form. In this region lobe-shaped mounded deposits commonly occur along the fronts of rock shelters and overhangs, and in general it is this specific topographic location rather than the species composition that has determined the form of such middens. Estuarine shellfish species in the Sydney Basin are commonly found as disturbed deposits along the shorelines of the drowned Hawkesbury and Georges River estuaries, and around Sydney Harbour. Their original form is now generally difficult to recognise. This factor of modern disturbance may account for the relatively low proportion of mounded middens in this region. In the Molong-South Coast region the proportion of mounded estuarine shell middens is 35%, with no mounded beach species shell middens and only 2% of the dominantly rock platform species middens occurring as mounded deposits.

There is no readily apparent determining factor for this phenomenon of mounding associated mainly with estuarine shell middens. Large mounds have been suggested as a means of elevating camping sites above swampy mosquito-ridden landscapes along the coastline of tropical Australia in Arnhemland (Peterson 1973) and on Cape York (Bailey 1977), and at Ballina in New South Wales (Bailey 1975). Perhaps some insight is also given by a conversation in March 1981 with Jack Campbell, a senior member of the Jerringa Aboriginal community from Orient Point near Nowra in the southern part of the Sydney Basin. He remarked that when he was a child he and his peers were encouraged by the adults present always to put shells from their food, or even from their fishing bait back "on the heap...because if you just leave them anywhere they run away...they run off you know."

When pressed for further explanation he said that coastal camps were always established very close to pre-existing shell middens, where it was seen to have been "...a good place to camp because people had stopped there before..." and the shells discarded by the group were put on the existing heap. This implies that shell middens were used, by some Aboriginal groups at least, as markers of good campsites and fishing spots, and the maintenance of the midden was to some extent a deliberate activity. It is also likely that the locations in which estuarine shell middens occur (most commonly on the banks of estuaries), are in landscape terms the least distinctive. While some degree of intuition, or basic common sense, might lead a group to the
sheltered sandy campsite where a creek had breached a coastal dune on the north side of a headland, perhaps markers were more necessary for estuarine sites.

This explanation is consistent with archaeological observations. Sites which contain a large variety of contents, shell, bones of land mammals as well as fish, worked stone and other cultural remains, are likely to have been occupation sites rather than shell processing dumps or dinner-time camps (Meehan 1975, 1977). The large mounded shell middens which have been excavated in New South Wales—Ballina (Bailey 1975), Stuarts Point (Connah 1976, Coleman 1978, Callaghan 1980), Wombah (McBryde 1974), St. Georges Basin (Barz 1977), Wagonga Inlet (Anderson 1890), Pambula Lake (Anderson 1890, Chapter 8)—have all been sites of this type, and all represent repeated phases of occupation. No small, non-mounded, open estuarine deposits have so far been excavated, but it is likely that these may have represented dinner-time camps, with a fortuitous choice of location for a single meal, but not for repeated use involving a number of activities. If this were the case it would be expected that such sites would contain little else but shells and hearth stones.

FACTORS IN SITE LOCATION

Several factors influence the patterns of site location, and these were identified in Chapter 3. All of these however can be grouped into three categories: access to water, availability of food and shelter and comfort in campsite locations.

Access to Water

The general relationship between the numbers of sites and distance from fresh (or slightly brackish) water is shown in Fig. 3-8. This relationship is a simple one, and proximity to drinking water or sources of water which may have attracted game, is apparently the single most important factor in site location, especially in warmer areas in the north of the coastal zone. When total volumes of shell middens are considered in relation to water sources however, the relationship can be refined somewhat (Fig. 4-1). Volumes of middens more closely reflect the distribution in relation to water than do
Fig. 4-1. Numbers of sites weighted for midden volume related to distance from fresh water.
numbers of sites. Fig. 4-1 shows the numbers of sites weighted for midden volume such that the numbers in the largest volume class (4) have been multiplied by 3, those in the middle class (3) by 2 and those in the smallest class (2) by 1. When these values are plotted against grouped distance from water, there is a very close relationship between volume of midden and distance from water. Large volumes of shell middens are found within 100m of water, and beyond 200m from water there is a sharp decline in the volume of middens found.

As occurred for numbers of sites in relation to distance from water, there is a tendency for larger volumes of midden to be found further from water in the southern part of the coastal zone than in the north. Nevertheless proximity to water appears to be a major factor in site location.

**Availability of Food**

The availability of food resources, especially of shellfish, is influenced by a number of factors which in turn influence midden site locations. Several of these have been considered in this study, and their influence assessed. In doing this the best guide to "preferred" locations is the total volume of shell midden in any location. From survey information alone it is not generally possible to interpret the meaning of any deposit in terms of repeated use by a few people, a single event of prolonged use by a few people or an event representing a short use of the site by a very large number of people. Whatever any single site represents in term of prehistoric use however, larger midden volumes reflect greater total use of a site than do smaller volumes. Midden volume can therefore be used as a variable which reflects "preferred" locational factors.

The arbitrary weighting system described above was used with the numbers of sites in each of the three volume classes delimited in Fig. 3-6, to assess the effects of a number of landscape variables on midden locations: lithology, area, slope and form of the nearby rock platforms, specific landform units and substrata.
For shell middens associated with rock platforms there is a
definite correlation between platform lithology (and thus form) and
the numbers or volumes of shell middens which occur nearby. In Table
4-4 the number of sites per kilometre of coastline of each rock type
is shown. It can be seen from this that the relative density of sites
on coarse acidic (granitic) rocks and sandstones is higher than on
other rock types, both generally and within each region where they
occur. For the New England region fine grained acidic rocks also
produced a high density of midden sites. When midden volumes are
taken into account this tendency is more pronounced. Fig. 4-2 shows
the result of weighting as above for six volume classes (as shown in
Table 4-3) per kilometre of coastline. Coarse acidic, sandstone,
shale and coarse basic rock platforms have provided a decreasing
proportion of midden volumes per kilometre of coastline.

This is almost certainly not related to the shellfish species
which occur on the platforms. There is no difference in the shellfish
suites associated with various lithologies in eastern Australia (Dakin
1952:53). Differences do occur however in the relative numbers of
shellfish on platforms of various types, largely due to the range of
habitats provided.

Exfoliating and jointed granitic platforms and jointed or
honeycombed sandstone platforms maintain deep cracks and pools within
which large gastropods congregate. The broken or smooth platforms on
fine grained acidic or metamorphic rocks do not provide such niches.
Broad smooth platforms on flat-lying shale are commonly jointed along
lines of mineral segregation, or develop rock pools within which such
organisms are found, but lumpy shale reefs or platforms do not provide
such habitats. This can be seen from Fig. 4-3; when weighted volume
class is plotted against platform form, there is a clear indication
that the largest volumes of midden deposit are associated with jointed
platforms.

Platform slope also appears to have influenced the volumes of
shell middens associated with rock platforms. Fig. 4-4 shows weighted
numbers of shell middens from three volume classes related to the
slope of nearby rock platforms. The greatest volumes of shell midden
are associated with platforms of low slope angles (0 to 2 degrees).
This probably reflects the higher shellfish productivity of gently
sloping platforms as the intertidal area which tends to be rich in
TABLE 4-4

Number of Sites per Kilometre of Coastline on
Each Rock Type

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Fig. 4-2. Weighted midden number per kilometre of coastline associated with each rock platform type
Fig. 4-3. Midden volume related to form of adjacent rock platforms.
### Crosstabulation of VOL by PSLOPE

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Number of missing observations = 9

Fig. 4-4A

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Weighted number of sites

C Clarence-Moreton
N New England
S Sydney Basin
M Molong-South Coast

0-2° 3-5° 6-10° 10°

Fig. 4-4, Relationship between midden volume as shown by weighted numbers of sites and platform slope.

A - computer cross-tabulation for the Molong-South Coast region
B - graph showing weighted numbers of sites in each platform slope class
shellfish is greater on such platforms than that on most flat-lying platforms. Rocks which dip much more steeply tend to produce reef-like platforms with small surface areas subject to tidal inundation. Such platforms are commonly also associated with steep cliffs which make the platforms inaccessible.

In contrast platform area is not a major factor determining the volumes of associated middens, as indicated by the absence of a relationship between midden volume and platform area (Fig. 4-5). This observation is relevant to the question of pressure on coastal resources. The fact that small rock platforms are associated with similar midden volumes to larger platforms implies that similar amounts of shellfish were collected from the whole range of platform sizes. Presumably larger platforms could have provided greater amounts of shellfish if required, since there is a direct relationship between the areas of intertidal platforms and the numbers of organisms recorded on them (Besly and Meyer 1954). Had there been pressure on coastal resources during the periods of prehistory in which the middens which are now visible on the coastline accumulated, it would be expected that collectors of shellfish would have focussed on the largest platforms, or that larger platforms would have been exploited to a greater degree.

It can be inferred from these results that the exploitation of platforms followed a similar pattern (perhaps similar amounts of time spent near any single platform before the group moved on) and that nowhere on the coast was there gross evidence of pressure on available shellfish resources.

While carrying out observations in the field, I attempted to note examples where particular shellfish species appeared to decrease in size through the middens. No such trend was apparent for any species in any region, although several middens had lenses of smaller and larger shells of some common species. In other areas decrease in shellfish size has been shown to reflect over-exploitation of the community due to human population pressure (Swadling 1976). If there was pressure on New South Wales coastal resources this can only have been manifested in subtle changes, and will be detected in future only by carrying out detailed measurements on large numbers of shells from a number of excavated midden deposits.
Fig. 4-5. Proportions of midden volumes (weighted) near platforms of each area class.
A showing total weighted volumes
B weighted midden volume per unit of platform in each area class
Site Aspect and Shelter

Site locational factors which relate directly to the immediate site are those which affect the comfort of the site's users. Two factors appear to be important from this point of view, immediate substrate and site aspect and shelter. In Chapter 3 it was shown that sites are almost all located on sand, and this can only reflect a preference for a soft substrate on which to camp. Site aspects and shelter however vary along the coastline.

Total Sites

Although most New South Wales coastal sites have an easterly aspect towards the coastline (Fig. 3-5A), in detail site aspect reflects the different climatic conditions in the four geographic areas. The two northernmost regions show a predominance of sites facing east to slightly south of east, directly towards the near north-south trending coastline (Fig. 3-5B and C). Most of these sites are pipi (Plebidonax deltoides) shell middens distributed along the seaward side of the foredunes behind the beaches. Pipis can now be collected along the intertidal zone of most open sandy beaches in these regions, and the predictable aspect for such middens, if they represent the local consumption or processing of shellfish, is facing the coastline. A small number of sites face slightly south of east to slightly north of east in each of the two northern divisions of the coastline, and a larger number of sites face west. Sites with a westerly aspect are those at the back of coastal sand dunes, facing towards lagoons or swamps impounded or perched behind the dunes. They are generally pipi shell middens, comprising shell carried inland from the beach zone as much as 4km away to the east, and apparently represent campsites adjacent to fresh water and perhaps other swamp resources such as edible or fibre-producing plants, where shellfish were consumed.

Southward along the coastline there is a gradual change in site aspect which undoubtedly reflects a response to the increasingly cold and effective southerly to southwesterly onshore winds (Fig. 3-5D and E). Through the Sydney Basin area there is a dominance of sites facing east to distinctly north of east, with a considerably lower
proportion of sites facing the prevailing southerly wind than in either of the regions to the north. This trend is apparent despite the orientation of the coastline which south of Newcastle is directed toward the southeast, and hence it might be expected that more coastal sites would display a southerly aspect. In the Molong-South Coast region the tendency of sites to face away from the wind (Sullivan 1976:67) is most pronounced, and in this region sites face predominantly north of east. This undoubtedly reflects the strong cold onshore winds which dominate the air movement pattern of southern coastal New South Wales.

Open Sites

When rock shelter deposits (which hence incorporate a local sheltering factor) are omitted from the sites considered, some difference in the pattern of site aspect results. For the Clarence-Moreton Basin and New England Fold Belt where less than 1% of the shell midden deposits are within rock shelters, there is no change in the pattern. For the Sydney Basin where 33% of the sites considered are shelter deposits, the pattern changes appreciably. At open site locations, where people were much more exposed to the effects of wind, there was clearly a tendency to seek shelter on the northerly side of dunes and headlands, away from the prevailing southerly to southeasterly winds (Fig. 3-5G and H). Shelter sites with shell midden deposits on the other hand face mainly north east or west, and predominantly north rather than south (Fig. 3-5F). This is a reflection of both NS-EW jointing and stream patterns determining the aspect of the shelters as well as locations chosen apparently for winter warmth as well as for shelter from cold winds or rain.

For the Molong-South Coast area, the pattern of site aspect is also altered somewhat when shelter sites are excluded from the sample (Fig. 3-5H). In this case sites face overwhelmingly to the north and east, and are mainly located on the northern sides of headlands in areas where their occupants were sheltered from the southerly to southeasterly winter winds.
SUMMARY

The consideration of individual factors in midden site location contributes to an understanding of prehistoric use of the landscape. In this analysis a number of relationships between sites and their environmental settings have been demonstrated, and patterns typical of the northern and southern sections of the coastline have been identified.

In the north, beach and estuarine sites were important, and in the following chapter particular examples of sites of these types are considered in more detail. In the south, rock platform and estuarine sites predominate, and details of the nature and distribution of these sites are given in the next three chapters.
CHAPTER 5

SPECIFIC LANDSCAPE STUDIES

BACKGROUND

In the two preceding chapters general patterns of the nature and location of coastal sites have been identified and their relationships with their landscape settings explained. In this chapter particular examples of sites which exemplify these patterns are considered in more detail. It has been shown (Chapters 3 and 4) that the New South Wales coastline can be divided on environmental and archaeological grounds into a northern and a southern section with the division occurring near Port Stephens. Specific sites and complexes of sites are now considered which reflect the typical patterns so far recognised within these two coastal units. In addition ethnohistorical evidence, and information resulting from a number of archaeological investigations, will be used to exemplify these patterns.

In recent years the archaeology of offshore islands has received increasing attention both to the north of the study area along the Queensland coast (Campbell 1979, Rowland 1980, in press), and to the south in Bass Strait (Bowdler 1979, Gaughwin 1978, Jones 1977). Too few island sites are known from New South Wales to allow statistical analyses to be undertaken on this special group of sites as distinct from "mainland" coastal sites. They nevertheless reflect a specific type of landscape utilisation which is important in reconstructing coastal prehistory and accordingly island archaeology is considered qualitatively in some detail in this chapter.

THE NORTH COAST

In the far north of New South Wales the change from the New England Fold Belt to the Clarence-Moreton Basin makes little difference to the largely sand-mantled coastal landscape, and the coastline north from Port Stephens can thus be considered as one major
unit. In landscape terms it differs from the southern unit mainly because of its relatively unstable depositional coastline, which has changed markedly during the time of Aboriginal occupation.

Several studies of shell middens have been carried out in this coastal unit, and these have enabled the main patterns of landscape use to be described in some detail. They include a systematic study of the Clarence River Valley, involving the excavation of a large mounded midden at Wombah (McBryde 1974, 1976, 1982), auger sampling of shell midden deposits in the Macleay River Valley (Campbell 1972), and major excavations of large mounded shell middens near Ballina (Bailey 1975). Systematic surveys of areas of the coastline between Brooms Head and Sandon Bluffs (Rowland 1978) and of proposed sand mining areas (Starling 1974) have also been carried out. Other investigations which have been used in this study are:

* investigations of sites on a headland, barrier beach and perched swamp complex near Evans Head (Sullivan 1979);
* detailed analyses by members of the Department of Prehistory and Archaeology, University of New England, of the material from a large mounded estuarine midden at Stuarts Point (Connah 1976);
* investigations of dune site complexes near Crowdy Bay (Sullivan 1978a) and at Stockton Bight (Sullivan 1980a).

To the north of this area a major project by archaeologists at the University of Queensland is underway to identify patterns of site occurrence in the Moreton Bay area (Hall 1980). Preliminary results only from that study have been reported to date, and as these are insufficiently detailed to allow comparisons to be drawn, the present study has been directed at areas south of the junction of the Brisbane Block and the Clarence-Moretort Basin, near Cape Byron.

The Archaeological Record

Archaeological evidence from the north coast presented in Chapters 3 and 4, has demonstrated the importance of estuarine and beach environments as sources of food in prehistoric times. There is a rich ethnohistorical record for the northern section of the coastline, and this can also be used to infer many aspects of recent prehistoric land use. Although the ethnographic analogy is likely to be directly relevant only to the most recent prehistoric period, the
ethnohistorical observations (summarised in McBryde 1978) seem to be consistent with much of the archaeological evidence presented by Connah (1976), Coleman (1978) and Callaghan (1980) for the Macleay Valley sites. Other aspects of prehistoric land use can be inferred from the nature and locations of archaeological sites, and from consideration of their contents and chronologies where these are known. The archaeological sites considered below include a number of pipi middens, and estuarine sites in the Macleay Valley.

**Pipi Middens in the Evans Head Area**

An archaeological survey was carried out as part of an environmental assessment of an area near Evans Head (Fig. 2-3), being used by the Australian Department of Defence (Sullivan 1979). The results of this survey provide considerable information on site locations which can be related to the use of the area in recent prehistoric times. Sixteen pipi shell middens were recorded in the survey, in an area of about 25sq.km (Fig. 5-1). These ranged in size from small scatters less than 5sq.m in area to bands of shell extending over hundreds of metres within the foredunes. No rock platform species of shellfish were observed, although some of the middens were within a few hundred metres of the Schnapper Point headland. There appeared to have been a focus of Aboriginal activity towards the immediate coastal zone, with an emphasis on the collecting of pipis. Several split pebble earth stones were noted in the single layer of shells which made up most of the middens, indicating that people had camped and cooked food in the near-coastal dunes. Flaked stone was observed on only two such sites, and it is likely that most of these sites were not campsites, but "dinner time" camps. A second focus of activity appeared to have been the perched lagoons immediately west of the inner barrier dunes. Four sites were observed on somewhat disturbed ground adjacent to the lagoons, and pipis had been carried inland about 1.5 to 3km to the lagoon shorelines. Flaked stone and hearthstones were also present, suggesting these lagoon margin sites were campsites rather than single meal deposits.
Fig. 5-1. Archaeological sites in the Evans Head area
Other Coastal Foredune Sites With Pipi

Several other pipi shell middens in the northern section of the coastline have been investigated (Fig. 5-2). In each case there are similarities with the foredune sites in the Evans Head area. A site at Crowdy Head (Fig. 5-3) investigated as part of an environmental impact assessment (Sullivan 1978a) produced a radiocarbon date on shell from the single layer of pipi shell of 410+80 years B.P. (ANU 2381). No worked stone was recovered in the material collected over 2sq.m where this midden was being deflated onto a dune blowout, however more than 150 fragments of heat-shattered acidic volcanic rock were collected, and these all appeared to have been derived from at least 14 hearth stones (Plate 5-1). In this site occasional rock platform shellfish occurred at the margin of the site nearest to the headland. No rock platform shellfish were observed in the midden further than about 400m from the headland, pipi making up the entire shell assemblage beyond that. The site formerly may have extended further along the beach, as pipi shells are now scattered on the re-established surface of the previously sand-mined dunes. It now extends over about 2km within the undisturbed foredune.

A pipi shell midden at Freshwater Lagoons behind Stockton Bight (Fig. 5-4), also recorded during an environmental assessment survey (Sullivan 1980b), is somewhat different from the other pipi shell middens considered here, although like many other such sites it rests on a podzolised formerly stable dune surface. The site is unusual because of its location. Fresh water soaking from the surrounding high sand dunes has maintained an open water swamp, and pipi shells have been carried about 2km inland to the site (A of Fig. 5-4). A second less disturbed deposit (site B) was observed nearby at the margin of the backdunes, and adjacent to a riverine floodplain. Estuarine shell species (mainly cockle), and fish and macropod bones were present in this site, as well as pipi shells. There was also a considerable amount of both flaked and heat shattered stone, suggesting this location on the margin of a number of environmental zones was a campsite.

A deflated section of the swamp margin site (Plate 5-2) revealed a large number of flaked stone artefacts made on silicified tuff, Merewether chert and silcretes. These included unmodified flakes,
PLATE 5-1. HEARTH STONES FROM THE CROWDY HEAD PIPI MIDDEN.

PLATE 5-2. STONE ARTEFACTS ON THE DEFLATED SITE (A) AT STOCKTON BIGHT.
Fig. 5-2. Locations of some pipi midden deposits which have been investigated on the north coast.
Aboriginal archaeological sites previously recorded
R Z M plant
Swampland
Flood
Approximate limit of loose sand
Area of previous sand mining

Fig. 5-3. Shell midden exposures in the Crowdy Head dunes
Fig. 5-4. Location of archaeological sites in the Freshwater Lagoons area.
cores and flaked pieces, elouras and other geometric microliths at a
density of about 5 to 10 per sq.m. Charcoal on this deflating surface
gave a radiocarbon date of 700 ± 80 years B.P. (ANU 2380), however
this charcoal could well be more recent than the bulk of the deflated
material. This location also appears to have been an area of stone
working as well as of food preparation, and the large amount of varied
stone suggests it represents a campsite of long duration or of
repeated use.

At Maguires Crossing a pipi shell midden behind a barrier dune
complex was investigated along with other lower Macleay Valley sites
(see below). It was concluded that the site was not an occupation
site, but rather a dinner time camp (Coleman 1978:170, Callaghan
1980:80). A similar conclusion could be drawn for most pipi middens of
the north coast which contain virtually only shell and occasional
hearthstones, since from such minimal archaeological evidence it is
difficult to assign a site function apart from the processing of
shellfish and the preparation of a meal.

Pipi shell middens thus seem to have reflected an important
aspect of north coast economies. Most of the sites appear to lack
depth of deposit or variation in structure of contents. In general
these sites seem to represent the use only of these shellfish, and the
lack of contents other than hearthstones and occasional stone flakes
in these sites makes it likely that they represent short-stay
campsites. They nevertheless make up a large proportion of the sites
recorded from the north coast, and although comprising only a single
layer of shells, many such sites extend over several kilometres along
the foredunes. The collecting of pipis on the north coast beaches
therefore must have been an important activity in recent prehistoric
times.

**Estuarine Sites in the Macleay Valley**

Several sites in the Macleay Valley have been studied (Fig. 5-5),
and detailed work has been carried out on the Stuarts Point-Glybucca
complex by Connah (1976), Coleman (1978) and Callaghan (1980).
The findings of these studies can be very broadly summarised:
Fig. 5-5. Location of archaeological sites studied in the lower Macleay River Valley
The sites in the lower Macleay Valley include the largest shell midden deposits in New South Wales. These are elongated mounds comprising mainly cockle shells (Anadara trapezia) in the basal layers, and rock oyster (Crassostrea commercialis) in the upper layers. All of the estuarine sites appear to have been occupied between about 5,000 and 2,000 years B.P.

At Stuarts Point, an estuarine site near the Macleay River mouth, fishing was more important than the hunting of land mammals while 12km inland at Clybucca, a deltaic floodplain site at the inland end of the same Stuarts Point-Clybucca midden complex, hunting land mammals was more important than fishing (Callaghan 1980:105). At both sites backed blades were recovered, suggestive of hunting land animals (Coleman 1978:179). At Connection Creek, now on a swamp but once on an estuarine embayment, fishing and hunting were about equivalent in importance. Although no backed blades were recovered from the excavated material (Coleman 1978:179), the bones of large macropods were present in the site.

At Clybucca and Stuarts Point stout bone points presumed to have been used for hunting land mammals outnumbered the slender points used for fishing, and at Connection Creek the slender forms predominated (Callaghan 1980:105). Lampert (1966:107-112) noted the presence of a large number of similar slender bone points in the Durras North deposit, and argued a case for their having been used as the prong tips or barbs of fishing spears. There are ethnohistorical accounts of the use of such spears in the Macleay area, and Coleman (1978:138) suggested a change through time, based on excavated material from Stuarts Point, from bone to marsupial teeth to hardened wood for spear barbs.

In the three estuarine sites over 90% of fishbones represented were of dusky flathead (Platypus fusca) and black bream (Myliobatis australis). Both the bream and flathead were mostly sexually immature (on size grounds) and thus were probably netted in the estuary in the summer prior to the May-August spawn periods (Coleman 1978:164), however some larger bream, snapper and possibly flathead must have been speared or netted offshore.
All the sites studied indicate that a summer occupation was likely for the lower Macleay Valley. The ethnohistorical evidence for the Macleay Valley (Campbell 1978:94) indicates a similar pattern of seasonal movement to that recorded for the Clarence River (McBryde 1976:54,66). This evidence suggests population mobility in the upper reaches of the valleys, and a more sedentary existence on the lower reaches of the floodplains. There are also reports for many areas in northern New South Wales, including the Clarence Valley, of Aboriginal use of the uplands during summer (McBryde 1974:338). It is likely that Aborigines were also using the coastal areas during winter, and that the lack of evidence of winter occupation is due to the nature of preservation of winter seasonal indicators.

The archaeological evidence for the estuarine sites in the Macleay Valley thus suggests that estuarine exploitation was carried out in conjunction with the exploitation of terrestrial environments. There is a good correspondence between the impression gained from an overview of a large number of sites and information available from excavations and other detailed investigations. These confirm the ethnohistorical accounts of an emphasis on the use of estuarine and terrestrial environments, but emphasise as well the use of beach resources on the north coast. Detailed archaeological investigations support the impression of an economy strongly influenced by the local environment. Beaches and estuaries were important bases for subsistence, while rock platforms (which are widely spaced, and commonly on steeply dipping rocks and backed by steep cliffs) were apparently of little importance in the area (Fig. 3-7).

Environmental Changes on the North Coast

As discussed in Chapter 2, coastal landforms along the north coast underwent complex and radical changes in Holocene times, as did the deltaic floodplains that filled in the estuaries that formed behind these coastal landforms. In this section I will illustrate the relationship between such environmental change and prehistoric land use as reflected in shell middens with reference to the Macleay River deltaic floodplain, as this is the only system to have been investigated closely from both geomorphological and archaeological perspectives.
There have been major changes in the configuration of the Macleay deltaic floodplain in Holocene times (Voisey 1934, Hails 1968, Walker 1970). At the time when sea level reached its present level about 6,000 years ago, the lower Macleay Valley was a large open estuary (Hails 1968:142). It then gradually filled in with sediment and the open estuary progressively gave way to swampy lowlands with migrating river channels which in turn filled in further to form alluvial plains. By about 3,500 years B.P. the estuary had largely filled in with sediment such that sedimentation was predominantly alluvial rather than estuarine (Walker 1970:683). The process of filling continued into European times; Hails noted for example that "some small lagoons have been infilled since white people settled in the valley" (1968:114).

A detailed analysis of the sources of sediment and the modes and rates of erosion, transport and deposition is clearly beyond the scope of this study. It is tempting however to speculate that Aboriginal activity in the catchment, especially burning, provided some of the sediment which so markedly changed the delta environment (see Hughes and Sullivan 1981). Certainly the role that prehistoric people on the north coast had in modifying the landscape is a topic that has received scant attention.

These major landscape changes must have affected Aboriginal usage of the resources of the estuary-floodplain, especially fish and shellfish, and thus the nature and location of shell middens. Such changes are reflected in the archaeological record, but at our present stage of knowledge only gross correlations can be drawn between the archaeology of the Macleay River valley and the history of landscape change. Archaeological and historical evidence indicate that at the time of European contact the floodplain was the richest resource zone in the catchment and that Aboriginal occupation was concentrated on the lower, estuarine, reaches of the river system (e.g. Hodgkinson 1845:233, Callaghan 1980:52 ff.). At the time of the earliest evidence for occupation of the valley, between 5,000 and 2,500 B.P., the picture was markedly different. The estuarine embayment had not yet completely filled in with sediment and the Glybucca and Stuarts Point shell midden complexes were located along the shorelines of what were then relatively open bodies of saline water. The lower levels of all of these middens are dominated by cockles (Anadara trapezia) which prefer open estuarine conditions with fine textured beds. In contrast,
the upper levels are dominated by rock oysters (*Crassostrea commercialis*) and these indicate that the open estuarine conditions had given way to confined channels with mangrove communities which provided a firm substrate on which the oysters could grow. The deltaic floodplain in these areas has filled in further over the last 2,500 years such that the rich supplies of estuarine shellfish and fish are no longer locally available.

These changes are best illustrated with reference to the Stuarts Point shell midden complex. The midden accumulated along a beachridge on the eastern shoreline of an estuarine embayment (Fig. 5-6). This former embayment has filled through sediment deposition, and now consists of a low swampy area traversed by creeks, and supporting characteristic swamp vegetation including *Melaleuca* and *Casuarina* trees, and a ground cover of sedges and grasses (Sullivan and Hughes 1978). It seems probable that the Stuarts Point complex was abandoned simply because the estuarine embayment filled with sediment, thus eliminating the locally available supply of estuarine food.

Coleman (in press) questions that the Stuarts Point complex was abandoned because of environmental change (see below). She clearly sees the still fish and shellfish-rich estuarine Macleay Arm to the east as having been the major source of estuarine food brought to the middens (Fig. 5-6). From the location of the midden complex with respect to the former estuarine embayment to the west however it is more likely that the estuarine foods represented in the middens were gathered from the immediately adjacent estuary to the west rather than from the more distant Macleay Arm to the east.

Although there were pronounced changes in the compositions of these middens through time, Callaghan (1980:105) nevertheless concluded, on the basis of calculations of amounts of food consumed, that there was "no apparent" change in overall economic activity at these sites throughout the time they were occupied.

Barz (1980, in press), looking at a much more recent phase of prehistory, sought to explain changes in the species composition of shell middens in terms of the impact of European land clearance. She used the change in the proportions of the shells of *Crassostrea commercialis* and *Anadara tereza* in a midden at Terranora on the Tweed River to suggest changes in the amount of silt in suspension,
Fig. 5-6. The Stuarts Point shell midden mound on a former estuarine embayment within the Macleay River.
and thus to propose a major environmental change, caused by European
land clearance. Consideration of shellfish biology however does not in
fact support this hypothesis that a local environmental change has
markedly affected the site. Her assumption that black humic soil
overlying the main shell deposit relates to European clearance of the
landscape is unlikely. The black humic layer almost certainly
represents a layer of rotted shell, a common phenomenon in upper
midden layers in high rainfall areas. Its composition is similar to
the dark soil formed beneath most midden shell deposits and explained
in detail by Hughes (1977) as part of an organic breakdown process.

_Crassostrea_ oysters are not particularly vulnerable to a change in the
amount of silt in suspension, so the decrease in oysters cannot be
readily explained by changes in silt content of the river. It is more
likely that the very small oyster numbers simply reflect a small and
easily over-predated oyster community. Cockles, _Anadara trapezia_, are
considerably more sensitive than oysters to changes in turbidity, and
cockle mortality can be readily explained by a change to colder or
less saline water, so again there is no need to invoke a change in
suspended load in the river. It is thus more likely that major river
flooding (perhaps just one event), with associated temperature and
salinity changes, was the cause.

**Ethnohistorical Information**

There is a considerable amount of ethnohistorical information
available for the north coast which relates to Aboriginal use of the
environment as reflected in shell midden deposits. Mathews (1897) had
realised in his search for totemic symbols among the Australian
Aborigines that in northern New South Wales they had suffered
"...gradual disappearance...before the white population", however
although the ethnohistorical accounts do not relate to the earliest
contact period, there are a number of careful accounts of observations
by interested early settlers.

Three observers in particular described the lifestyles of
Aboriginal people on the north coast in a way that allows ethnographic
testing of the archaeological record. They were Hodgkinson, writing in
1845, Henderson in 1851 and Bundock in 1898. In addition studies by
Lane (1970), Campbell (1978), Pierce (1978), and S. Sullivan (1978) drew
together information from such sources to produce a picture of the lifestyle of the Aborigines of the Tweed, Richmond, Macleay and Nambucca Valleys which was probably very little different from that of groups living in the other major valleys of the north coast. Belshaw (1978) also provided a summary of suggested population distribution and seasonal movement at the time of early European settlement. From these accounts it appears that the north coast people were generally more sedentary than those of southern New South Wales, and subsisted largely on fish and forest marsupials, in an area commonly referred to as being rich in resources.

Hodgkinson (1845:220) commented that:

...the natives between Port Macquarie and Moreton Bay...differ in several of their customs and habits of life from those in the southern and western parts of the colony...

Early accounts of the area stressed the occurrence of what were perceived to be abundant resources for the Aboriginal inhabitants of the broad river valleys. Hodgkinson (1845) for instance noted:

(p.22) ...the blacks on the banks of the numerous coast rivers, beyond Port Macquarie, are able to procure an abundance of food with little trouble.

(p.223) ...Fish were abundant. Shell-fish too were plentiful, as were many forms of marine crustacean.

and (p.225) that the Aborigines also ate

...brush-turkey...whose large nests are often robbed by the native women... and (p.205)...a beautiful blue bird with scarlet bill and legs and as large as a fowl... (presumably the common waterhen or Pukecko).

Fish he continually referred to as very important in the Aboriginal diet,

(e.g. p.223)... Fish, in the numerous rivers along this part of the coast, forms a never-failing article of food for the blacks, whom I have seen, at the Macleay and Nambucca rivers, spear in a few minutes sufficient food for the whole tribe, on the shallow sand-banks and mud-flats on that part of the river which rises and falls with the tide.

and observed (p.52-53) Aborigines

...spearing salmon and bream... (and, p.223) ...The sea beach abounds with clams, oysters and cockles, at all times procurable, whilst large cray-fish and crabs are caught among the rocks...and...in lagoons and running streams are a small kind of lobster and fresh-water muscles...several kinds of fish, large eels...
Dawson (1935:25) in naming Aboriginal food sources commented that on the north coast food was plentiful:

with the sea, many rivers, creeks and lagoons teeming with fish, oysters and mussels...and forests abundantly stocked with game...

Banks, sailing near the Macleay River mouth with Cook in May 1770 (Beaglehole 1955:62) commented on "Innumerable shoals of fish about the ship in the afternoon". Presumably these were spawning mullet which commonly school in late April (Callaghan 1980:17), and are often followed by porpoises, which were also recorded by Banks. Pierce (1973:19) noted that according to Ainsworth, an early settler in the Ballina area, fish was the most important item in the local diet in the Richmond River area, with oysters seasonally very important. Sea mullet (Mugil dobula or M. cephalus) and salmon (Arripis trutta) were the important fish species caught.

Land plants and animals, especially those of the rainforest bordering the rivers, also played an important part in the Aboriginal diet. Lane (1970:II-6 to II-12) noted numerous accounts of a large number of plants providing food, and Callaghan (1980:24) noted that succulent edible fruit is available in all months except July, August and September. Lane listed Teredo navalis grubs in rotting wood, cabbage palm hearts, other palms, figs, native grape, fruits of creepers, yams, cunjevoi (Alocasia macorrhiza), coastal pandanus, breadfruit and other roots as important plant foods. The celebrated Bunya nuts (Araucaria bidwillii) for which the north coastal Aborigines used to travel some 300-400 kms northwest each three years (Bundock 1898:265), were eaten when available. There are also several accounts of animal foods featuring regularly in the diet. Goannas and all types of snake were eaten, as was honey from native bees. Sullivan (1978:110-13) listed over twenty sources of animal foods and ten vegetable foods which were noted by early settlers in the Tweed and Richmond Valleys as having been eaten by the local Aborigines, and Campbell (1978:95-100) similarly listed in excess of twenty animal and eight plant foods observed by the early settlers in the Macleay River Valley to have provided food for the local Aboriginal people.

Marsupials which appear to have played an important role in the Aboriginal diet were possums, flying foxes and pademelons. Henderson (1851:122-3) described Aborigines cutting toe holds on trees to take possums and "flying-squirrels". Bundock (1898) referred frequently to
"opossums" as a food source, as well as to the use of their skins for cloaks. Flying foxes were caught while sleeping in the daytime by being "broken down" or by felling the trees where they were sleeping. (Henderson 1851:129) "An important article of food was...the 'possum... It is in the upper branches of the trees...that the greater part of his (the Aborigine's) food lies." Pademelons were frequently mentioned. Hodgkinson (1845:45-6) described a pademelon hunt in which a number of people beat inwards in a circle, finally hitting the pademelons on the head with "...short cylindrical pieces of wood...". Lane (1970:II-1) suggested that pademelons were "a common and consistent part of the Aborigines diet...while kangaroos appear to have been seldom hunted." Bundock (1898:263) however described organised group kangaroo hunts as well as single occurrences of kangaroo kills, suggesting that in some areas kangaroos were sought out by hunters.

It seems likely that the country was fired and kept more open than at present to assist in hunting for prized marsupials. Cook sailed past the Macleay mouth on 13th May 1770 and noted so many fires that he named the headland Smoky Cape (Beaglehole 1955:315-6). Banks (Beaglehole 1955:62) also noted "several fires ashore". Henderson (1851:141) commented that "Large tracts of country are...frequently burned by the natives, sometimes in hunting, at others by accident." Lane (1970:I-12) reported that the Nambucca Valley "...gave more of an impression of being open forest before the coming of the white man than it now does", and Campbell (1978:83) suggested that this may have been true also for the Macleay Valley.

For all the wide estuarine floodplains of the north coast, it appears therefore that fish formed the major item in the diet. Shellfish, land mammals and birds were also important locally available resources, regularly exploited. All of these animal foods should therefore be represented in local archaeological deposits. Traces of the plant foods, which were also apparently a very important part of the diet, are less likely to have survived in the archaeological record.

The equipment used to catch sea and river fish was described by both Hodgkinson and Henderson. Hodgkinson (1845:115) provided a drawing of "natives spearing fish on the Bellinger" in which he showed men fishing both from canoes and standing on the bank using a
three-pronged spear, and also described the use of a two-piece spear having a shaft of grass-tree and a head of sharpened hardwood. Henderson (1851:136,143) described a "two-piece" hunting spear, ". . . the lower end sharpened to a point and occasionally jagged with flint or glass, fixed with gum ... and used with a spearthrower" and a "shorter spear for fishing from canoes . . . with four or five points . . . and thrown by hand." He also noted that "on the coast" he had seen these spears "barbed with kangaroo teeth", that ". . . people catch eels in the rivers at nightfall" and that they made "... little dams . . . of boulders and pebbles . . . " to catch fish by "... driving the fish down into one corner . . . " to "... spear them, or secure them with their little nets." Bundock (1898:264) described the use of both lines and nets to catch mullet and cod in the Richmond River.

North Coast Settlement Patterns

It is interesting to note, despite the conclusions of Coleman (1978:181) and Callaghan (1980:112) that there is only positive archaeological evidence for summer occupation of the lower Macleay Valley site. Comments by the early observers that food was plentiful and procurable throughout the year might suggest that Aborigines were present along the coast throughout the year. Belshaw (1978:74) quoted the use of the term "village" for a settlement at the mouth of the Clarence River, and suggested a relatively sedentary lifestyle. Although he cited accounts indicating the movement of people both towards and away from the coast during the winter months (1978:75), it seemed that the number of people involved was small, and this did not reflect a major population shift in response to some stress. Lane (1970:22-23) stated that in the Nambucca area there does not seem to have been much variation of diet in terms of seasonal availability of food, although he noted that different seafoods were available at different times as were different fruits and berries. His statements were made on the basis of a consideration of ethnographic accounts, not on the basis of any archaeological evidence, and this would suggest that the historical observers did not note a major change in population density throughout the year. Population movements appear to have reflected a search for different or for seasonally abundant foods or other commodities, rather than the result of food shortages at any time during the yearly cycle. It is possible therefore that the
archaeological record reflects not the absence of people on the coastline through the winter, but rather the absence of identifiable winter indicators preserved in the deposits studied.

The best indicator of winter occupation which might be expected from the Stuarts Point-Clybucca complex is mullet remains. Walters (1979) analysed material from two comparable shell midden sites on Moreton Island (26km from the mainland in Moreton Bay). Ethnohistorical accounts for that area had also stressed Aboriginal exploitation of the schools of mullet which entered the bay in winter. Walters used a statistical model to relate information retrieved from the archaeological sample to the diet of the site's occupants, taking into account both the techniques of recovery and the decay of organic material. A significant result of his analysis was the recovery from the fine sieve fraction of one spit of a large number of mullet bone fragments, consistent with the ethnography. Coleman however, following Walters study, and taking into account his techniques for recovering mullet fragments, searched for indicators of winter occupation, particularly mullet bones, in a rock platform species midden site at South West Rocks near the Macleay mouth, but again failed to recover mullet remains (Coleman pers. comm.).

A Subsistence Model for the North Coast

McBryde (1974:338) used ethnohistorical observations and all available archaeological evidence to suggest seasonal population movements for the Clarence River Valley. These suggested a pattern of spring and summer movement of people towards the coast, and a winter dispersal of people along the Clarence Valley and on the coastal hinterland. Based on ethnohistorical accounts, Belshaw (1978:72-3) estimated population densities for the north coastal strip of between 2 and 6 persons per sq km, with much lower densities of about 1 person per 45 sq km in the more rugged tablelands, and about 1 per 12 sq km on the western slopes, suggesting a generally densely populated coastal strip.

Coleman (in press) used the evidence of reconstructed population densities, reports by early settlers and explorers, and the presence of stone fish traps presumably able to supply large amounts of fish, to suggest that at least in late prehistoric times Aborigines in
northern coastal New South Wales were near-sedentary and living in "villages" rather than ranging widely. On that evidence she built up a case for

..consistently high, semi-sedentary local populations on the coast, with a highly sophisticated organic material culture, which vanished almost overnight with European contact.

It is worth quoting the postscript of the article in full:

It has always seemed curious...that Stuarts Point was abandoned at about the same time as Clybucca 3 and Connection Creek 1, c.3000 - 2500 B.P. An argument can be put forward for the depauperisation of the local environment due to changes in salinity levels for the two latter sites, but not for the area around Stuarts Point, which to this day remains richly endowed with fish and shellfish.

Perhaps, as some sites in lagoonal and riverine areas came under environmental stress caused by the aggradation of the coastal plain, a general shift in economic strategy took place. Large groups, which had adapted to a semi-sedentary way of life based on the abundance of aquatic resources in these areas, sought an alternative strategy which maintained this adaptation. The coast proper offers some aquatic resources, though poor in comparison with the rock platform zones of the south coast of N.S.W. These resources could be maximised however through the construction of sophisticated fish traps. Such a technological advance would enable a group to intensify its use of this zone...

If this highly speculative model is to hold water, data from sites dating to the period between 3000 - 2500 B.P. are needed. Unfortunately if occupation did shift to the coast during this period, the likelihood of finding such sites seems low as a result of high rates of erosion due to tidal and wind action, and European development.

Coleman has raised a number of questions in this speculative conclusion, but archaeological evidence does seem to favour the suggestion of the intensive use of the immediate coastal zone in the recent prehistoric past. One such line of evidence is the lack of apparently earlier pipi shell middens and the abundance of relatively recent sites. Most dated pipi middens consist of a single shell horizon, commonly set on the bleached horizon of a sand podzol in a coastal dune, and most date from the last 1,000 years, many from 300 to 500 years B.P. or even later. Examples of such dated sites are few; Evans Head-Schnapper Point sites which date from the last 300 to 350 years (McBryde 1982), Maguires Crossing dating from about 1,000 years B.P. (Coleman 1978:70), Freshwater Lagoons dated at 700 years B.P. and Crowdy Head with a shell date of 410 years B.P. Many similar sites have been recorded however, and the midden layer is almost invariably a single shell horizon sitting on a stable but apparently not very old dune surface, and now covered by very recent windblown sand. It is possible however that earlier sites of this type have been destroyed.
The pipi midden at Jerusalem Creek, south of Schnapper Point (Fig. 5-1), although only about 350 years old (McBryde 1982), rests on sandrock, indicating that older dune deposits have been removed by erosion. These deposits may also have contained shell middens.

A problem recognised by Coleman and Campbell is that of the age of the fish traps. Campbell (1978) noted that the traps may not in fact be prehistoric but argued that this was unlikely. The Arrawarra and Angourie fish traps were built (or re-built?) during the 1930's and used by both Aborigines and out-of-work Europeans. The Pt. Plomer and Broughton Island traps are more closely associated with what are clearly Aboriginal shell middens of some antiquity, and it can perhaps be inferred from this that these fish traps were in existence in prehistoric times. It is unlikely that the question will be answered archaeologically however, and given the doubts as to the antiquity of the fish traps, Coleman's hypothesis rests on somewhat shaky evidence.

Summary

It is worth considering the degree of correspondence between the three lines of evidence; the statistical analysis of the nature and location of shell middens (Chapters 3 and 4), detailed archaeological investigations and the ethnohistorical records. All three sources indicate that rivers and estuaries were important sources of food, particularly of fish and shellfish. Both detailed archaeological investigations and a consideration of ethnohistorical sources indicate that exploitation of estuaries was commonly associated with the exploitation of terrestrial environments, especially the hunting of land mammals. All three sources also indicate that the use of rocky shorelines was of minor importance in prehistoric and early contact times.

It is interesting that the archaeological evidence also points to the exploitation of beaches as having been important. Very few ethnohistorical accounts stress the importance of beach shellfish to the economy of the north coast, yet both a broad overview of the sites known and the detailed investigation of a number of these indicate that pipis were an important item in the diet of people on the north coast in the recent past.
The data from all these sources apply largely to the recent prehistoric past and to the European contact period. Given the degree of environmental change that the north coast has undergone in Holocene times and the paucity of archaeological evidence dating from earlier than the last 1,000 years, it would be rash to propose detailed subsistence strategies and hence the nature and location of archaeological sites, from mid Holocene times for example.

THE SOUTH COAST

Most archaeological excavations and detailed investigations of shell middens carried out to date in New South Wales have been within the Sydney Basin region of the southern section of the coastal zone. Excavated shell middens include sites at:

Birubi (Dyall 1979)  Swansea (Dyall 1978)
Bateau Bay (Stockton 1981)  Daleys Point (Clegg 1979)
Newport (Tracey 1974)  Forty Baskets Beach (David and Etheridge 1889)
Bantry Bay (Specht 1976)  Kurnell (Megaw 1965)
Boat Harbour (Dickson 1968)  Gymea (Megaw 1966)
Yowie Bay (Poiner 1974)  Wattamolla (Megaw and Roberts 1974)
Curra Curran (Megaw 1965, 1974)  Hooka Point (Hughes and Sullivan 1974)
Curra Rag (Lampert 1971a)  Lake Wollumboola (Lampert 1971b)
Bowen Island (Blackwell 1980)  St. Georges Basin (Barz 1977)
Cemetery Point (Collier 1975)  Church Point (Goodwin 1975, Hughes 1977)
Murrarang Point (Lampert)  Durras North (Lampert 1966)

The locations of these excavated sites are shown on Fig. 5-7.

In addition detailed surveys have been carried out within the Gosford-Wyong area (Vinnicombe in press) and on Beecroft and Bherwerre Peninsulas (Lampert and Sanders 1973, Sullivan 1977). In the southernmost Molong-South Coast region a systematic survey of part of the coastline has been carried out (Sullivan 1976, 1978), but no previous excavations have been reported.
Fig. 5.7 Excavated sites and localities mentioned in the text.
Archaeological and ethnographic evidence for the south coast shows that in Holocene times at least people exploited a wide range of resources in coastal environments, especially those of the intertidal and near-tidal zones of the rocky shorelines and estuaries. There is very little evidence however for the use of beach resources. Rock platform and estuarine shellfish and fish appear from shell middens to have been everywhere very important in the diet. Land animals and birds were also important but the proportions of these in shell middens varies greatly. Plant foods were undoubtedly widely used but they have left no traces which have yet been identified by archaeological investigators. Systematic analysis of this information has been published, and much of the available data summarised by Lampert (1971b) and Lampert and Hughes (1974), who emphasised the importance of coastal resources in southern New South Wales.

**Subsistence Models for the South Coast**

For the southern coastline of New South Wales, i.e. for the the Sydney Basin and for the Molong-South Coast regions, Poiner (1974, 1976) and Attenbro/or (1976) have set up models of subsistence economy based largely on ethnohistorical sources but with recourse to archaeological information for the Sydney Basin region and the southernmost parts of the Molong-South Coast regions respectively.

Poiner (1976:188) stressed the importance of seasonal change within hunter-gatherer subsistence patterns. In general groups in either high latitudes or in tropical zones are more sedentary during the season of more favourable climatic conditions. In temperate climates where no clear seasonal indicators exist to be recognised in the archaeological record, it is difficult to establish seasonal patterns of movement.

The subsistence model proposed by Poiner for the southern Sydney Basin region was based on the fact that although some sources of food are available throughout the year, winter is the season during which both the range and abundance of food are smallest. It involved "semi-nomadic" settlement concentrated on the coast during summer, and "nomadic" during winter, perhaps with an inland orientation (1976:196).
Attenbrow (1976) developed a model of subsistence behaviour for the southern part of the Molong-South Coast region based on ethnographic sightings of Aborigines, on an assessment of available food resources and on limited archaeological evidence. The model proposed differences from north to south in the area (1976:95). In the north near the Bega Valley people were on the coast and inland throughout the year, with more people on the coast in summer and the population more evenly distributed in winter. In the south, near Twofold Bay, people were more evenly spread during summer and concentrated on the coast during winter. Attenbrow suggested (1976:97) that although large groups may have gathered to exploit particular abundant resources (for example beached whales, or daisy yams or macrozamias when in season), the people were mobile throughout the year.

Both Poiner and Attenbrow equated mobility ("nomadism") with restricted resource availability and "semi-sedentism" with a wider range of resources available. For the Sydney and south coast areas food resources, although available, are somewhat more limited in winter in both range and abundance. Although there is more archaeological information now available than there was in 1974 and 1976, this does not alter or refine either of these two subsistence models, chiefly because (as noted by both Poiner and Attenbrow) no clear seasonal indicators are present in the archaeological deposits recorded.

Attenbrow presented an appendix to her study a detailed itemisation of 51 dated ethnohistorical observations of Aborigines in the southernmost part of coastal New South Wales. Although mainly dating from the 1840's, by which time the whaling stations set up in the early part of the century were well established (see also Chapter 8), these observations show a dramatic difference in the numbers of people recorded at different times of the year. The observations, which covered both coastal and inland areas, were presented as coastal (along the coastal plain) and inland (on the eastern slopes of the Monaro Tableland), and may be summarised as:

**Summer (October to March inclusive)**
- number of people recorded on coast: about 200
inland: about 70

Winter (April to September inclusive)
number of people recorded
coast: upwards of 1,000, possibly as many as 2,000
inland: about 60.

Although not conclusive in terms of numbers, since many may be repeated sightings of the same group, the observations summarised by Attenbrow do seem to indicate that large groups of people were congregating on the coast in winter, with smaller more dispersed groups on the coast in summer, and inland throughout the year. This may be explicable in terms of specific resources. If muttonbirds and seals were as important in the seasonal diet as was true of areas much further south (Jones 1977, Bowdler 1979, Gaughwin 1978) it is possible that Aborigines were not congregated near the bays in summer, but rather were spread around the headlands and offshore islands where such resources could be reliably obtained. It is likely however, that the whaling stations were even more of a focus of attention in winter when otherwise coastal resources may have been more scarce.

Many of the sightings of large parties however were made near Twofold Bay in the 1840's. If whaling stations were the attraction to the coast in winter this move began early. In 1812 the schooner "Unity" was attacked on the south side of Twofold Bay by "several hundreds of natives" (Wellings 1931), and this was early in the history of whaling for the far south coast. It is likely that the early influence of this type of European settlement had radically altered Aboriginal lifestyles by the 1840's, from which time most of the ethnographic accounts derive.

SUMMARY

The broad differences between the exploitation of beach and estuarine resources and a wide range of terrestrial resources in the north, and an economy more heavily dependent on fishing and shellfish gathering off rocky shorelines and in estuaries in the south is confirmed by the statistical analyses of the contents and distributions of sites described in chapters 3 and 4.
For the Sydney area and the south coast (but not the far south coast – see below) there appears to be a good correlation between the nature and distribution of midden sites analysed in this study, the ethnohistorical evidence and available archaeological evidence from excavations. In the two northern regions the archaeology suggests a much greater dependence on beach resources than is indicated by ethnohistorical observations.

Although whaling may have biased the ethnohistorical evidence to place more emphasis on a winter concentration of population on the far south coast, the available evidence does suggest a trend from north to south along the entire coastline towards greater population mobility throughout the year. This greater mobility southwards also appears to have been associated with a concentration of people on the coast in winter.

Whereas for the north coast and the Sydney Basin all three lines of evidence are available (excavation data, survey data and ethnohistorical records) against which subsistence models can be tested, no excavations had been carried out previously in the Molong-South Coast region. One of the aims of this study was to undertake detailed archaeological investigations in this southernmost region, including excavation, as described in Chapters 6, 7 and 8).

EXPLOITATION OF OFFSHORE ISLANDS

Previous Work

Islands in rivers or estuaries along the coastal zone commonly have shell midden sites on them which appear from survey information to be very similar to adjacent "mainland" sites. Examples of islands that I have examined which have such sites include Pulbah Island in Lake Macquarie, Scotland Island in the Hawkesbury River, Dangar Island in Sydney Harbour, Merriman Island in the Deua River and Horse Island in Tuross Lake. On Yahoo Island in Wallis Lake a large estuarine shell midden occurs within dense rainforest, and this midden is very similar in character to other sites on the lake shoreline which lie within now partially cleared rainforest.
Few studies have been carried out on the exploitation of islands off the New South Wales coastline, although evidence of occupation by Aborigines, in the form of shell middens or worked stone known or reported to occur on them, is known from most of those lying within Jones' (1977: Figs. 6 and 7) limit of regularly or seasonally exploitable distance, roughly 8km. Such islands include South West Solitary, Cabbage Tree and Broughton in the New England region, Bare, Bowen, Brush, Wasp and O'Hara in the Sydney Basin, Snapper, Tollgates, Broulee, Montagu and Gabo in the Molong-South Coast region (Fig. 5-8). All of these islands are bedrock islands with broad rocky shoreline platforms. There are very few ethnohistorical accounts of the use of these islands by Aborigines. Boss (1797-8: 41) remarked that "natives" were present on Brush Island when he sailed nearby and Harper (1826) reported seeing Aborigines fishing from Bowen Island. Mann (1883: 39) commented that the Tollgates were visited and suggested that this may have been to collect birds' eggs, and Barlow (1888 and 1892) noted that canoe-loads of Aborigines had visited Montagu Island for this purpose.

Although in each instance the archaeological evidence for occupation is mainly in the form of middens, as Sullivan (1975) Gaughwin (1978) and Blackwell (1980) have shown, it is unlikely that shellfish exploitation was the major drawcard for what must commonly have been a hazardous journey by frail watercraft. The risk of such journeys was also noted by Lampert (1975) in his reference to the "Moruya Examiner" articles by Barlow in 1888 and 1892. Visits to those islands, especially when that involved long hazardous crossings of open water, merely to collect shellfish would have been particularly unlikely as rock platforms and estuaries on the nearby mainland coast could and did provide similar shellfish resources, as evidenced by the numerous shell middens along these stretches of the coastline. While Jones (1977), Sullivan (1975) and Gaughwin (1978) took a pragmatic view of island exploitation, others have taken a more romantic stance.

Wright (1975) for instance suggested that the prehistoric occupants of Broughton Island which lies 3km offshore from Port Stephens were castaways, despite the fact that in the same article he noted the occurrence of fishtraps constructed over the extensive rock platform on the northeastern side of the island, and that his illustrated vertical sections through the deposit indicate a minimum
Fig. 5.8 Locations of offshore islands
of two midden layers each at least 30 to 50 cm deep and separated by some 50 cm of sterile windblown sand. He appears to have approached this study, which was a salvage operation, with less forethought about the role of islands within coastal economies than about this midden as a particular site, and visited the island with some preconceptions of its prehistory (or the unlikelihood of its having had a real prehistory). He saw no evidence of Bondaian occupation, yet this probably reflected the age of the midden deposit rather than its geography. "As is to be expected I found no trace of specific implement types of the Bondaian tradition, which are characteristic of recent middens only to the south of Newcastle" (1975:20).

Wright did however report some interesting findings, including (in the unpublished site description accompanying the NSW NPWS archaeological site form) "some sort of bulbous bone about 5 cm long" (perhaps these were snapper head bones), fishbones, jaws, scales and bird bones, which he described as common throughout, and the bones of young seal and dog. A radiocarbon date from the upper midden indicated an age of 440±180 years B.P. suggesting the exploitation of the island began more than 500 years ago. Two eroding human skeletons (the reason for his salvage excavations) he re-buried and in his unpublished report to the NPWS on this salvage operation, Wright noted that these were of a male and a female adult.

The contents of the midden deposits described by Wright in fact suggest a different reason for occupation of the island than a chance landfall by castaways. Young seal bone and bird bones, presumed to be those of muttonbirds, which were noted to have been present throughout the deposit suggest the likelihood of repeated summer usage of the island to obtain muttonbirds and young seals from breeding colonies—a frequently associated pattern of island use noted by Gaughwin (1978). The occurrence of extensive shell midden layers and the presence of dog bones and a female skeleton could indicate perhaps extended visits or occupation by family groups on the island at times of seal or muttonbird exploitation.

Sullivan (1975) carried out an archaeological survey of Montagu Island (Plate 5-3), 7km offshore from Barunga Point near Narooma in southern New South Wales, and located several archaeological sites. Visiting this island would have involved the Aborigines in a particularly long and difficult water crossing (Table 5-1), and the
PLATE 5-3. THE NORTHERN SECTION OF MONTAGU ISLAND, LOOKING TOWARDS AREAS OF MUTTON BIRD ROOKERY

PLATE 5-4. SLUMPING AT THE BOWEN ISLAND 1 DUNE SITE

PLATE 5-5. A SANDSTONE ROCK SHELTER ON BOWEN ISLAND WITH SHELL MIDDEN ACCUMULATION IN FRONT
<table>
<thead>
<tr>
<th>ISLAND</th>
<th>REGION</th>
<th>DISTANCE OFFSHORE (to nearest 0.5km)</th>
<th>SITES KNOWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW Solitary</td>
<td>New England</td>
<td>3</td>
<td>shell middens</td>
</tr>
<tr>
<td>Broughton</td>
<td>New England</td>
<td>3</td>
<td>shell middens, fish traps</td>
</tr>
<tr>
<td>Cabbage Tree</td>
<td>New England</td>
<td>2</td>
<td>shell middens</td>
</tr>
<tr>
<td>Bare</td>
<td>Sydney Basin</td>
<td>0.5</td>
<td>shell middens, stone artefact scatters</td>
</tr>
<tr>
<td>Bowen</td>
<td>Sydney Basin</td>
<td>0.5</td>
<td>shell middens, stone artefact scatters</td>
</tr>
<tr>
<td>Brush</td>
<td>Sydney Basin</td>
<td>1</td>
<td>shell middens, stone artefact scatters</td>
</tr>
<tr>
<td>Wasp</td>
<td>Sydney Basin</td>
<td>1</td>
<td>shell middens</td>
</tr>
<tr>
<td>O'Hara</td>
<td>Sydney Basin</td>
<td>1</td>
<td>shell middens</td>
</tr>
<tr>
<td>Snapper</td>
<td>Molong-South Coast</td>
<td>3</td>
<td>shell middens, stone artefact scatters</td>
</tr>
<tr>
<td>Tollgates</td>
<td>Molong-South Coast</td>
<td>5</td>
<td>shell middens</td>
</tr>
<tr>
<td>Broulee</td>
<td>Molong-South Coast</td>
<td>0.5</td>
<td>shell middens, stone artefact scatters</td>
</tr>
<tr>
<td>Tabourie</td>
<td>Molong-South Coast</td>
<td>0.5</td>
<td>shell middens, stone artefact scatters</td>
</tr>
<tr>
<td>Montagu</td>
<td>Molong-South Coast</td>
<td>7</td>
<td>shell middens, stone artefact scatters</td>
</tr>
<tr>
<td>Gabo</td>
<td>Molong-South Coast</td>
<td>1</td>
<td>shell middens, stone artefact scatters</td>
</tr>
</tbody>
</table>

**TABLE 5-1** Offshore islands with archaeological sites
island is situated near the limit of likely regular visits (Jones 1977:Fig. 7). The distribution of sites suggested seasonal visits to the island to obtain muttonbirds or seals from breeding colonies (1975:41).

A prolonged stay on Montagu Island would have been possible, since fresh water is available and there are numerous sources of food, notably fish, fairy penguins (*Eudyptula minor*), and the eggs of gulls and terns which breed on the island, apart from muttonbirds and seals. Given the prevailing sea conditions it is likely (Sullivan 1975:41) that Aborigines would have travelled to the island in December or January and could have remained there until perhaps as late as March or April, feeding on adult birds or later in the season on chicks. Even through the relatively calm summer season the crossing to the island can be hazardous. An incident in early February 1982 confirmed this. The lighthouse keeper suffered a severe heart attack in early February, and although a telephone message had been sent to the mainland, sea conditions were too rough to permit any vessel to reach the island to rescue him, so that a helicopter had to be used the next day ("Canberra Times" 5.2.1982). Whether winter visits to the seal colonies were carried out is not known, but if such visits were undertaken they would have depended on taking advantage of suitable weather and sea conditions as these occurred.

Blackwell’s (1980) report of an excavation on Bowen Island which lies about 400m offshore from Bherwerre Peninsula on the southern side of Jervis Bay, is to date by far the most detailed presentation of an island-based study off New South Wales. It is worth considering the evidence she presented in conjunction with more limited evidence available from Broughton and Montagu Islands. Seven archaeological sites had been recorded on Bowen Island (Sullivan 1977), and the open site excavated was the largest of these.

In her comparative study of the Bowen Island site and six mainland sites where detailed archaeological investigations had been carried out, Blackwell (1980) demonstrated that overall the prehistoric economy reflected in the shell midden on Bowen Island resembles most closely that of the beach shelter site at Durras North, and that the major differences probably related to the longer period over which the Bowen Island site was occupied. This study also tended to reinforce the hypothesis suggested by Lampert (1971b) that the most
coastward sites are those most specialised towards a coastal economy. Certainly Bowen Island reflects an almost total dependence on immediately local resources, apart from a very small quantity of imported stone. Stone for artefacts was similarly imported to Montagu Island from the nearby mainland coast (Sullivan 1975), but on Broughton Island Wright suggested that even stone for artefacts was locally derived.

Blackwell (1980, in press) presented scant evidence to support her contentions that a widespread move to island exploitation off the New South Wales south coast occurred at about 1,200 years B.P., and (that if this were so) it reflected population pressure. She did however present evidence from Lampert and Hughes (1974) and Hughes and Lampert (in press) to show that if such a widespread move in fact occurred, the two phenomena were broadly contemporaneous. Evidence from Glennie Island in Bass Strait (Jones and Allen 1980, Jones pers. comm.) indicated that this island was intermittently visited by Aborigines from about 1,600 to 1,800 years B.P., and that the intensity of site use, as reflected in the rate of accumulation, increased some time after 1,000 years B.P. Other islands in Bass Strait such as Flinders and King appear to have been visited by Aborigines between about 7,000 and 8,000 years ago (Jones 1979).

There is no evidence yet available to show that the use of islands off the New South Wales coast coincided with an upsurge in the use of islands in Bass Strait. There are however some similarities in the patterns of island use reported from the two areas. Both the site on Bowen Island and the midden examined by Wright (1975) on Broughton Island appear to have begun to accumulate within the last 1,000 years, and both are rich in bird and fish bones. In both instances however the middens are in unstable foredunes, which in the case of the Bowen Island site shows signs of severe slumping (Sullivan 1977:45, Blackwell 1980:17, Plate Foll.p.25, Plate 5-4). In all such situations there is a strong likelihood that evidence of earlier phases of occupation have been removed by erosion of the dunes. Only sites on stable landforms such as those on rock headlands or in rock shelters not subject to scour can be used reliably to ascertain the time of commencement of occupation, a point stressed by Hughes and Lampert (in press).
Preliminary radiocarbon dates (ANU 2344, ANU 2345) presented in the original Bowen Island report (Blackwell 1980) were later revised. The results of that study in fact suggest that unless erosion had removed traces of earlier occupation, the open site studied was initially used at about 900 to 1,000 years B.P. (see Fig. 6-3), not at 1,200 years B.P. There was a marked change in the midden composition to a dominance of the edible mussel *Mytilus planulatus* rather than of large gastropods at about 600 years B.P. The significance of this change is considered in detail in Chapters 6 and 9.

Blackwell (in press) stated that the intensity of occupation of the excavated site on Bowen Island "increased noticeably" with the change in "midden concentration", that is the change to the dominance of edible mussel shells in the deposit. Although this may in fact be the case, such a conclusion cannot be derived from the information provided in the report of the study (Blackwell 1980). Only two radiocarbon dates are available from this site and this does not allow a depth/age curve to be constructed which would enable changes in the rate of midden accumulation to be demonstrated (Hughes and Djohadze 1980).

In attempting to mould the available information into evidence supporting a case for intensification of site usage, Blackwell (1980, in press) appears to have overlooked the real contribution which this study could have provided to an understanding of island exploitation. In each of the three case studies, Broughton, Bowen and Montagu Islands, although there are clear similarities between shell middens on the island and those on the nearby mainland, the differences suggest the reasons for island exploitation. Shell middens on these three islands exhibit the same shellfish suites as those adjacent to wave-washed rock platforms on the nearby mainland, but the differences lie mainly in the quantities of bone and the species of vertebrates represented.

It is in the proportion of bone contained in their midden deposits that island economies appear to stand apart from those of mainland areas. Blackwell (1980:52-58) attempted to derive a comparative measure of the concentration of bone in sites but found most excavation reports did not provide this information. Table 5-2 presents a comparison of several excavated sites to indicate relative amounts of bone noted in the deposits. The Bowen Island site has twice
### TABLE 5-2
Relative Proportions of Bone in a Number of Excavated Shell Middens

<table>
<thead>
<tr>
<th>Excavated shell midden</th>
<th>Average weight of bone per m$^3$ of deposit (gm)</th>
<th>Distance from marine shore-line (metres)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballina</td>
<td>103.3</td>
<td>2,000</td>
<td>Bailey, 1975</td>
</tr>
<tr>
<td>Birubi</td>
<td>1,000</td>
<td>0</td>
<td>Dyall, 1979</td>
</tr>
<tr>
<td>Bass Point</td>
<td>362</td>
<td>40</td>
<td>Bowdler, 1970</td>
</tr>
<tr>
<td>Currarong Shelter 2</td>
<td>146.6</td>
<td>700</td>
<td>Lampert, 1971a</td>
</tr>
<tr>
<td>Bowen Island</td>
<td>2,000</td>
<td>0</td>
<td>Blackwell, 1980</td>
</tr>
<tr>
<td>St Georges Basin</td>
<td>160</td>
<td>500</td>
<td>Barz, 1977</td>
</tr>
<tr>
<td>Cemetery Point</td>
<td>700</td>
<td>100</td>
<td>Collier, 1975</td>
</tr>
<tr>
<td>Durras North</td>
<td>no value given mainly bird &amp; fish</td>
<td>0</td>
<td>Lampert, 1966</td>
</tr>
<tr>
<td>Nundera</td>
<td>300</td>
<td>40</td>
<td>Chapter 6</td>
</tr>
<tr>
<td>Pambula Lake</td>
<td>450</td>
<td>1,000</td>
<td>Chapter 8</td>
</tr>
</tbody>
</table>
as much bone as that recovered from the foredune site at Birubi, and more than four times as much as sites lying some hundreds of metres inland. Like the immediately coastal mainland sites, most of the bone in the Bowen Island midden is bird and fish bone. Unfortunately it is only for Bowen Island that this level of detail is available to begin to compare island and mainland sites, however other observations are relevant. The most intensive scatters of stone on Montagu Island are located in the areas of muttonbird breeding colonies (Sullivan 1975), suggesting that exploitation of these bird colonies was a major reason for exploitation of the island. Similarly Wright's (1975) observation that fishbones, jaws, scales and bird bones were common throughout the Broughton Island midden would suggest a very high density of bone in the deposit, especially as fine fishbones and small bird bones tend to be amongst the least obvious contents of a shell midden on initial observation and without analysis of excavated contents. They are therefore commonly underestimated from field observations.

Even given this minimal amount of information, the evidence from these three island studies appears to present a pattern of seasonal exploitation more marked than the adjacent mainland. Blackwell (in press) stated that there is no evidence for seasonal occupation or use of Bowen Island, but does acknowledge (1980:70) that the presence in the excavated shell midden of very large quantities of adult muttonbird bone certainly indicates at least summer occupation. Other birds represented in the Bowen Island deposit however reinforce the probability of summer occupation. Fairy prions (Pachyptila turtur) are likely to be washed ashore on the New South Wales coast or to land on offshore islands only during their summer breeding season, when they occasionally fly north from Bass Strait or the sub-Antarctic (Slater 1970:167). Fairy penguins which breed on Bowen Island are most likely to have been taken from their burrows during their moulting season in late summer, when they are both fat, having recovered weight lost during the breeding period, and confined ashore (Slater 1970:141).

Summer occupation of both Broughton and Montagu Islands is also indicated from the archaeological record. On Broughton Island adult muttonbird bones were noted in the midden (Wright 1975) and on Montagu Island the closest association observed is between Aboriginal sites and the muttonbird colonies. A large silcrete core or chopper tool found on Montagu Island adjacent to the seal rookery is enigmatic. It
is possible that some sealing activity was carried out in winter, but there is no evidence for this.

This impression of probable seasonal visits to obtain specific resources such as muttonbirds, birds' eggs or seals is reinforced when islands such as Cabbage Tree, The Tollgates, Snapper, Brush, O'Hara and Grasshopper are considered. All of these islands have shell middens, scatters of worked stone, and appear (from the amounts of bone reported to be present in the middens) to have been the foci of fishing, sealing or bird gathering activities. They were almost certainly visited primarily if not only during summer to obtain these resources.

A case for intensification of use of the southern New South Wales coastline over the last 6,000 years, accelerating over the last 1,000 to 1,500 years of prehistory has been argued by Hughes and Lampert (in press). The only dated shell midden from an offshore island in this area (Bowen Island) began to accumulate within this time period. Although no relationship between these events has yet been demonstrated the use of offshore island resources needs to be considered in the light of a likely increase in population and changes in technology. Certainly shell fish hooks appear to have come into use in the area within this time period, and it is likely that this and other changes in technology were related to increases in population. Jones and Allen (1980) noted that for the southern coastline of Australia prehistory during Bondaiian times was "cast in a regional mould" and that this was followed by "some degree of collapse of coherence of this system into a series of local sub-units". It seems likely that a widespread change in technology, perhaps facilitated by an exchange of knowledge between local groups of a significantly expanding population, some time during the last 2,000 years of prehistory may have brought islands within a range of reasonable access for exploitation.

It is unlikely that islands were used because of real pressure on mainland food resources. There is no evidence of such pressure in excavated mainland shell midden sites, despite other evidence which suggested population increase (Hughes and Lampert in press). Moves to island exploitation however may reflect an increase in sophistication of technology. It is possible that canoes improved after line fishing rendered their use essential (although those used by Australia's
colonists must certainly have been capable of open ocean voyages, and
the technology may have remained viable). Islands, with their
surrounding platforms, were almost certainly better fishing spots, and
it may be that initially near-island reefs attracted fishing parties
who then used the islands for other purposes. Improved technology may
thus have brought muttonbird or seal colonies within regular seasonal
reach. Evidence emerging from the excavated site on Glennie Island in
Bass Strait however suggests that the importance of fishing increased
through time (Allen pers. comm.). Some other reason may have taken the
first visitors to the island.

Islands which are now intermittently linked to the mainland by
ephemeral sand spits, such as Broulee, Tabourie and Gavo, are the
locations of very large shell middens - probably the result of the
exploitation of relatively very large surface areas of rock platform.
Even from survey observations alone it is apparent that these middens
are rich in fish and bird bones, so it is likely that here again
fishing or bird collecting was the main reason for their use.

Whether there is a north-south variation in the prehistoric use
of islands remains to be determined by the results of more detailed
studies of islands, but the evidence so far available would suggest
the existence of an island pattern appreciably different from the
mainland pattern, but the motivation for this not yet known.

**Future Research Into Island Archaeology.**

There is now a good basis for a detailed study of Aboriginal
exploitation of islands off the New South Wales coast. Such a study
could contribute greatly to a better understanding of prehistoric land
use, and may well provide valuable information on the question of
intensification of land use. This however should be a secondary aim of
such a study. Initially the questions to be resolved are
straightforward:

1. What are the nature and contents of archaeological deposits on
offshore islands? Do these indicate particular seasonal use of the
islands?

2. When was each island first occupied? To answer this clearly
several deposits would need to be investigated from those islands with
more than one site. Rock shelter deposits on islands, in situations
where there has clearly been no loss of deposit through slumping or erosion would also be preferred study sites. Two or three such deposits occur on Bowen Island (Plate 5-5), and there may be similar sites on other offshore islands if these were thoroughly surveyed. If such deposits do not exist then open midden deposits on rock headlands could be used. One such site exists on the northern section of Montagu Island, and others almost certainly occur on most rocky islands.

3. When did each site cease accumulating, or when did island occupation cease? This could be answered along with the foregoing question from stable island deposits.

4. Is there evidence of cultural change? If evidence of cultural changes occurs in island deposits, such as the change from large gastropods to mussels as the dominant shellfish type, these changes need to be characterised and bracketed by radiocarbon dates.

5. What was the pattern of accumulation of island deposits? Excavations of island sites should aim not only at answering questions on the nature and contents of the sites, but also at deriving rates of accumulation. An approach which involved the complete weighing and thorough sampling and analysis of the inorganic sedimentary component of the sites would be needed to do this.

Such a study could be divided into three phases. Question 1 could be answered by carrying out a systematic survey of offshore islands, and lends itself to a single small project. Questions 2 and 3 could also provide another self-contained project which would provide the basis for further study. Ideally however the whole study should be undertaken as a single major project. Although expensive in terms of fieldwork costs and dates, and difficult in the demands for a boat suitable to visit all the islands and carry excavation equipment and samples, the study would provide valuable information on an aspect of the prehistory of the New South Wales coastal zone so far lacking.
CHAPTER 6

THE FAR SOUTH COAST

My field survey observations and re-assessment of previous shell midden excavation reports indicate that there are strong similarities between sites in the Sydney Basin and those in the Molong-South Coast region. Aspects of similarity lie in the nature of the sites recorded, their particular locations within the coastal landscape, their state of preservation and disturbance, and their gross contents (Chapters 3 and 4).

The degree of similarity between the two regions raises a number of questions regarding the prehistory of the far south coast, as the southernmost excavation carried out previously in the New South Wales coastal zone was that at Durras North (Lampert 1966) in the extreme south of the Sydney Basin. Questions which relate primarily to the contents of sites are:

* Do sites in the Molong-South Coast region contain the same range of shellfish species, land and sea mammals and fish as those in the Sydney Basin?
* Are the stone, bone and shell artefact assemblages in the far south of New South Wales similar to those further north?
* Are the changes in nature and through time in the economic contents and stone artefact assemblages similar?
* In particular is the apparent change, through time to a recent dominance of edible mussel (Mytilus planulatus) in the shell assemblages of south coast midden sites related to a similar change observed in sites to the north?

Another question concerns site survival through time. Given the high proportion of sites in the two southern regions which are at least partly reworked (55%), it is likely that a very large number of similar sites which were originally closer to the shoreline or to river banks have now been destroyed by natural erosional processes. No estimates can be made of the numbers or types of sites which have been
lost in this way. Certainly however, given a gradually retreating coastline as the result of erosion over the last few thousand years (Thom 1974), the number has been large. Another factor in the level of survival of shell middens is that of human interference, and some information is available on which to assess this factor.

With these questions in mind, a number of more detailed studies were carried out within the Molong-South Coast region. One such study was a detailed survey of two estuarine shorelines where groups of mounded middens had been recorded in the past (Anderson 1890). The purpose was to examine the nature and locations of these sites, and to obtain some knowledge of the rate of destruction of such sites over the intervening 90 years and of the causes of destruction. This detailed re-survey of the shorelines of Wagonga Inlet and Pambula Lake is described in Chapter 7, where the implications of the results for current patterns of site distribution are discussed.

A second investigation involved the test-excavation of one of these sites within which edible mussel shells were apparent in the surface layers, and in which it was likely that a range of cultural material had accumulated over a long period. The results of this test-excavation, which was of a mounded site on the shoreline of Pambula Lake, and their archaeological implications are discussed in Chapter 8. The more general question of the change to edible mussel is discussed below; the implications of the findings of the Pambula excavation are also discussed in the concluding chapter (Chapter 9).

THE SIGNIFICANCE OF THE RECENT DOMINANCE OF EDIBLE MUSSEL

The change to the mussel *Mytilus planulatus* as the dominant shellfish species represented in the uppermost horizons of shell middens on the southern coast of New South Wales is widespread. In addition in sites where mussel does not achieve dominant proportions it is commonly a significant component of only the most recent midden layers.
Environmental Factors

Although it is tempting to postulate environmental change to account for the phenomenon, it will be argued in this chapter that this is unlikely to be the reason. Not only is it difficult to envisage a change sufficiently widespread to have affected several types of coastal environment (rocky shorelines, barrier beaches, bays and estuaries), but such a change would need to have been particularly subtle since several other species of shellfish which predominate in layers below the mussel-rich horizons require growth environments very similar to those in which the mussels thrive. A case might be put for environmental change of a very subtle nature since in general the edible mussel is a species extremely tolerant of a wide range of environmental changes, however the rock oyster *Crassostrea commercialis* is similarly tolerant of these changes, and is better able to re-colonise a depleted area rapidly (Chapter 2). The rock oyster therefore would be more likely than the mussel to take up this role in the shell middens following such an environmental change.

It has been suggested (Hum 1970:112, Poiner 1971:66,126) that the increase in the numbers of mussels may reflect their introduction to Australia on the hulls of early sailing vessels, and that the mussels present in shell middens pre-dating the time of European arrival in Australia were only the hairy mussel, *Trichomya hirsuta* and the small mussel *Brachiodontes rostratus*. A careful analysis of the contents of excavated middens in which a pronounced changeover to mussel occurs however generally shows *Mytilus* to have been present throughout the time of deposition, but only to have dominated the shellfish suites during the more recent prehistoric phases of occupation. This is the case for shell middens excavated from Wattamolla (Megaw and Roberts 1974), Curracarrang 10US/ (Megaw 1965, 1968), Bass Point (Bowler 1970, 1976), Cemetery Point (Collier 1975), Bowen Island (Blackwell 1980), Nundera Point (see below) and Pambula Lake (Chapter 8).

Shellfish biology is well known for the estuarine and rock platform species commonly represented in the lower layers of shell middens in which the changeover to mussel occurs. Species represented below the mussel-dominated layers include gastropods found on both sheltered and exposed rock platforms, and oysters found on rock platforms or the shorelines of estuaries. The edible mussel thrives
best in conditions which occur most commonly near the mouths of estuaries or in more sheltered niches on exposed rock platforms. Mussels therefore replace shellfish of those same habitats in the most recent layers of archaeological deposits.

Mussel communities have been observed to become established for no apparent reason. Such occurrences are generally localised, and a climax may be reached and the numbers decline as rapidly as they appeared (Hum 1970:24). Although such factors as overcrowding and predation, especially by the carnivorous cartrut shellfish _Dicathais orbita_, have been suggested to explain this decline, Hum commented (1970:24) that the dynamics of the mussel bed "remains a mystery" and this was still the case ten years later (Blackwell 1980: Appendix 5, quoting McIntyre, Curator of Molluscs at the Australian Museum).

A number of known factors of mussel ecology however are relevant to a consideration of their role in prehistoric economies. The preferred substratum of the mussel bed is firm and rough and thus rocky reefs and platforms, other shell beds and man-made structures such as piles, chains and frayed ropes provide a base for mussel beds. Communities have almost certainly proliferated in some estuaries since Europeans have provided such substrata in abundance (Hum 1970:122).

Mussel communities can occur in the lower littoral zone of inlets open to the sea along the entire New South Wales coastline south of Wallis Lake, and their distribution extends southward to the sub-Antarctic islands (Hum 1970:89). The hairy mussel _Trichomya hirsutus_, which cannot tolerate very cold water, overlaps in range with _Mytilus_ throughout southeastern Australia, and beds of the two species commonly occur together. _Trichomya_ is less tolerant of changes in salinity, turbulence and turbidity, and thus is of more restricted range. The hairy mussel population is therefore also more readily affected than _Mytilus_ by sudden environmental changes within an estuary or bay (Hum 1970:31).

Populations of _Mytilus_ are however very variable in occurrence and development through time. Numerous surveys carried out at various times have failed to locate mussel beds in several estuaries where at other times thriving communities have been recorded. It is apparent from these surveys that the tolerance limits of individual mussel communities are more variable than for the species as a whole, and
particular communities may be more vulnerable to specific but unidentified environmental changes. Edible mussels are generally uncommon in small inlets and are present more constantly as well developed beds in large deep inlets (Hum 1970:120ff). Although generally tolerant of a wide range of salinities, at salt concentrations similar to that of seawater predation by carnivorous molluscs and starfish is an important demographic factor. Systematic destruction of patches of *Mytilus* by the predator *Dicathais orbita* has been observed frequently near estuary mouths (Hum 1970:122).

Growth rates vary directly with the abundance of diatomaceous and other planktonic food. Growth rates are highest where the mussel beds are constantly submerged, where salinity remains at concentrations in excess of 14 parts per thousand and where water temperatures remain between 10 and 20 degrees Centigrade. Optimum growth conditions also include low turbidity and constantly fast-moving water with preferred velocities of about 8km per hour (Hum 1970:10-20). Shell thickness is greatest when the environment is a less protected one (Seed 1968), and shell shape is highly variable depending almost entirely on a range of environmental conditions during growth (Hum 1970:91). Observations of midden deposits on the New South Wales south coast suggest that shell thickness is generally greater towards the south, and in middens behind open beaches and very exposed platforms.

The main factor of mussel ecology which might affect significantly the economic role of this shellfish is the pattern of colonisation. Hum (1970:44,91) noted that although mussel larvae select their site of settlement with some care, and have considerable freedom in the duration of the free-swimming stage, there is only very occasional introduction of "foreign" *Mytilus* spat into any estuary. Populations within any coastal inlet tend therefore to re-populate within the same inlet, and hence may take considerable time to recover from over-predation or other trauma.

This factor would be important in explaining a sudden decrease in mussels along any estuary and hence the number available as a food resource. It does not however help to explain the "sudden" increase in edible mussel in the recent prehistory of many coastal sites, which may in part reflect the number of mussels available. Given the range of tolerance of individual mussel communities and the superior re-colonising ability of the rock oyster, if environmental factors
were the main reason for the change to mussel, population dynamics ought to have favoured instead a change to rock oyster. A cultural explanation for the change is therefore preferred.

**Cultural Factors**

Bowdler suggested (1976:255) that the change to mussel represented a change of strategy to one in which women began to fish with hook and line, and spent less time collecting shellfish. As a result they gathered mussels which are more readily available in the intertidal reaches of rock platforms, rather than engaged in the more time consuming diving for large gastropods sheltering in cracks on the platform edges, as they had done previously. This is the most convincing explanation yet advanced. An associated but largely untestable hypothesis relates to their use as bait. It is possible that mussels were used as bait rather than eaten directly (Aborigines on the Murray and Darling Rivers still use freshwater mussels as bait — Beryl Philip pers. comm.), and that they were removed from the shells at the campsite for this purpose. Such an explanation however would not explain the decrease in large gastropods which accompanied the change to mussel, and which would suggest the mussels are in fact the remains of human meals. Blackwell (1980:69) suggested that the change to edible mussel in the Bowen Island site correlated with "intensification of subsistence activities". Intensification of subsistence which involved a change in shellfish exploited would be likely to have resulted in an increase in the numbers or types of shellfish consumed, however at Bowen Island as at other sites mussel appears to replace gastropods through time, not to have been consumed in addition to them.

The change to edible mussel as a dominant species in shell middens is widespread. It can be observed in many sites in the Sydney Basin and Molong-South Coast regions. If Bowdler's hypothesis applies, then the change to mussel is a cultural marker in the sense of denoting the change to a hook and line fishing strategy. There are few such marker horizons in shell middens, particularly of examples which can be so readily recognised during field survey as the change to a predominance of mussel shells. Three aspects of this change were therefore followed up in detail:
Determining the nature of the changeover at a number of shell midden sites described in previous excavation reports. At some sites for example Bass Point, the change is abrupt, at others it appears to have been more gradual.

Dating the changeover at these sites.

Ascertaining the nature and timing of the changeover at two sites I have investigated, Nunderry Point and Pambula Lake, to determine whether sites on the far south coast demonstrate a changeover at a similar time to those previously excavated to the north.

Some of these questions are addressed in this chapter, and a more detailed examination and interpretation is undertaken in the concluding chapter, taking into account also information from the Pambula Lake site (Chapter 8).

Evidence From Previously Excavated Sites

Ten shell midden excavations had been carried out previously which provided information on the pattern of the change to mussel. These were at Birubi (Dyall 1979), Daley's Point (Clegg 1979), Newport (Tracey 1974), Gymea Bay (Megaw 1966), Yowie Bay (Poineer 1974), Wattamolla Cove (Megaw and Roberts 1974), Curra-carrang 1CU5/- (Megaw 1965, Glover 1974), Bass Point (Bowdler 1970, 1967, Hughes 1977), Bowen Island (Blackwell 1980), Cemetery Point (Collier 1975) and Durras North (Lampert 1966), (Fig. 6-1).

In most instances the change to mussel had not been of major concern in the analyses, and the changeover dates are commonly not well established. For some of these sites however sufficient dating evidence is available to construct depth/age curves from which the most likely changeover date could be determined (Figs. 6-2, 6-3), and in others an estimate could be made from published dates and section drawings. The changeover generally occurred between 900 and 700 years B.P. At Bass Point it was well dated at 740 years B.P. (Hughes and Djobadze 1980:18).

Only at Bass Point is there a definite association between the commencement of use of shell fish hooks and the change to mussel. At Gymea Bay fish hook files were recovered from a site in which evidence of use ceased about 1,220 years B.P., and where hairy mussel but no
Fig. 6-1. Sites used to show the changeover to edible mussel.
Fig. 6-2. Depth/age curve for Cemetery Point. For details of dating see Gillespie and Temple 1977.
Fig. 6-3. Depth/age curve for Bowen Island 1.
edible mussel was found (Megaw 1966:40 ff.). There is also a record of a possible broken fish hook file from the lowest level at Currarong shelter 1 (Lampert 1971a:49,55), a level dated at more than 1,900 years B.P. (Hughes and Djohadze 1980:8-12).

At other sites there does appear to be some association between the exploitation of edible mussel and the use of shell fish hooks, although there is also difficulty in establishing the time of initial use of shell fish hooks. At Birubi shell fish hooks were found in the basal layers, dated at about 790 years B.P. (Dyall 1979), and the proportion of edible mussel shell increased from the layer immediately above this. Fish hooks were found at Cemetery Point, but not in stratigraphic section (Collier 1975:22). At Curra-currawang a fish hook file was recovered from a level dated at about 230 years B.P., along with edible mussel shells (Megaw 1965:206). The fish identified from the edible mussel rich layers of the Boven Island site would suggest the possible use of hooks and lines (Blackwell 1980:39,58).

Lampert presented in tabulated form all the data relating to fish hooks, fish hook blanks and fish hook files from Currarong shelters 1 and 2 (1971a:39). From shelter 1 all fish hooks and blanks were from layers dated by Hughes and Djohadze (1980:12) as less than 350 years B.P. and from Currarong shelter 2 all the hooks and blanks were recovered from layers more recent than 1,100 years B.P. Definite fish hook files from the two shelters all date from less than 900 years B.P., except the possible broken file from a layer more than 1,900 years B.P. At Bass Point shell fish hooks and fish hook blanks were recovered from layers dated to less than 740 years B.P. (Bowdler 1970:61, Hughes 1977:170, Hughes and Djohadze 1980:17). At St. Georges Basin shell fish hooks were in use at about 700 years B.P. (Barz 1977), at Wattamolla shell fish hooks and fish hook blanks were recovered from layers dated to 840-160 years B.P. (ANU 177, Megaw and Roberts 1974:3,4), and at Durras North fish hooks, blanks and fish hook files were recovered only from the upper layers, certainly deposited less than 400 years B.P. (Lampert 1966:94-5).

No other definite dates are available for the use of shell fish hooks, but there is a good general association for the two sets of dates. Apart from the fish hook file from Gymea and the doubtful broken fish hook file from Currarong shelter 1, all evidence of the manufacture of shell fish hooks dates from more recently than about
1,100 years B.P. Edible mussel became important in many sites after that time. The association of dates and the occurrence of both evidence of fish hook manufacture and a change to mussel shell in several middens suggests that mussel did indeed become more important after the introduction of shell fish hooks.

The Nundera Point Site

Other work which contributed answers to the general question of resource use, and particularly the increased use of mussel, was my investigation of a shell midden at Nundera Point within which the change to a predominance of edible mussel was apparent. Two columns of deposit were removed for analysis when the site was undergoing a stabilisation programme in 1981-82. Although some 15km north of the southern boundary of the Sydney Basin, the Nundera site lies well south of other previously excavated shell middens in which the changeover was recorded.

This shell midden consists of three cultural layers in a high dune at the back of the headland. The midden layers are separated by layers of sterile windblown sand more than 20cm thick (Fig. 6-4, Plates 6-1, 6-2). Radiocarbon dates on shell were obtained from the central portion of each of the three layers, and when the marine reservoir environmental correction factor of 450±35 years was applied, the conventional radiocarbon ages for these layers were: 240±80 years B.P. (Beta 2758), 740±90 years B.P. (SUA 1699) and 1,700±100 years B.P. (SUA 1700), respectively.

Mussel shell was not present in the lowermost midden layer, but appeared to dominate the shellfish observed in the top midden layer. Analysis of the column samples revealed that in fact mussel was present in the middle layer, where it made up a small proportion of the shell content. Other shells such as limpets and turban shells were clearly identifiable from the lowest excavated layer, so the apparent absence of mussel from that layer is almost certainly because no mussel was collected at that time, not because of poor preservation of mussel. Edible mussel therefore became important at the site at some time before 740 years B.P., and became dominant only in the most recent phase of use, about 240 years B.P.
PLATE 6-1. UPPER SHELL MIDDEN LAYER AT NUNDERA POINT, EXPOSED IN THE DUNE.

PLATE 6-2. NUNDERA POINT COLUMN SAMPLES. SCALE INDICATED = 10CM.
Fig. 6-4. Nunderra Point shell column sections
Discussion of the similarities between sites in the Molong-South Coast region and the Sydney Basin is continued in the concluding chapter, where the results and interpretation of the Pambula midden investigation are also continued. In that chapter I also return to the questions of the nature and timing of the change to mussel, again in the light of the evidence from the Pambula midden.
CHAPTER 7

NINETY YEARS LATER: A RE-SURVEY OF THE SHELL MIDDENS ON WAGONA INLET AND PAMBULA LAKE

PREVIOUS SURVEY

In 1890 the Geological Surveyor William Anderson published his "Notes on the Shell-heaps or Kitchen-middens accumulated by the Aborigines of the Southern Coastal District" which he described as that part of the coastal plain between Moruya and the Victorian Border (Anderson 1890). Anderson's interest in these shell middens, which obviously arose from his awareness of the substitution of shell for limestone as a source of lime, extended well beyond their economic potential. His paper is primarily concerned with the locations and contents of shell middens around the shores of the "innumerable estuaries and salt-water lakes" which occupy large tracts of the coastal plain, although it also contains a number of detailed observations on Aboriginal behaviour and the customs and material culture of the "coastal tribes".

Anderson's general observations on the locations of archaeological sites reflected an interest not widely held at that time when he noted that it was still possible to find Aboriginal groups living in the area and their material traces were commonly uncovered (p.53): As he observed,

Relics of these coastal tribes, which are now nearly extinct (certainly so as a pure race), are frequently met with over the whole district.

He noted that the shorelines of the estuaries and lakes were very irregular, consisting of deep bays, sandy "spits" (beaches) and rocky promontories, and that shell heaps occurred more frequently on the promontories and beaches than on the steep shores of the deep embayments. He argued that the location of the shell heaps was related to the availability of molluscs which in turn occurred more abundantly off rocky points (p.53). He also observed that on low narrow promonories the entire surface was covered with empty shells to a
variable depth, while on sandy spits shells occurred in distinct heaps. Shell accumulations were generally close to the tidal limit, and the seaward margins of many of the heaps had suffered erosion from high spring tides.

The contents of the shell heaps were of interest to this geologist and he saw in them the chance to reconstruct something of a regional prehistory. Noting large lenses of ash, he concluded that these must represent long periods of campsite occupation, since Aborigines usually lit small fires. He also noted that only the shells immediately below the hearth areas were burnt, and concluded that most of the molluscs had been eaten raw. He did however suggest that only heat could have induced some of the larger gastropods to emerge from their unbroken shells, and wondered if these had been collected inadvertently along with edible bivalves. Anderson (p.54) also related discrete lenses of different shellfish species to meals gathered at somewhat different times.

SHELL MIDDENS AT WAGONGA INLET AND PAMBULA LAKE

The two areas in which Anderson carried out intensive site survey and detailed description of the shell mounds were the margins of Wagonga Inlet near Narooma, and Pambula Lake north of Eden. In each of these areas he mapped the occurrences of major shell mounds, and carried out some excavations.

The locations of these study areas are shown in Fig. 7-1. Anderson's maps of the locations of the major shell heaps are reproduced in Figs. 7-2 and 7-3. Most sites were not described individually, but general comments on the nature and dimensions of the mounds were given which apparently applied to each of the sites mapped. In other instances however, particularly when the heaps were "opened up", details of their structure and contents were given.

Now, ninety years after Anderson first described these deposits I have returned to his survey area to assess the changes which have occurred in that time, and to re-investigate the deposits. My investigation was in two parts. In November 1978 I carried out a test excavation into a shell mound on the shore of Pambula Lake; the details of this investigation are reported in Chapter 8. In February
Fig. 7-1. Locations of Wagonga Inlet and Pambula Lake, and other localities mentioned in the text.
Fig. 7-2. Anderson's map of shell middens on Wagonga Inlet. Reproduced with permission of the Dept. Mineral Resources, N.S.W.
Fig. 7-3. Anderson's map of shell middens on Pambula (Panbula) Lake.
Reproduced with permission of the Dept. Mineral Resources N.S.W.
1980 I re-surveyed the banks of the two estuaries, using a small power boat and observed the changes which have occurred over the last ninety years. This chapter presents the results of the survey, with details on the locations and descriptions of the mounds. It also raises questions of differences in the numbers of sites which have survived and their states of preservation, and reasons for these differences. This is an important problem when constructing regional and local prehistory on the basis of present site distributions. There are also important implications for site management, in understanding the factors which influence site survival.

WAGONGA INLET

Wagonga Inlet is a deep estuarine embayment about 8 sq.km in area which forms the drowned river mouth of the Wagonga River. The estuary is generally less than 10m deep, but tidal scour maintains a channel to 14m deep (Fig. 7-4). The lake bottom in the near-shore zone comprises fine sediments and supports dense stands of sea grasses, mainly *Posidonia australis* with some *Zostera capricorni*, and beds of cockle (*Anadara trapezia*) in about 2m or more of clear water. In deeper water further offshore the bed is more sandy, and occasional specimens of mud oyster (*Ostrea angasi*) can now be seen on the bottom. Estuarine species of fish are prolific, and numerous fingerlings of several species can be seen among the weed beds. Owen (1978b) noted that fish were plentiful in the estuary, especially luderick (*Girella tricuspidata*) and mullet (chiefly *Mugil cephalus*).

Anderson recorded ten shell midden mounds on the banks of the estuary of the Wagonga River, and these are shown in Fig. 7-2. As he noted, most of these occur on rocky promontories, and many can now be reached easily only by water, or by walking or driving across-country. Vehicle tracks allow access to some of these sites, and it is likely that most of these were developed from tracks initially constructed at about the time of Anderson's survey. Some of the deposits have been recorded and described in other surveys (e.g. Sullivan 1976, 1978, 1981, Barz 1979) but others on private property where access was denied have not been recorded since 1890.
Fig. 7-4. Present distribution of mounded shell middens on Wagonga Inlet.
The method used to re-survey the estuary was to travel close to the shoreline by boat, locating the recorded sites by using Anderson's map in conjunction with a recent 1:25,000 Wagonga topographic sheet. Although the survey data available in 1890 were not as detailed as those on the topographic map, it was possible to clearly relate the locations of the sites mapped by Anderson to the recent map. All site locations recorded in 1890 were visited, and as well a close watch was kept for other shell deposits not recorded by Anderson. Five new sites were noted during this survey. If the sites were well vegetated in 1890, which seems likely as they had undoubtedly gone out of use before that time, it is not surprising that Anderson did not record all the mounds located in 1880, since the deposits generally merge into the landscape unless their highly reflective shell contents are exposed. The locations of all sites recorded are shown in Fig. 7-4, which is based on the Wagonga 1:25,000 topographic sheet. Sites recorded by Anderson are numbered 1-10, and the additional sites A-E.

A detailed description of each site is given below, and these are summarised in Table 7-1. Where possible a comparison is made with Anderson's observations of 1890. As many of the mounds have accumulated at breaks of slope in the underlying landsurface, they are generally not regularly conical in form. The present midden volumes were therefore calculated by multiplying the observed basal area by the estimated average thickness of deposit. Some attempt was made to infer the former volumes of sites recorded by Anderson but now largely or completely destroyed. Where Anderson had described the sites in sufficient detail volumes were calculated from his descriptions. Anderson described all the sites he recorded as "shell heaps", and referred to some as "accumulations...which...take no definite shape" and others as "mounds" (p.54). It can therefore be assumed, consistent with these descriptions, that a conservative estimate of the depth of each deposit was 50cm. For sites not described in detail in 1890, the area over which traces of shell now remain, or the area mapped by Anderson, was therefore multiplied by 0.5m, to obtain an estimate of the volume of the sites.

Site 1 lies on the western bank of Forsters Bay, on the promontory known as Shell Point. Although Anderson mapped the entire promontory as covered with mounded midden, little now remains. From the water no midden is visible, but within the woodland on the print
<table>
<thead>
<tr>
<th>Site No.</th>
<th>Site Contents</th>
<th>Approximate volumes (m$^3$) 1980</th>
<th>Estimated approximate volume (m$^3$) 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cockle (<em>Anadara trapezia</em>) and some mud oyster (<em>Ostrea angasi</em>) shells in a disturbed mound. Some chipped stone noted.</td>
<td>100</td>
<td>3,000</td>
</tr>
<tr>
<td>2</td>
<td>Mainly cockle shells in scatters and small lenses.</td>
<td>15</td>
<td>&lt;500</td>
</tr>
<tr>
<td>3</td>
<td>Cockle with some mud oyster and rock oyster (<em>Crassostrea commercialis</em>) shells in a single small mound with additional scatters of shell.</td>
<td>50</td>
<td>1,000</td>
</tr>
<tr>
<td>A</td>
<td>Cockle with some mud oyster, rock oyster and mud whelk (<em>Pyrazus ebeninus</em>) shells evenly distributed across headland</td>
<td>250</td>
<td>Not recorded Minimum 250</td>
</tr>
<tr>
<td>B</td>
<td>Cockle with minor mud oyster, rock oyster and mud whelk shells evenly distributed across lower slopes of headland</td>
<td>60</td>
<td>Not recorded Minimum 60</td>
</tr>
<tr>
<td>C</td>
<td>Cockle and mud oyster with minor rock oyster and mud whelk shells in a disturbed mound with additional scatters of shell.</td>
<td>100</td>
<td>Not recorded Probably &gt;200</td>
</tr>
<tr>
<td>4</td>
<td>Cockle, mud oyster and mud whelk shells in a disturbed mound</td>
<td>&lt;100</td>
<td>1,000</td>
</tr>
<tr>
<td>D</td>
<td>Mainly cockle shells in a disturbed mound</td>
<td>100</td>
<td>Not recorded Probably &gt;1,000</td>
</tr>
<tr>
<td>5</td>
<td>Cockle and mud oyster shell lenses in a compact mound, little disturbed</td>
<td>850</td>
<td>1,000</td>
</tr>
<tr>
<td>E</td>
<td>Cockle and minor mud oyster shells in a disturbed mound</td>
<td>10</td>
<td>Not recorded Probably &gt;500</td>
</tr>
<tr>
<td>6</td>
<td>Cockle and mud oyster shells in a reworked layer along backshore</td>
<td>5</td>
<td>500</td>
</tr>
<tr>
<td>7</td>
<td>Mud oyster, cockle and some rock oyster shells in patches along shoreline and on headland</td>
<td>700</td>
<td>6,000</td>
</tr>
<tr>
<td>8</td>
<td>Cockles and mud oyster with some rock oyster shells in a disturbed layer behind shoreline of headland</td>
<td>600</td>
<td>10,000</td>
</tr>
<tr>
<td>9</td>
<td>Cockles and mud oyster with some rock oyster shells in a disturbed layer behind shoreline of headland</td>
<td>750</td>
<td>10,000</td>
</tr>
<tr>
<td>10</td>
<td>Mud oyster and cockle shells in a truncated mound with additional scatters of shell</td>
<td>80</td>
<td>12,000</td>
</tr>
</tbody>
</table>
traces of mounds can be found. Shell is scattered thinly over an area of about 100m X 60m at the end of a vehicle track leading to the point, and this shell seems to have been scattered as the bulk of the material was removed (see below).

Over an area of 10 sq. m near the end of the promontory is a compact midden deposit which in places is more than 1m deep. This deposit has been disturbed by European digging, some of which may relate to Anderson's examination of the site, but most of which appears to be of very recent origin, particularly as the site now functions as a local rubbish dump. The shells are predominantly Sydney Cockle (*Anadara trapezia*) with some mud oyster (*Ostrea angasi*) and rock oyster (*Crassostrea commercialis*). A few chips of quartz and acidic volcanic rock were seen, but no bone.

Shell Point was the site of Anderson's excavation A, and he mapped the deposit and reported shell mounds in excess of 5 ft (1.5m) containing layers of shells, ash, hearthstones and the bones of fish and small land animals.

It appears that a relatively small portion of the site, immediately behind the point is all that remains of the large mounded deposit existing at the time of Anderson's survey. It seems likely that Anderson's own excavation may have partially destroyed some of the mounds which had previously existed. He gives no details of his excavation method, but it is likely that a shovel or spade was the tool used.

**Site 2** lies in the embayment between Shell Point and Ringlands Point. The area is now ploughed, the pastures improved, and little trace remains of the site recorded in 1890. At the locality close to the shoreline where this site was mapped there is now a wharf and a commercial oyster farm, with abundant traces of very recent oyster shelling activity. A large European oyster shell midden is confined within wooden bank supports, and is evenly spread along the shoreline to a depth of more than 1m, obscuring any Aboriginal midden which may have survived the processes of ploughing, grading the land and constructing the wharf.
At the western end of the site mapped by Anderson there is a remnant lens of Anadara midden protected among the roots of a large tree which has grown through it. This lens is about 10m X 5m and 30cm deep, and consists of stratified shell in dark sand. The remainder of the deposit has presumably been removed.

From this site along the slope to Ringlands Point traces of shell midden occur as patches of shell in dark sand, generally on the rocky slopes below the cleared pastures, and exposed at the shoreward margin. The shells are mainly cockle, with some mud oyster. The surviving patches were probably once part of a continuous deposit extending over about 60m along the shoreline.

Site 3 was mapped as covering the entire northern end of a promontory about 1.5km west of Ringlands Point. Again little of the original mound has survived. On the eastern side of the point a single small mound about 10m in diameter, and less than 1m in depth remains. This mound comprises mainly cockle shells with some mud oyster and rock oyster. It is built up at the break of slope between the rocky spur and the footslope (Fig. 7-5), and shell extends in a thin scatter back up the hillslope.

To the west of the shell mound the dry sclerophyll forest does not appear to have been disturbed, yet no shell could be found. It seems likely that any disturbance which resulted in the removal of shell from this area must have occurred many years ago, as the forest has re-established. This therefore probably occurred shortly after Anderson's visit.

Above the main point, shell is scattered thinly over the surface of the headland over an area about 100m X 20m, its outline marked by a thick growth of honeyrush (Lomandra longifolia). An old vehicle track extends onto the headland, and this track was perhaps used initially to remove shell from the former mounds.

Site A lies on the point west of Site 3. This site was not recorded by Anderson, so any change since 1890 cannot be estimated. The midden is evenly distributed across the gentle footslope of the headland. The deposit covers an area of 50m X 10m, and is about 50cm in depth. It consists of densely packed cockle shell with minor
amounts of mud oyster, hercules club whelk or mud whelk (*Pyrazus
ebeninus*), and rock oyster. Considerable amounts of fired stone,
mainly acidic volcanic rock, are exposed on eroded patches. Occasional
chipped quartz was also noted. The site is now grassed and grazed, and
a picnic area has been established on its surface.

**Site B** lies on the eastern headland of Flying Fox Bay. A deposit
of shell midden similar to that at Site A covers an area of 60m X 20m
to a depth of about 50cm. The slopes of the headland are cleared and
grazed, and shell can be seen scattered over the lower parts of the
slopes above this more concentrated deposit.

**Site C** lies on the end of Hobbs Point on the western side of
Flying Fox Bay. The site, which was not noted by Anderson, is now very
disturbed. Traces of a shell mound lie at the base of the point, over
an area about 15m in diameter, with additional small patches of midden
exceeding 50cm in depth. Shell appears to have been removed from the
site, and the surface is irregular. Cockles, mud oyster, rock oyster
and mud whelk shells were noted, in a dark sandy matrix.

**Site D** was mapped and partially excavated by Anderson, who
described its contents as similar to Site 1, with more cockles in the
upper part, more mud oyster in the lower part, and mud whelks
distributed throughout. From the base of this deposit Anderson also
recovered the skeleton of a dingo in a poor state of preservation, but
no other details of this find are available.

On this occasion it was not possible to reach the site because
access was blocked by racks of a commercial oyster lease, which
completely surround the point.

**Site D** lies on the headland north of Sites C and 4. It consists
of a compact deposit, predominantly of cockle shells, which has been
disturbed and cut into, probably during the last ten years, for the
construction of a modern commercial oyster farm, the leases of which
date from 1971 to 1974. This remnant of what was probably a large
mounded site now occupies about 20m X 10m to a depth of about 50cm, in
a dark sandy matrix.
Site 5 lies on the southern side of the southern headland of Brices Bay, and was partially excavated by Anderson. The most intact of all the shell mounds on Wagonga Inlet, this appears to have been little disturbed since being recorded by Anderson. The headland is not cleared, and although there is an oyster lease at the base of the deposit this appears to have resulted in little disturbance to the site. The mound is approximately circular, and about 30m in diameter. The shoreward edge has slumped as the result of wave undercutting, exposing alternating uneven lenses of compact cockle and mud oyster shells in dark sand (Plate 7-1), possibly indicating different events of site use. The mound is about 1m deep at the shoreward edge, and rises to a height of over 2m at the break of slope, with an average thickness of about 1.2m. Although Anderson reported that the midden was composed almost entirely of cockle and mud whelk shells, the face exposed by slumping showed that mud oyster shells are also present in discrete layers.

Site 5 lies on the northern headland of Brices Bay. The site is now within a complex of access tracks to the wharf of a commercial oyster farm, and only patches of midden remain as evidence that there was a shell midden on this point. Several local patches about 3m X 3m indicate that the midden contained mainly cockle shells with minor quantities of mud oysters, in a dark sandy matrix, and extended along about 40m of the shoreline.

Site 6 lies to the west of a rainforested gully which divides Paradise Point. Although Anderson recorded a shell mound on this point, no trace of the deposit now remains. The point is marked by a massive outcrop of quartzite, and on the western side of this outcrop extending for about 20m along the backshore zone, is a scatter of reworked midden shell (see Hughes and Sullivan, 1974), chiefly cockle with some mud oyster. No trace of intact deposit remains, and it appears that the entire deposit has been dispersed.

Site 7 lies on the eastern side of the rainforest gully, on Paradise Point. Anderson also recorded a shell mound on this side of the headland, however little midden now remains. This point is also formed by an outcrop of quartzite and more shaley sedimentary rocks of
PLATE 7-1. WAGONGA INLET SITE 5, SHELL MIDDEN MOUND

PLATE 7-2. WAGONGA INLET SITE 8, NOW FARMLAND
the Wagonga Beds. On the western side of the rock outcrop is a layer of shell midden, totally reworked at its shoreward edge, but grading inland into intact deposit. The deposit covers an area of about 30 sq.m, and consists of mud oyster, cockle and rock oyster shells in dark sand. On the eastern side of the rock outcrop a layer of shell midden, slightly reworked at the shoreward edge, extends for about 100m along the shoreline, and inland for 10 to 20m. The deposit is about 30cm deep at the shoreward edge and rises to about 60 cm deep on the eastern point.

Although the presence of rainforest species in the gully between Sites 6 and 7 gives an impression from the water that the site is untouched, a track extends onto the headland upslope from the sites, and it again appears likely that shell has been removed from these sites.

**Site 8** is on Black Bream Point, and was recorded by Anderson as covering an area of about 200m x 100m across the entire eastern half of the promontory. The area is now farmed, with cattle grazing on improved pastures. Little of the original site remains. A deposit of shell midden in dark sand is present along the eastern margin of the point for a distance of about 120m, but extends inland only about 10m (Plate 7-2). The deposit is on average 50cm deep, with patches to 1m deep. The shells are mainly cockles and mud oyster, with some rock oyster. The shoreward edge of the deposit is reworked, and contains admixed pumice. No mounds now exist, and most of their contained shell appears to have been completely removed from the point. As the lower terrace on which the midden remnant occurs has been ploughed for pasture improvement, the entire deposit may be disturbed.

**Site 9** lies on the headland between Clarks Bay and Barlows Bay, and was recorded by Anderson as being similar in extent to Site 8. All that remains of the site is a layer of midden which extends for about 150m along the eastern side of the headland, and inland for about 10m. The depth of the deposit varies between 30 and 80cm, and like Site 8 it may all have been disturbed by pasture improvement practices.
Where a water tank has recently been installed on the hillslope the ground has been disturbed and no shell is present. It seems likely that the contents of the original mounds have been completely removed.

**Site 10** was recorded by Anderson as covering the entire narrow promontory to the east of Barlowa Bay. Virtually nothing of this extensive deposit now survives. The promontory is farmed, with improved pastures, and the entire surface has been disturbed. Traces of shell midden, comprising mainly cockle shells, occur as patches at the back of the beach on the western side of the point, and a partly truncated shell mound remains on the southern end of the point. This mound contains mud oyster and cockle shells in dark sand, and is about 10m in diameter and 1m high. Most of the shell from the original deposit seems to have been removed from the point.

**PAMBULA LAKE**

The inlet of Pambula Lake, and the open body of water behind it (sometimes known as the Broadwater) seem to have been, like Wagonga Inlet, a focus of Aboriginal activity. This estuary occupies about 5 sq. km, and is generally less than 6m deep, with a sandy bottom. The hillslopes surrounding the lake and its inlet are steep (Fig. 7-5), and most of the shoreline has never been cleared.

Like Wagonga Inlet the sandy bed of the Pambula Inlet supports dense communities of *Zostera* and *Posidonia* with their attendant shellfish communities dominated by the cockle *Anadara trapezia*. Hunt (1970:21) noted that the inlet of Pambula Lake provided ideal conditions for maintaining beds of the edible mussel *Mytilus planulatus* in terms of substratum, salinity and water flow. In a number of surveys reported by Hunt (1970) thriving mussel communities were recorded on the shoreline of the Pambula Inlet, and mussel beds were also noted on the shoreline during my 1980 survey.

The sites recorded by Anderson in his survey of 1890 are mainly concentrated along the inlet rather than around the lake, and therefore it was to the shoreline of the inlet rather than the open lake that this re-survey was directed. Anderson recorded midden concentrations in seventeen locations along the shoreline, all of
Fig 7-5. Typical hillslope and shell midden sections at Wagonga Inlet and Pambula Lake.
which were re-visited. In addition another four sites were described which were not recorded in the 1890 survey. The locations of these sites are shown on Fig. 7-6, drawn from the Pambula 1:25,000 topographic sheet, with the sites noted by Anderson numbered 1 - 17, and the four additional sites designated A - D. The descriptions are summarised in Table 7-2.

**Site 1** lies on the western shoreline of the open body of water forming Pambula Lake, in an area now cleared and used as a public picnic area, adjacent to a public boat ramp. Although Anderson recorded mounded shell deposits on this site, the land surface has been levelled to develop the picnic area, hence very little of the original site now remains.

Shell is scattered over the stony surface of the hillslope, and near the base of the slope patches of cockle and mud oyster midden in dark sand can be seen. These patches are about 10m X 5m, and generally less than 10cm deep.

It seems likely that this deposit has been destroyed by machinery used in clearing rather than removed entirely although the shell may have been removed a short distance to provide a firm road base for the picnic area and boat ramp.

**Site 2** is at Tee Tree Point, and actually lies nearer to the Point than mapped by Anderson. The area is covered with dry sclerophyll woodland, which does not appear to have been extensively disturbed. The site consists of a number of shell deposits. At the southern end is a mound containing mainly mud oyster shells, 8m X 5m and 1.5m high. To the north are two patches of mud oyster shell in dark sand, each about 4m X 3m, and 50cm deep, adjacent to a strip of midden deposit about 100m long and 30m deep extending inland about 10m. At the northern end of the site is another mounded concentration of shell, set at the break of slope and extending 2 to 3m upslope. At its deepest part this mound is approximately 1m, and similarly it consists of mud oyster shells with minor amounts of cockle, mud whelk and rock oyster.
Fig. 7-6. Present distribution of mounded shell middens on Pambula Lake.
<table>
<thead>
<tr>
<th>Site No.</th>
<th>Site Contents</th>
<th>Approximate volumes (m³) 1980</th>
<th>Estimated Approximate volume (m³) 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cockle and mud oyster shells in patches on hillslope</td>
<td>5</td>
<td>500</td>
</tr>
<tr>
<td>2</td>
<td>Mud oyster with some cockle, rock oyster and mud whelk shells in mounds and patches</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>3</td>
<td>Mud oyster with cockle, mud whelk, rock oyster and some rock platform shells in six mounds. Chipped stone noted</td>
<td>3,000</td>
<td>3,000</td>
</tr>
<tr>
<td>4</td>
<td>Mainly mud oyster shells in a single mound</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>A</td>
<td>Mud oyster and rock oyster shells in a single mound and associated non-mounded deposits</td>
<td>40</td>
<td>Not recorded Minimum 40</td>
</tr>
<tr>
<td>5</td>
<td>Mainly mud oyster shells exposed in six well vegetated mounds</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>6</td>
<td>Mud oyster shells with cockle, rock oyster, mud whelk and mussels (Mytilus planulatus and Trichomya hirsutus) and stone fragments in a deposit built up into break of slope at base of hill</td>
<td>6,500</td>
<td>7,000</td>
</tr>
<tr>
<td>7</td>
<td>Mud oyster shells exposed in four oval mounds on headland</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>8</td>
<td>Mainly compact mud oyster shells in a mound on headland</td>
<td>1,000</td>
<td>1,000</td>
</tr>
<tr>
<td>9</td>
<td>Mainly mud oyster shell in three small mounds on headland</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>Mud oyster shells in patches remaining from a disturbed mound</td>
<td>10</td>
<td>700</td>
</tr>
<tr>
<td>B</td>
<td>Mainly mud oyster and mussel shells in a complex of mounded and non-mounded deposits</td>
<td>20,000</td>
<td>Not recorded Minimum 20,000</td>
</tr>
<tr>
<td>11-16</td>
<td>Continuous deposits of mainly mud oyster shells along shoreline and on hillslopes, more concentrated on western sides of small gullies</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>C</td>
<td>Mainly mud oyster shells in four mounds on lower slopes of headland</td>
<td>1,500</td>
<td>Not recorded Minimum 1,500</td>
</tr>
<tr>
<td>17</td>
<td>Mainly mud oyster shells in a mound and surrounding deposit</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>D</td>
<td>Mainly mud oyster shells in a mound and surrounding deposit</td>
<td>50</td>
<td>Not recorded Minimum 50</td>
</tr>
</tbody>
</table>
Scattered shell occurs on the hillslope between Sites 2 and 3.

Site 3 is at the southern edge of the indentation in the concave river bank known as Shark Hole. It consists of six mounds, three approximately 15m in diameter and more than 2m high and three about half that diameter and at least 1.5m high, and has probably changed little since recorded by Anderson. The mounds lie within an area of about 50m X 50m, and extend from the landward side of the narrow platform on acidic volcanic rock about 40m up the steep hillslope. The shells are mainly those of mud oyster, but some cockle, mud whelk and rock oyster shells are present. Occasional shells of rock platform species were also noted, including abalone (Haliotis ruber), warreners (Gasteropera plengleri), and smaller gastropods such as the nerite Merita atramentosa and a top shell Austroconchlea constricta. Some differentiation in shell species between the mounds was noted during the 1980 survey, and within the mounds lenses of each species are somewhat segregated, suggesting different occasions of shell collecting.

Site 4 lies at the northern end of a shallow mangrove-filled embayment, and although mounded, is a smaller site than Sites 2 and 3. A single mound, mainly of mud oyster shells, lies at and just above the break of slope against the steep hillside behind the embayment. This well grassed stable mound lies within undisturbed woodland. It is about 10m in diameter, and more than 1m deep.

Site 5 is on the north bank of the narrow outlet of the estuary, and was not noted by Anderson. The site consists of a stratified deposit of solid shell, mainly mud oyster and rock oyster, covering an area of 6m X 5m to a depth of 1m. To the east are scattered patches of shell, which grade into a mounded deposit 5m X 3m and 50cm deep. The mound lies in the break of slope, and shell is scattered uphill for another 10m.

Site 5 lies on a rocky headland to the west of a small creek, adjacent to where this stream ends in a gravelly beach. It consists of a complex of six mounds, each about 5m in diameter and at least 1m
deep. The entire complex extends for more than 60m along the shoreline, and inland for about 10m. The mounds appear to contain mainly mud oyster shells, however they are covered with honeyrush, so little of their contents is exposed.

Between Sites 5 and 6 patches of mud oyster midden are present along the shoreline. The shoreward margins of these deposits are truncated by wave action, revealing stratified shell in places 1 to 1.5m deep.

Site 6 similarly lies on the western side of a small gully which ends in a sand and gravel beach. The site is large, extending along the shoreline for 200m, and inland for 10 to 30m. The deposit is not clearly mounded, although it is built up into the break of slope and is deepest at that point. The midden rises upslope in a series of steps, each about 1.5m deep, and where exposed these can be seen to consist of lenses of ash and solidly packed shell (Plate 7-3). The shell is mainly mud oyster, with minor amounts of other estuarine shells. Stone fragments are common in the deposit.

Most of the surface is thickly vegetated except where a large hole has been dug into the deposit at its eastern end. The hole is 5m square, and 2 to 2.5m of compact midden is exposed, with the bottom still in shell. This hole appears to be relatively recent, probably no more than 5 years old, since little re-vegetation has occurred. The shell has been removed from the site. No information is yet available on this shell removal.

Uphill from the major deposit is a mounded midden, 15m in diameter and 1.5m deep. Although well-vegetated, where shell is exposed its composition appears to be similar to that of the remainder of the deposit.

Site 7 comprises four large oval shaped mounds on a headland. Each mound is about 30m X 10m and at least 2m deep.

Between Sites 7 and 8 are discontinuous patches of shell midden to 50cm deep. The mound surfaces are well vegetated, but where shell is exposed it is mainly mud oyster.
PLATE 7-3. PAMBULA LAKE SITE 6, SHELL MIDDEN MOUND
Site 8 is on a promontory immediately west of a small creek. The site is mounded, about 30m in diameter and 2m deep. Although most of its surface is well grassed and stable, the shoreward edge is exposed by wave action, and consists of solid, closely packed mud oyster shells with minor amounts of other estuarine species and occasional ash lenses.

Site 9 also lies immediately west of a small creek. This is a smaller site comprising three small steep mounds, each 4m in diameter and about 2m deep. The mounds are well vegetated, but the shells visible are all of mud oyster.

Site 10 lies on the south bank of the estuary and is the only site on Pambula Lake excavated by Anderson. Although mapped by Anderson slightly further south, the site lies on the headland northeast of the creek outlet which forms Severs Beach. Although described by Anderson as a mound, the site is now very much disturbed, and little remains but scattered heaps of mud oyster shells.

Anderson concluded on the basis of this excavation and of his general observations, that the Pambula mounds had more mud oyster and two species of mussel (Nystius planulatus and Trichomya hirautus) which did not generally occur in the Wagonga mounds. Fish bones and the bones of small "vertebrates" were also recorded from this excavation.

Site B is the mound complex at Severs Beach described in detail in Chapter 8. This complex is scarcely visible from the water (Plate 7-4), and was not recorded by Anderson. The site is very large, covering an area of about 4000 sq.m, and consists of several mounds varying from less than 1m in diameter to several in excess of 10m in diameter and more than 1.5m deep (Plate 7-5). The shells are mainly of mud oyster and mussel, and fish bones are common.

From 100m west of the Severs Beach complex scattered mud oyster midden is visible for about 10m up the entire hillslope, with patches to 1m deep.
PLATE 7-4. SEVERS BEACH MOUNDS, PAMBULA LAKE SITE B, VIEWED FROM THE WATER. (MOUND TO RIGHT IS PLA - SEE CHAPTER 8).

PLATE 7-5. A MOUNDED SHELL MIDDEN (PLB) IN THE SEVERS BEACH COMPLEX.
Sites 11 to 16, although marked by Anderson as separate zones of midden concentration, these actually merge to form a nearly continuous layer of shell midden along the shoreline. The deposits tend to be thicker on the western sides of small tributary creeks, and consist mainly of compact stratified mud oyster shells, with occasional ash lenses. The middens extend inshore between 10 and 30m, and their depths vary between 10cm and 2m, with an average depth of 1m.

The shoreline is undisturbed, with no vehicle tracks present, and there is no evidence of the forest's having been cleared. The midden surfaces are grassed and stable, and only the shoreward margins are disturbed by some wave action.

Site C is a complex of four large midden mounds on Peach Tree Point. The ground surface is rocky, and rises steeply, and the four mounds are in the break of slope near the shoreline. Each is about 20m in diameter, and up to 1m deep. They are composed mainly of mud oyster shells. The site was not recorded by Anderson.

Site 17 is on the shoreline of the Lake, and consists of a single mound with a spread of midden around it. The mound, which contains mainly mud oyster shells, is oval, about 5m x 3m and 1.5m deep. It is surrounded by a deposit about 5m wide and 50cm deep and of similar composition.

Between Site 17 and D is a scatter of mud oyster shell midden to 30cm deep, along the shoreline.

Site D is a deposit similar to that at Site 17, and not recorded by Anderson. The deposit is mounded, about 5m in diameter and 1.2m deep, surrounded by a midden layer 30cm deep, and 5m wide. The shells are mainly of mud oyster. The deposit is well vegetated, and mainly undisturbed, except for some wave erosion at its shoreward edge.
THE STATE OF PRESERVATION OF SITES AND THE IMPLICATIONS FOR MANAGEMENT

The difference between the shell mounds on Wagonga Inlet and those on Pambula Lake is significant, not only in their content, but also in their state of preservation. It is worth comparing what volume of shell midden initially recorded still remains in each of these areas. At Wagonga Inlet it is estimated from Anderson's report and the results of the 1980 survey, that in 1890 a total volume of approximately 47,000 cu.m of shell midden was present on the shores of the Inlet. Today only about 4,000 cu.m or somewhat less than 10% of the volume of shell deposits present in 1890 still remains. At Pambula Lake it is similarly estimated that in 1890 there was about 57,000 cu.m of shell midden on the estuarine shoreline, of which about 55,000 cu.m (or more than 95%) has survived. The changes in individual midden deposits are shown in Tables 7-1 and 7-2.

In terms of physical setting there is little difference between the sites on Wagonga Inlet and on Pambula Lake. At Pambula where the hilltops are steep the middens most commonly occur on the more gentle lower slopes, particularly on the western sides of small gullies. The sites tend to be concentrated on the southern bank of the estuary. At Wagonga the headlands are more prominent and not so steep, and sites are concentrated towards their extremities. Nevertheless these minor differences cannot account for the differences in preservation. In each case middens close to the shoreline show some degree of wave reworking along their lower margins, however this is not the result of severe storm wave disturbance, and it seems unlikely that much material has been lost from the middens as a result of wave action.

Undoubtedly the most significant factor in the difference in preservation of the two sets of sites is the pattern of European settlement. Pambula Lake is relatively undeveloped. Cleared farmland encroaches on the western side of the estuary, but in the east there are few roads, holiday cottage development has barely occurred, and much of the area is within Ben Boyd National Park. In contrast the Narooma area has had a considerable period of rural development, and more recently, development of the coastal fringe as a holiday resort.
There is a long history of shell midden destruction in Australia. The initial threat came from the need to use shell to obtain lime for mortar, and several instances of midden destruction for this purpose have been recorded by Pearson (1981). Collins, writing in 1802 of his experiences in the very early years of the English colony at Sydney Cove (p. 555), noted that as shelter from wind and rain the Aborigines of the area made use of ... excavations in the rock at the mouths of which heaps of shell and "luxuriant soil" accumulated.

These proved a valuable resource to us, and many loads of shells were burnt into lime, while the other parts were wheeled into our gardens.

The shell heaps of Wagonga Inlet were similarly being actively destroyed for the same reasons by settlers in 1890, and it seems likely that since 1890 the sites have suffered as Anderson predicted (p. 60):

...as the rocks of this district are almost entirely devoid of limestone, which could be utilised by the settlers for building and other purposes, these shell-heaps, with their interesting contents, are gradually disappearing, the mounds being dug into and the shells burnt for the lime that they will produce.

A later threat to the survival of large shell middens was the need for sources of road surfacing materials that would drain readily, and in many coastal areas shell has been used as "road gravel". Many minor roads and boat ramps in the Narooma district are paved with estuarine shells, and it is possible that some of this has also been dug from the shell middens.

There seems little doubt that most of the destruction to these sites occurred shortly after Anderson's survey, and that modern development has therefore probably caused little further damage. On other parts of the New South Wales coast housing and industrial developments which involve large scale clearing and earth moving, have in the past and are currently encroaching on areas rich in shell middens.
It is instructive to compare the amount of midden shell in each of these localities with other large shell midden complexes. The largest estuarine shell midden deposits known in New South Wales are those in the Macleay River estuary, particularly at Glybucca and Stuarts Point (Chapter 5). I have examined these deposits and estimate their total volume to be between 150,000 - 200,000 cu.m. Along the shores of the Richmond River estuary are a number of very large mounded shell middens whose total volume has been estimated by Bailey (1975) to be 33,000 cu.m. Like these north coast middens, the mounded deposits on both the Wagonga and Pambula estuaries were extensive and those remaining on the Pambula estuary are still relatively large.

Although extensive shallow shell middens are common on the shores of other estuaries on the far south coast of New South Wales, few large mounded deposits like those on Wagonga Inlet and Pambula Lake are known. Near the mouths of several other estuaries in this area, such as those on the Bermagui, Murrah, Bega, Wonboyn and Nadgee Rivers, Bithery Inlet and Merrimbula Lake (Fig. 7-1), are numerous smaller shell middens, commonly clustered in the foredunes, behind rock platforms or on the slopes of headlands. Only on Wallaga Lake are there large mounded deposits and like those on Wagonga Inlet most seem to have been largely destroyed.

The only other complex of large mounded middens on the South Coast, of which I am aware, are those I recorded around the entrance to Sussex Inlet in the southern part of the Sydney Basin (Sullivan 1977:23-9, see also Barz 1977).

The complex of sites on Pambula Lake forms one of the few almost intact groups of mounded shell middens remaining in New South Wales. Clearly this complex has considerable scientific potential. Not only does it have considerable potential for comprehensive locational studies, but one site which was test excavated (Chapter 8) demonstrated that there was a history of occupation extending back more than 3,000 years, and that it was a rich source of information on both prehistoric economy and cultural changes over that time.

Future development in the Pambula area could easily result in destruction of one of the few almost intact complexes of mounded middens remaining in New South Wales. It is fortunate that sites on the southern side of the estuary are somewhat protected by being
within Ben Boyd National Park. It is to be hoped any future regional environmental plan for this area will also take into account the considerable archaeological value of the remaining sites on the northern shoreline.

It is also important to note the relatively small amount of midden material remaining from what are known to have been much more extensive deposits on Wagonga Inlet.

This study has implications for the reconstruction of the prehistory of coastal New South Wales. Whether removed for lime burning, for roads or merely ploughed and thus dispersed, it is likely that most shell middens in "developed" coastal areas have suffered like those on Wagonga Inlet. Reconstructions of regional prehistories, especially prehistoric coastal economies, based on the present distribution of shell midden deposits may well underestimate the importance of such middens, even where remnants of these remain. Accepting that many shell middens have been largely or totally destroyed, it is only in undisturbed landscapes that it is possible to obtain an accurate estimate of the amounts of food debris, especially shell, discarded in such middens and a realistic appreciation of patterns of site locations.

It can only be concluded from this that surviving archaeological sites within developed areas represent a tiny fraction of what previously existed. The implications of this for site management are clear. Development and associated increased pressure of land use threatens site survival. Only education programmes and planned land use can possibly ensure the survival of these remnants of Aboriginal prehistory. It is important that plans of management for conservation areas such as National Parks, especially those which include a number of such sites, should take into account the need to protect these sites from abuse by people, either deliberate or through lack of information.
CHAPTER 8

A SHELL MIDDEN EXCAVATION AT PAMBULA LAKE

Along the shoreline of the Pambula River estuary are numerous mounded shell middens; others occur further upstream along the banks of the tidal reach of the river. Many of the localities (mapped by Anderson 1890) contain a number of discrete midden mounds, one of which he excavated, and in the course of this, removed the entire mound.

The mound which Anderson excavated (site 10 of Chapter 7), lay on the headland to the east of a small sandy tributary delta known as Severs Beach. The area now lies within Ben Boyd National Park, and is relatively undisturbed since vehicle access is controlled. To the west of this tributary delta is a group of several well grassed stable midden mounds (Pambula Lake Site B of Chapter 7). These mounds (Plate 8-1) appear from survey information to be typical of estuarine shell middens in southern New South Wales (Chapter 5). The distribution of the mounds at Severs Beach is shown in Fig. 8-1, and the excavated mound designated PLA is indicated. Cross sections of the ground surface through the three main shell midden mounds are shown in Fig. 8-2. Anderson's description of the mound sites around the shoreline of Pambula Lake suggested that they could provide a deep sequence of well preserved shell with other faunal remains. Consequently a mound in the Severs Beach complex (PLA) was test-excavated as described below.

THE SITE AND ITS SETTING

The Pambula River drains an area of approximately 250 sq. km of upland ranges rising to 500m, with footslopes of low relief (Fig. 7-1). The river was drowned by the postglacial rise in sealevel and behind a constricted inlet cut through Devonian
PLATE 8-1. THE SEVERS BEACH SITE, WITH MOUNDED SHELL MIDDENS. TOP MOUND IS PLA, LOWER MOUND IS PLB.
Fig. 8-1. Distribution of shell midden mounds at Severs Beach.
Fig. 8-2. Cross-sections through the major shell midden mounds at the Severs Beach site. Transect locations shown in Fig. 8-1.
sandstones the ria-like estuary opens into a larger water body, Pambula Lake, which is about 5 sq. km in area.

The lake and its constricted outlet are backed by rounded hills with a cover of dry sclerophyll forest and woodland, with patches of wet sclerophyll forest in sheltered valleys. On the sandy shorelines and low dunes adjacent to the lake and estuary, coastal heath communities predominate. Much of the area around the lake and estuary was farmed in the early part of the century and light grazing of cattle resulted in the destruction of much of the vegetation understory. Near the shoreline of the lake however no intensive clearing was carried out, and no pasture improvement was practised.

A homestead was located on the hillcrest above the Severs Beach site, and traces of associated landscape disturbance now remain in the form of an overgrown access track, and the presence along this track of tall exotic pines (Pinus radiata). Some disturbance of the midden deposits undoubtedly resulted from this settlement, but most of the deposits still appear to be intact.

The present vegetation adjacent to the site is a woodland of yellow stringybark (Eucalyptus muellerana), red bloodwood (E. gummifera) and black wattles (Acacia decurrens and A. mearnsii) with some banksias (Banksia integrifolia) and other coastal heath plants. The areas of heath contain several edible plants such as native cherry (Exocarpus aphylla) and geebung (Persoonia linearis). The brush understory of the woodland has been largely destroyed, and there is a ground cover of introduced and native grasses, with honeyrush tussocks (Lomandra longifolia and L. filiformis). The shell middens are well grassed and their surfaces are stable.

Rabbits are present in the area, and their burrows occur in most of the loose sandy deposits which have accumulated in the Severs Beach inlet (Fig. 8-1), however the densely packed mounded shell middens appear to have offered resistance to this form of disturbance.
THE EXCAVATED SITE PLA

The PLA shell midden was excavated in November 1978 by a team of 5 archaeologists under my direction. The surface of the mounded deposit was covered with both honeyrush and introduced grasses. Part of this mound had been previously disturbed, probably by people digging for shellgrit or garden soil, and animals had further enlarged the disturbed area. As the shell midden was densely packed however, it appeared that the central core of the deposit was undisturbed, so the excavation trench was placed near the centre of the mound as shown in Figs. 8-2 and 8-3. Loose disturbed material was cleaned back from one side of the mound to expose a face of undisturbed shell midden 42cm deep. The upper part of the trench was excavated laterally into this exposed face, and the lower part extended as a trench below the ground surface on all four sides (Plates 8-2 and 8-3).

The purpose of the excavation was to examine the stratigraphy and contents of the mound in order to determine whether there were differences between its inferred composition, from survey information, and its contents when excavated. This detailed information would also enable the site to be compared with other excavated coastal shell middens to the north of this area, for example those at Durras (Lampert 1966), Burrill Lake (Lampert 1971a), Curramong (Lampert 1971a), Murramarang Point (Lampert and Hughes pers. comm.), Bass Point (Bowdler 1970, 1976), St. Georges Basin (Barz 1977) and Bowen Island (Blackwell 1980) (see Fig. 6-1). For this reason a small trench was excavated, since no attempt was made to determine the overall structure of the mound or the distribution of activity areas within it.

METHODS OF INVESTIGATION

Excavation Method

There is a considerable body of literature on the excavation of shell middens. The prolonged discussion on the appropriate volume of the deposit which needs to be excavated and on the validity of extrapolating from an excavated sample to the whole
EXCAVATION OF THE PLA SITE. NOTE COCKLES PRESENT IN UPPERMOST LAYER.
PLATE 8-3. EXCAVATED SECTIONS OF THE PLA DEPOSIT, MUD OYSTER SHELLS ARE PROMINENT.
Approximate break of slope
Survey transect
Likely continuation of landsurface
PLA excavation
Mounded shell midden (>1m deep)
Dense shell midden (probably <1m deep)
Scattered shell midden
Beach sand
Recent dune sand
Footslope/ terrace
Rock outcrop
Alluvium

Fig. 8-1. The PLA shell midden mound, showing the position of the excavation
midden contents (e.g. Cook and Treganza 1948, Treganza and Cook 1948, Heizer and Cook 1956, Barz 1977) serves mainly to illustrate that the techniques used must be appropriate to the purpose of the study. In this instance the primary aim of the excavation was to determine broadly the contents of the mound, to note any major changes in stratigraphy and contents with depth within the deposit, and to assign a chronology to its deposition. No attempt was made to assess in any detail the total food-energy output which the mound represented, nor to derive a theoretical human population which this area may have supported in prehistoric times. Only a small trench was needed therefore to observe the contents and basic stratigraphy of the deposit, and to enable the collection of a bulk sample large enough to contain both whole shells and sufficient sediment for mechanical analysis and some limited chemical analysis. From such a small excavation no detailed information could be derived on the way in which the mound had accumulated, or if the chronology of accumulation had varied across the site this could not be recognised. The sample was taken from the central core of the mound however, and was likely to reflect the general contents and stratigraphy. No differences in the pattern of accumulation from that observed in the excavation were visible in the disturbed parts of the mound.

The trench excavated was 1m x 0.5m in area, and the excavation continued down to sandstone bedrock at a depth of about 1.2m across the entire base of the trench. The deposit was removed in units following the natural stratigraphy where this could be identified. Within each natural stratigraphic unit the material was removed in arbitrary spits, varying in thickness from 5 to 10cm, depending on the sizes of shells or shell fragments being removed.

Height control was maintained using a line level from a fixed datum point which was levelled in to a local altimetric survey using a standard Zeiss dumpy level. Heights were measured to each corner of the trench and to the centre of the floor at the completion of excavation of each spit. Vertical control was maintained using a line and plumb bob. Excavated finds were recorded using two distance co-ordinates along the sides of the trench, and a height co-ordinate as above.
The deposit was removed with a trowel and collected in plastic buckets. Each bucketload was weighed before sieving. Initially it had been intended to discard the shells, and to collect only the other contents of the midden from field sieving. The entire contents of the mound however were coated with organically stained sediment, so that it was not possible to distinguish them without wet sieving. When the sieves were immersed in water, organic material such as charcoal and fish scales floated away. Therefore each bucketload was sieved through a set of screens of 8mm, 5mm, and 2mm, by hand shaking. Large shell fragments or whole shells coarser than 8mm were weighed and discarded, but the fractions retained by the 5mm and 2mm sieves were weighed then collected in large polythene bags and returned to the laboratory for washing and sorting. Charcoal and any bone or stone recognised were collected from the sieves and bagged in the field. Other bone and stone retrieved in the laboratory during washing and sorting was added to this for the analysis of the spit contents.

A CSIRO soil pH test kit was used for field determinations of pH values for the less than 2mm matrix of each spit. This kit enables pH to be measured to the nearest 0.5 pH unit under field conditions and thus gives a good indication of the conditions for preservation which occur within the deposit. Measurement of pH in this way eliminates the possibility of changes due to the action of soil micro-organisms which may result when samples are stored in plastic bags for some time.

Column Sample

During the course of the excavation a bulk sample of the midden was collected for more detailed analyses. At the completion of excavation of each spit a square column of deposit with sides 25cm which had been left intact in the northwestern corner of the trench, was removed and bagged. Such a sample is taken to be sufficiently large to be representative of the unit in which it occurs (Barz 1977:38, Bowdler in press). The column samples were taken back to the laboratory for analysis. They were immediately opened and weighed, then stored in open bags for
approximately eight months. At the end of this time the samples were completely air-dried, and they were then re-weighed before any analyses were begun. The field moisture content of each spit of the deposit was calculated from the weight loss, and the dry weight used in calculating proportions by weight of fractions of the deposit.

At the completion of the excavation stratigraphic sections of the standing walls of the trench were drawn, and the units identified in these sections correlated with those recognised during excavation. These sections are shown in Fig 8-4, and the stratigraphy of the deposit is discussed below.

Laboratory Analyses

Sieve Residues Collected in the Field

All sieve fractions, which comprised mainly whole shells or shell fragments, were washed under a shower-jet of warm water to remove adhering sediment, and dried in a ventilated cabinet at approximately 25 degrees C. These fractions were then sorted across a white tabletop, under good light from overhead fluorescent tubes, using a flexible stainless steel spatula. All the samples coarser than 5mm were sorted completely into the categories outlined below.

The fraction which passed through the 5mm sieve, but was retained by the 2mm screen, consisted mainly of finely divided uniformly dispersed shell fragments, with small whole shells, fragments of stone and bone, small whole bones, teeth, otoliths and fragments of charcoal. This fraction was sorted completely into the categories listed below for five spits: 6, 12, 16, 17 and 18. After completely sorting through the relatively large 2-5mm fraction from spits 6 and 12, and the much smaller volumes from spits 16, 17, and 18, it was apparent that the bone fragments were generally too small to identify and were useful only to estimate the proportion of bone present in the sample. For all other spits therefore, a 10% by weight subsample was extracted from the 2-5mm fraction, and only these subsamples were sorted completely. Since the 2-5mm fraction is well sorted and the
**KEY TO PLA STRATIGRAPHIC SECTION**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Disturbed earth and fine shell grit</td>
</tr>
<tr>
<td>2</td>
<td>Hearth, charcoal and stone</td>
</tr>
<tr>
<td>3</td>
<td>Compact finely divided edible mussel shell in a dark grey matrix</td>
</tr>
<tr>
<td>4</td>
<td>Lens of coarse edible mussel shell in dark grey matrix</td>
</tr>
<tr>
<td>5</td>
<td>Lens of coarse edible mussel shell with a small amount of dark grey matrix</td>
</tr>
<tr>
<td>6</td>
<td>Light grey ashy sediment with some shell</td>
</tr>
<tr>
<td>7</td>
<td>Pale yellow ashy sediment</td>
</tr>
<tr>
<td>8</td>
<td>Light grey ashy sediment with fragments of edible mussel shell</td>
</tr>
<tr>
<td>9</td>
<td>Coarse edible mussel shell in a dark grey matrix</td>
</tr>
<tr>
<td>10</td>
<td>Finely divided mussel and oyster shell in a brown-grey matrix</td>
</tr>
<tr>
<td>11</td>
<td>Coarse edible mussel shell in a dark grey matrix</td>
</tr>
<tr>
<td>12</td>
<td>Band of mud oyster shell</td>
</tr>
<tr>
<td>13</td>
<td>Coarse hairy mussel and oyster shell in medium grey, slightly ashy matrix</td>
</tr>
<tr>
<td>14</td>
<td>Dense mud oyster layers in a light grey ashy sediment matrix</td>
</tr>
<tr>
<td>15</td>
<td>Whole and fragmented oyster shells in a very dark matrix</td>
</tr>
<tr>
<td>16</td>
<td>Basal sediment, yellowish grey clayey sand, some shell and organic material</td>
</tr>
<tr>
<td>17</td>
<td>Complex mixture of ash, organic material, shell and sediment in indistinct lenses</td>
</tr>
</tbody>
</table>

**Fig. 8-4.** Stratigraphy of the PLA excavated sections
contents uniformly distributed (Barz 1977:42), these 10% subsamples should be representative of the whole unit.

The coarser fraction (+5mm) was sorted into the following categories:

* edible estuarine shellfish species
* small or inedible shellfish species (e.g. seaweed adherents, boring predators)
* barnacle fragments
* beach or rock platform shellfish species
* bone (including artefacts), otoliths, spines, teeth
* fragments of local stone (sandstone, quartz and acidic volcanic rock)
* stone artefacts
* ochre
* other.

The 2-5mm fraction was sorted into the following categories:

* shell fragments
* small whole shells
* barnacle fragments
* bone (including artefacts), otoliths, spines, teeth
* fragments of locally occurring stone
* stone artefacts
* ochre
* other.

**Column Samples**

After drying and weighing, the column samples were dry-sieved by hand shaking them through a set of 8mm, 5mm and 2mm sieves, and the shells on each screen were brushed to remove as much adhering matrix as possible. The matrix (defined as all material finer than 2mm, see Hughes 1980) was collected and weighed, and stored for mechanical and chemical analysis. The sieve fractions were washed under a jet of warm water, dried and re-weighed. The material retained on the sieves was then hand sorted in the same manner as described above for the sieve residues collected in the field.
The fractions collected on the 8mm and 5mm sieves from the column sample were sorted in the same manner as for the field sieve residues, but in addition the shell was further subdivided. Edible estuarine shellfish were sorted into individual species, and any rock platform shells present were noted. In this way an assessment was made of the proportion by weight of each species of shellfish in the deposit, and changes in these proportions through time.

In the case of the 2-5mm fraction a small subsample generally of less than 100gm (between 10 and 30% by weight of the fraction) was sorted into the same categories as for the field sieve residues. In this way a consistent record of the proportions of each category was obtained. No attempt was made to identify shell fragments at the specific level since although it was possible to identify some species, others were mutually indistinguishable. Barz (1977:43) also noted instances where the species of shells she was sorting were similarly indistinguishable in this size range. In addition, even when shell species can be identified, this fraction is commonly not representative of the overall spit contents. For example in the PLA midden, in those spits where the mud oyster (Ostrea angasi) makes up a high proportion of the shell coarser than 5mm, the amount of shell finer than 5mm is relatively small (Table 8-1). This is due to the tendency for Ostrea shell to crumble into very small flakes as it breaks. These flakes pass through the 2mm sieve into the matrix fraction. Barz (pers. comm.) made the same observation for the small number of Ostrea shells present in the midden at St. Georges Basin. Hence the fine shell fraction from the PLA midden is biased towards more brittle but cohesive shells, especially the mussels Mytilus planulatus and Trichomya hirsutus, and does not represent the total shellfish population of the spit. I observed a similar pattern of shell breakdown and loss during the excavation and sorting of an estuarine shell midden at Mallacoota (Fig. 6-1), conducted by members of a Victoria Archaeological Survey Summer School (January 1980). In the case of the PLA midden therefore, the finest shell fraction from the column samples was used only to determine relative amounts of shell, bone and stone in the deposit, and not for shell species identification.
A Change in Procedure

In October 1979, as the result of a laboratory accident, the shell fractions from column samples 13-16 inclusive were thrown to the floor and crushed. Very little could be recovered since all the boxes had burst open, and their contents had become totally mixed. Only two small boxes retained their contents (an otolith from spit 15 and some fishbones from spit 14). The large fragments and whole shells of Ostrea, the >8mm, the 5-8mm, the 2-5mm shell fractions and the sediment fractions had been separated and weighed, but not further sorted. Hence the proportion of each fraction from each spit was known but not their composition. The sediment samples were stored separately, and were not affected by the accident.

To obtain comparable information on the species composition of this part of the deposit, the field sieve residues which had been sorted but not discarded, were used. One kg subsamples were taken from the 5-8mm fraction, and the shell sorted into species, as above. The admixed sample of material from spits 13 to 16 was swept up, sieved, and sorted to recover any material useful for identification, but no other information was recorded for this part of the column sample.

SITE CHRONOLOGY

Ten samples of shell and charcoal from the midden were submitted to the radiocarbon dating laboratory at the Australian National University for dating. These dates are listed in Table 8-1. The shell dates were corrected for the marine reservoir environmental effect by subtracting 450+35 years (Gillespie and Temple 1977). Using these dates a depth/age curve was constructed (Fig. 8-5) by drawing an envelope which encompassed the spread of dates at 1 standard deviation. A line of best fit was drawn to pass within 1 standard deviation of each of the charcoal dates and of each of the shell dates except ANU 2829. This date did not overlap at 1 standard deviation with its charcoal pair (ANU 2830) and as there is some doubt that for the south coast of New South Wales the environmental correction factor is as high as 450 years.
<table>
<thead>
<tr>
<th>Mean depth below surface (cm)</th>
<th>Depth range (cm)</th>
<th>Spit No.</th>
<th>Type of material dated</th>
<th>Age in years (B.P.) (± life 5570y)</th>
<th>Lab No.</th>
<th>Shell dates corrected for environmental reservoir effect*</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5</td>
<td>5-12</td>
<td>2</td>
<td>shell</td>
<td>540±70</td>
<td>ANU 2253</td>
<td>90±80</td>
<td></td>
</tr>
<tr>
<td>14.5</td>
<td>12-17</td>
<td>3</td>
<td>charcoal</td>
<td>260±80</td>
<td>ANU 2245</td>
<td>modern</td>
<td></td>
</tr>
<tr>
<td>20.5</td>
<td>17-25</td>
<td>4</td>
<td>shell</td>
<td>modern</td>
<td>ANU 2591</td>
<td>modern</td>
<td></td>
</tr>
<tr>
<td>35.5</td>
<td>33-38</td>
<td>7</td>
<td>charcoal</td>
<td>590±170</td>
<td>ANU 2828</td>
<td>670±90</td>
<td>Rejecte...</td>
</tr>
<tr>
<td>50.5</td>
<td>48-53</td>
<td>10</td>
<td>charcoal</td>
<td>1820±80</td>
<td>ANU 2830</td>
<td>1540±90</td>
<td></td>
</tr>
<tr>
<td>50.5</td>
<td>48-53</td>
<td>10</td>
<td>shell</td>
<td>1990±80</td>
<td>ANU 2829</td>
<td>1540±90</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>53-61</td>
<td>11</td>
<td>charcoal</td>
<td>1850±80</td>
<td>ANU 2246</td>
<td></td>
<td></td>
</tr>
<tr>
<td>99</td>
<td>92-123</td>
<td>16, 17, 18</td>
<td>charcoal</td>
<td>1250±270</td>
<td>ANU 2247</td>
<td></td>
<td></td>
</tr>
<tr>
<td>105</td>
<td>99-110</td>
<td>17</td>
<td>shell</td>
<td>3150±170</td>
<td>ANU 2254</td>
<td>2700±175</td>
<td></td>
</tr>
</tbody>
</table>

* (after Gillespie and Temple, 1977)
Fig. 8-5. Depth/age curve for the PLA site.
(see Chapter 9) the curve was drawn to overlap the charcoal rather than the shell date.

By extrapolation the age of the base of the deposit is about 3,000 years B.P., however there is a possibility that the lowest spit contains a record of sparse occupation going back much further but which is not now "archaeologically visible" (see Hughes and Lampert in press).

If the depth/age curve reflects the true depositional history of the site, the basal 75cm of the deposit accumulated between 3,000 and 1,700 years B.P. at an average rate of 6cm per 100 years. The deposit between 35 and 50cm accumulated between 1,700 and 600 years B.P. at an average rate of 1.4cm per 100 years. The top 35cm of deposit accumulated in about 600 years at an average rate of 6cm per 100 years.

An alternative interpretation is that the rate of accumulation of the deposit was constant at about 6cm per 100 years, and that there was a break in the accumulation between 1,600 and 800 years ago (as indicated on the depth/age curve). Such a long break in site use could have occurred, as there are many other similar sites in the Severs Beach complex which could have been used during this period. If such an abandonment had occurred it might be expected that the shell in spit 9 would have been weathered and broken as a result of its long exposure at the surface. In fact the condition of the shell in this spit is no different from that in adjacent spits, and the hypothesis of slow deposition (as indicated by the depth/age curve) is considered more likely.

MIDDEN CONTENTS

The bulk composition of the midden is shown in Figs. 8-6 and 8-7. The midden contents were analysed separately as matrix less than 2mm, shell, bone, stone, and all of these were used in the archaeological interpretation of the site and its surrounds.
Fig. 8-6. Composition of the PLA deposit
Fig. 8-7. Bulk composition of PLA deposit
ANALYSES OF THE MIDDEN MATRIX

The matrix of the column samples, i.e. that fraction of the deposit passing through a 2mm screen, was analysed in order to characterise the sediment, determine its origin and rate of deposition and the post-depositional decay of the organic content of the midden. Eight samples of sediment from the surrounding landscape were also analysed to compare the grain size distributions and the characteristics of these sediments and so determine the likely origin of the sediment in the archaeological deposit. These comprised two samples from each of the surrounding landforms: beach, dune, hillslope and estuarine flat.

The methods of analysis followed those of Hughes (1977, 1980) as detailed in Appendix 4 of this thesis:
* the grain size distribution of the sediment by dry sieving,
* the mineralogy of the sediment by microscopic determination,
* the finely divided shell content using the modified rapid gravimetric method of Bauer, Beckett and Bie (1972),
* the organic matter content (humus and charcoal) by a loss on ignition method.

The bulk composition of the midden matrix is shown in Fig. 8-8, and the proportion of sediment in Fig. 8-9.

Inorganic Sediment Content.

Histograms were used to illustrate the texture of the deposit (Fig. 8-10) because it was apparent from the results of dry sieving that the sediment was strongly bimodal, and hence Folk (1974) sorting parameters and other sedimentary statistics based on unimodal distributions were inappropriate.

In the process of removing the finely divided shell by acid digestion, the sediment samples were decanted, and much of the silt and clay was lost. Thus in most cases amounts of silt+clay collected on the pan from dry sieving were not the total amounts present in the original sediments. The amount of silt+clay in the sediment was calculated by subtracting from the total weight of the sample the weights of sand, finely divided shell and other
Fig. 3-8. Composition of PLA fraction finer than 2mm
Fig. 8-9. Proportion by weight of sediment in the PLA samples
organic matter, and taking the residue to have been silt+clay. The sediments comprised mainly sand, and dry sieving along with microscopic observation was sufficient to characterise them.

Dry sieving and microscopic observation of the sediments indicated clearly that there was a bimodal grain size distribution, and that this correlated well with observed differences in the nature of the grains. The grain size histograms are shown in Fig.8-10. Two distinct modes occur, one in the medium sand grade, which correlates with rounded to subrounded frosted to clear quartz grains with slight organic staining, or slightly brown-stained quartz crystals. About 2% of the grains in this size grade were etched and these were heavily stained grey to black by charcoal or other organic material. The second mode was in the fine to very fine sand grades, and comprised mainly subrounded to subangular quartz grains with orange to brown staining, or with grey to black organic stains. This second mode tailed off gradually into silt+clay grades. It can be seen from Fig. 8-10 that there is a change in the texture of the sediment through the midden deposit. Samples PLA1-PLA5 were bimodal, with the medium sand mode dominating. They characteristically had a very low content of silt+clay. Samples PLA6-PLA13 had the fine to very fine sand mode increasingly dominant, but still had characteristically very little silt+clay. From sample PLA14 down through the deposit there was an increasing amount of silt+clay, the fine to very fine sand mode became broader, and the medium sand mode disappeared.

Samples from all the sandy environments; estuarine flat, dune and beach were characteristically very well sorted with a pronounced mode in the medium sand grade. Optically they consisted of rounded to subrounded clear or frosted quartz, with few grains showing slight yellowish staining.

Sediments from the slope above the site were very poorly sorted with a high silt+clay content, and a subdued mode in the fine to very fine sand grades. The grains were characteristically subrounded to subangular and stained orange to brown. It was apparent that two sources of sand were represented in the midden sediments, colluvium and windblown sand from the shoreline complex. Hughes (1977:167-70) demonstrated that for a similar
Fig. 8-10. Sediment texture histograms for PLA deposit showing percentage of sediment in each half-phi unit.
Fig. 8-10B Sediment texture histograms for samples from landforms surrounding the PLA site, showing percentage of sediment in each half-phi unit.
open midden at Bass Point the contribution to the deposit of sand carried up in shells or on the feet of the site occupants was negligible; it is assumed that a similar situation applied at Pambula.

At the base of the deposit (spits PLA16-PLA18) the sediment consisted almost entirely of slopewash-derived material (colluvium). Spit PLA15 represented a transitional situation, where windblown sand was present in appreciable quantities.

From spits PLA14 to PLA1 there was an increasing proportion of windblown sand in the deposit, such that in spits PLA8 to PLA5 slopewash and windblown sand were roughly equi-proportional, and from PLA4 to the top windblown sand dominated.

Above spit PLA16 the slopewash component no longer contained appreciable amounts of silt+clay, suggesting a winnowing effect during sediment transport or slight illuviation of silt+clay through the deposit.

Shell (calcium carbonate) Content.

Shell fragments made up a considerable proportion of the matrix of the midden deposit as shown in Fig. 8-8. In the upper 70 cm of the midden, to the base of spit PLA14, finely divided shell made up 40-55% of the matrix, but below this level there was a rapid decline to about 5% at the base of the deposit. There was an interesting correlation between fine shell content and pH. Down to spit 14 the pH remained constant at 8.5, indicating that the deposit was totally saturated with calcium carbonate. Below spit 14 the pH rose slightly to 7.5. The significance of this in terms of post-depositional decay will be discussed at a later stage.

This is consistent with the results of shell analyses from the sediments of other open shell midden sites e.g. Bass Point (Hughes 1977:158), and reflects the gradual removal of shell by rainwater percolation through the porous sandy deposit. Shell was present throughout the PLA deposit, and the pH was consistently maintained at an alkaline level which dropped slightly towards the base of the deposit reflecting shell deterioration downwards.
The Content of Other Organic Matter.

The term "other organic matter" is used to refer to organic material other than shell and bone. It comprises the humus, charcoal and charred wood incorporated into archaeological deposits as a result of human activity (see Hughes 1977:80), and was measured by a loss on ignition technique (Appendix 4).

The proportion of other organic material decreased with depth from between 10 and 20% of the matrix component in the top seven spits to about 5 to 10% below this depth, probably as the result of biochemical decay and the removal of breakdown products in solution. Towards the base of the deposit there was a slight increase in the proportion of other organic matter present in the matrix. This increase results from impeded drainage causing the concentration of illuviated humic material, and has been noted from other shell midden deposits accumulated on rock, such as the rock shelter deposit at Currarong Shelter 2 and the open midden at Bass Point (Hughes 1977).

Discussion of the Matrix Analyses

In looking at the total composition of the midden (Fig. 8-6), it can be seen that inorganic sediment made up 20-40% of the deposit except in the basal 30cm where it steadily increased to 90% as the proportion of organic material declined due to its decay.

The total weight of matrix accumulated in the excavated deposit was 505kg. This is equivalent to 1010kg per sq.m of surface, of which approximately 50% is inorganic sediment. If the excavated sample is representative of the mound as a whole, sediment accumulation throughout the midden was thus some 500kg per sq.m in 3,000 years, or a net input of 160gm per sq.m per year throughout the time that the site was occupied. If the progressive loss of shell below about 85cm is taken into account, the Pambula Lake midden accumulated with a generally constant
proportion of sediment throughout the time of occupation.

Inspection of the sediment texture histograms from the site (Fig. 8-10) suggests that poorly sorted sediment in the lower part of the deposit was derived from the hillslope above, presumably by slopewash. As the shell mound grew it began to trap windblown sand, and towards the top of the deposit the coarser windblown component became dominant. A possible explanation for the onset of accumulation of slopewash is that Aboriginal impact on the surrounding slopes (e.g. through firing) may have caused some disturbance to the soil mantle (see Hughes and Sullivan 1981). As the mound accumulated and the surface rose above the surrounding landscape slopewash could no longer contribute sediment to the mound, and windblown sand became the sole source of sediment. It is envisaged that the accumulating shell and organic debris trapped the sediment being transported across the site. This is similar to the pattern of accumulation proposed for the Bass Point site (Hughes 1977:166).

Although below about 90 cm there was a decline in shell of all size grades, the decay of organic material was not as severe at this site as at other sites studied on the south coast, possibly because leaching has been inhibited by the slightly impeded drainage at its base, and because of the high proportion of massive mud oyster shells. The pH of the deposit remained alkaline throughout, as some shell was preserved, and this has contributed to the good preservation of bone throughout the midden. As at the sites studied by Hughes (1977), the rate of decay of shell does not appear to be dependent on the size of the shell fragments. Once shell decay commences the rate of decay increases as the proportion of shell remaining decreases, and all size grades are affected.

ANALYSIS OF SHELL

On the basis of the observed shell content of the deposit during excavation and in the exposed sections of the trench (see Fig. 8.4), the shell deposit can be broadly divided into an upper, middle and lower midden.
The upper midden comprises spits 1-8, and is composed mainly of shells of *Mytilus planulatus*, the edible mussel with a very low proportion of *Trichomya hirsutus*, the hairy mussel. It accumulated between 1,200 years B.P. and the time of European contact.

The middle midden comprises spits 9-14, and is made up mainly of shells of *Trichomya hirsutus* with appreciable amounts of *Ostrea angasi*, the mud oyster. It accumulated between 2,300 and 1,200 years B.P.

The lower midden comprises spits 15-18 and its shell content is made up primarily of *Ostrea angasi*. This unit accumulated between 3,000 and 2,300 years B.P.

Within the deposit spits 8 and 13 are somewhat different from their adjacent layers, spit 8 comprising a discrete lens of *Ostrea angasi* shells, and spit 13 being mainly made up of a lens of *Trichomya hirsutus* shells. It seems likely that these lenses of shell represent individual events of shellfish collecting which stand out because of the marked difference in shell types.

The distribution of these major shell species within the deposit can be seen from Fig.8-11 which is based on the larger than 5mm fraction of the column sample. The concentration of the three main species of shells within the midden is shown, and the category "other" includes both other edible estuarine shellfish species, inedible estuarine species, rock platform shells, bone and stone (Fig. 8-7). Other edible estuarine species include *Anadara trapezia* the Sydney cockle which makes up almost 20% of this fraction from the top 4 cm of the deposit, but below this mainly makes up less than 3% of the fraction. *Crassostrea commercialis* the rock oyster everywhere makes up 5% or less of the deposit, and *Pyrazus ebeninus* hercules club whelk or mud whelk comprises less than 1% of the fraction, except in spit 16 where it represents slightly more of the deposit. The small mud whelk *Volscumantus australis* barely exceeds 1% of the fraction from spit 7, and elsewhere makes up less than that of the deposit.
Fig. 8-11. Shell species distribution in the PLA excavated sample.
Small inedible estuarine shellfish, mainly borers or seaweed adherents constantly make up less than 1% of this fraction, and a slightly higher proportion of the 2-5mm fraction.

Rock platform species generally represent up to 2% of the greater than 5mm fraction, but in spit 3 make up 4% and in spit 7 as much as 9% of that fraction. The proportion of barnacles is generally less than 1%, but slightly more in spits 10 and 11.

Individual shell and bone species identifications were carried out only on material from the column sample. For shell species however these correlated well with observations made during the excavation, and species identifications made from the trench walls at the completion of the excavation when vertical sections were being drawn. For other aspects in which comparative analyses were carried out, e.g. the weight of bone per volume of deposit, and the proportional weight of stone in the deposit, the results obtained from the column samples correlated well with those from the remainder of the deposit.

Broadly there were two major changes in the dominant species of estuarine shellfish collected during the use of the site. The earliest phase lasting about 700 years, was one in which mud oyster was the main shellfish used. This was followed by a period of about 1,100 years in which the dominant shellfish species was hairy mussel, although mud oyster was also important. For the last 1,200 years of occupation edible mussel was the most important shellfish in the midden. Throughout the deposit other estuarine shellfish and rock platform species were minor components.

In order to compare the results of this analysis with those from other sites, a very rough estimate of minimum numbers of shellfish of individual species was obtained. This was done by weighing a sample of "whole" dry shells from the each excavated spit of the midden. The total weight of all shells of that species from each spit was then used to calculate the approximate number of individuals represented within the midden mound. This method gives a real indication of the actual numbers represented, since it is a direct measure of the actual weight of the shell in its current state of preservation, overcoming the problem of
calculating the assumed weight loss over time faced for instance by Shawcross (1967), who extrapolated from midden shell weights to live weight of shellfish.

The approximate numbers of shellfish of each species in the deposit is shown in Table 8-2. This represents a total number of individuals of about 36,000 per cu.m. Given the relatively high proportion of the very large Ostrea shells, this is consistent with the numbers of individuals calculated from the Ballina shell mounds (Bailey 1975:50), where most of the shells were of rock oysters, of 45,000 per cu.m. It is also similar to the total numbers of rock oysters and cockles estimated by Callaghan (1980:76) as 41,000 per cu.m in the excavated portion of the Stuarts Point midden.

ANALYSIS OF VERTEBRATE REMAINS

The distribution of mammal and bird bones from the excavation is shown in Tables 8-3 to 8-5, and that of fish bones in Table 8-6 and Fig. 8-12.

The total amount of bone recovered from the midden was 240gms, giving an average density of 450gm per cu.m of deposit (Table 8-3). This was made up almost entirely of fragmented bones of fish, and land and sea mammals. Only a few bird bones were recovered, and no reptile bone was identified.

Birds

Only 3 fragments of bird bone were recovered from the deposit: one a fragment of ulna from a bird of about the size of a small duck, sandpiper or dotterel, and two long bone fragments of unidentified species. It may be inferred from this that birds were at least occasionally part of the local diet, but that they were probably not an important contribution to the food supply at the site. It is unlikely that the absence of bird bone is a function of preservation since the midden environment is alkaline throughout, and other bone, including very fragile fish bone, has survived well. These fragments were identified by Ken Aplin (see
<table>
<thead>
<tr>
<th>Shell spp.</th>
<th>Minimum number of individuals in column sample</th>
<th>Approximate number in PLA mound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ostrea angasi</td>
<td>100</td>
<td>30,000</td>
</tr>
<tr>
<td>Crassostrea commercialis</td>
<td>55</td>
<td>16,500</td>
</tr>
<tr>
<td>Mytilus planulatus</td>
<td>400</td>
<td>120,000</td>
</tr>
<tr>
<td>Trichomya hirsutus</td>
<td>1,500</td>
<td>450,000</td>
</tr>
<tr>
<td>Anadara trapezia</td>
<td>25</td>
<td>7,500</td>
</tr>
<tr>
<td>Pyrazus ebeninus</td>
<td>5</td>
<td>1,500</td>
</tr>
<tr>
<td>Other estuarine spp.</td>
<td>25</td>
<td>7,500</td>
</tr>
<tr>
<td>Turbo spp.</td>
<td>15</td>
<td>4,500</td>
</tr>
<tr>
<td>Other rock platform spp.</td>
<td>100</td>
<td>30,000</td>
</tr>
</tbody>
</table>
TABLE 8-3
Concentration of Bone in Sample Excavated from PLA mound

| Wt. of bone from column samples (gm) | 37.21 |
| Wt. of bone from remainder of excavated sample (gm) | 202.39 |
| Total Wt. of bone recovered (gm) | 239.60 |
| Volume of excavated deposit (m³) | 0.615 |
| Concentration of bone in deposit | 445.35 |
Mammal Bones

A number of different species of land and sea mammals are represented among the 115 pieces of mammal bone recovered from the excavation (Table 8-4). All the bones are burnt and extremely fragmented. Definite species identifications were not possible for most of the fragments, however they could be grouped into classes. Ken Aplin, then working on marsupial bone identification in the Department of Prehistory and Anthropology, Australian National University, examined the bones, and made species identifications for 30 fragments, identifications to the level of genus for 56 fragments, and to family level only for 13 fragments. There were 19 other small burnt and eroded fragments which remained unidentified. The bones in such categories as "wallaby", "medium sized marsupial" I checked against specimens in the Department of Prehistory collection and photographs in Merrilees and Porter (1979), then used lists of locally occurring animals (Marlow 1958, Tidemann 1978) to ascertain the most likely species represented.

Land Mammals

The land mammals occurring in the area which are probably represented by bone fragments recovered from the site are listed in Table 8-5. All are marsupials. Species positively identified are indicated (*), and the typical environments in which these animals are now found (Marlow 1958, Troughton 1967, Tidemann 1978) are described in Table 8-5. Included with the listing is an approximate weight for adults of each species (from Findlayson 1947). In summary these animals include:

1. Kangaroos which are represented by at least 23 bone fragments weighing approximately 42gm. Two kangaroos now occur in the area, Macropus robustus the euro or wallaroo and Macropus giganteus, the grey kangaroo.
2. Wallabies, of which there are 23 bone fragments weighing about 38gm, with an additional 6 fragments weighing 12gm, which could be from either kangaroo or wallaby. One piece of wallaby tibia appears to have been flaked and then passed through the digestive system of a dog or other carnivore (see Plate 8-4). Among the bone artefacts were two points made on wallaby tibiae (Plate 8-5). Four species of wallaby now occur in the area, *Wallabia bicolor*, the swamp wallaby, *Macropus rufogriseus*, the red necked wallaby, *Thylogale thetis*, the red necked pademelon, and *Petrogale penicillata*, the brush tailed wallaby.

3. Medium sized marsupials which are represented by 4 definite and as many as 6 possible additional species. Fragments include 20 pieces of potoroo bone, 5 pieces of at least one possum species, a single clearly identifiable marsupial cat long bone, 3 fragments from at least one species of bandicoot and 22 small bone fragments from these animals or slightly smaller marsupials such as one or more of four gliders. The total weight of bone of medium sized marsupials is about 50gm. All of these animals are now found in the area.

4. The only identifiable bone from a very small mammal was from a marsupial rat, *Pseudomys* sp.

The results of this analysis indicate that small to medium sized tree and ground dwelling forest marsupials contributed significantly to the diet of the occupants of the PLA site, and that macropod bones were used to manufacture tools. In this respect the site is similar to sites in the Sydney Basin region situated some hundreds of metres from the coast (Lampert 1971b:121) such as Curarrong Shelter 2 (Lampert 1971a:58), Burrell Lake (Lampert 1971a:11), Curracurra (Megaw 1968:326), St. Georges Basin (Barz 1977:55), Bass Point (Bowdler 1970:91-3) and Swansea (Dyall 1972, 1978:3). In contrast land animals were relatively sparse in the faunal assemblages from sites such as Durras North (Lampert 1966, 1971b:121), Bowen Island 1 (Blackwell 1980:59) or Birubi (Dyall 1979:4).
### TABLE 8-4

Distribution of bone fragments in excavated sample from PLA

<table>
<thead>
<tr>
<th>Spit</th>
<th>BIRD</th>
<th>SEA MAMMAL</th>
<th>LAND MAMMAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>kangaroo</td>
<td>wallaby</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>? + 3 + ?</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>? + 4 + ?</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>5</td>
<td></td>
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<tr>
<td>8</td>
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<td>9</td>
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<td>10</td>
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<td>11</td>
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<td>16</td>
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<td></td>
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<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE 8-5  Land Mammals in the Pambula Area

**Kangaroos**

Macropus robustus (Gould 1841), euro or wallaroo,
rainforests, wet and dry sclerophyll forest, woodland, coastal dune communities, heath, 22kg (♂)–50kg (♀).

Macropus giganteus (Shaw 1800), grey kangaroo,
wet and dry sclerophyll forest, woodland, open plains, 30–60kg.

* Identified from one phalange.

**Wallabies**

Wallabia bicolor (Desmarest 1804), swamp wallaby,
rainforest, wet and dry sclerophyll forest, woodland, coastal dune communities, heath, 10–15kg.

* Identified from the fibula of an adult female.

Macropus Rufogriseus (Desmarest 1817), red necked wallaby,
wet and dry sclerophyll forest, woodland, coastal dune communities, heath, 14–25kg.

Thylagale theria (Lesson 1827), red necked pademelon,
rainforest, wet and dry sclerophyll forest, 6–9kg.

Petrogale penicillata (Griffith, Smith and Pidgeon 1827), brush-tailed rock wallaby,
wet and dry sclerophyll forest, woodland, 8–6kg.

**Medium Sized Marsupials**

Potorous tridactylus (Kerr 1792), potoroo,
rainforest, wet and dry sclerophyll forest, woodland, heath, 1–2kg.

* Identified from 1 adult left mandible, 1 sub-adult left mandible, 1 left lower incisor, 2 tibias, 1 radius, numerous longbone fragments.

Trichosurus vulpecula (Kerr 1792), brushtail possum,
wet and dry sclerophyll forest, woodland, open plains, coastal dune communities, 3–4kg.

* Identified from 1 femur, 1 metatarsal, 1 molar, 2 smaller fragments of femur.

Pseudocheirus peregrinus (Gould 1858), ringtail possum,
rainforest, wet and dry sclerophyll forest, woodland, coastal dune communities, 0.8–1kg.

**Either**

Dasyurus viverrinus (Shaw 1800), eastern native cat,
wet and dry sclerophyll forest, woodland, 1–1.5kg.

or

Dasyurus maculatus (Kerr 1792), tiger cat,
rainforest, wet and dry sclerophyll forest, 2–3kg.
* Identified from 1 phalange and 3 possible longbone fragments.

* Identified from 1 right mandible and 2 probable tibia fragments.

** Isoodon obesulus** (Shaw and Nodder 1797), short nosed bandicoot, wet and dry schlerophyll forest, open plains, coastal dune communities, 1-1.5kg.

** Perameles nasuta** (Geoffroy 1804), long nosed bandicoot, rainforest, wet and dry schlerophyll forest, woodland, coastal dune communities, 0.8-0.7kg.

** Schoinobates vols** (Kerr 1792), greater glider, wet and dry schlerophyll forest, woodland, coastal dune communities, 1-1.5kg.

Small bone fragments could also have come from the smaller gliders

** Petaurus breviceps** (Waterhouse 1839), sugar glider, wet and dry schlerophyll forest, woodland, coastal dune communities, 150gm.

** Petaurus norfolcensis** (Kerr 1792), squirrel glider, wet and dry schlerophyll forest, woodland, 150gm.

** Petaurus australis** (Shaw and Nodder 1791), yellow bellied glider, wet and dry schlerophyll forest, 150gm.

** Small Mammals**

** Pseudomys sp.** (Gray 1832), pseudo-rats or mice, widespread, but particularly abundant in grassy plainland, and on swampy or sandy ground, 1.3-80gm.

* Identified from an upper incisor.
Sea Mammals

Ten fragments of burnt and weathered bone of sea mammal were recovered from the excavation. Sea mammals now found in the offshore waters include at least two species of baleen whales, and five of toothed whales (see Appendix 6), as well as four species of seal. Of these the most commonly occurring are the humpback, sperm, southern right and killer whales (on which the Eden whaling industry was based) dolphins and fur seals.

The bones were much altered by burning and weathering, so specific identification was not possible. Their distribution from two stratigraphic levels within the site suggests the exploitation of two beached animals at about 1,000 and 500 years B.P. Such exploitation was described by Fraser (1892:52) in Twofold Bay, in that instance of beached whales.

at Twofold Bay and along the South East Coast, a stranded whale is a god-send to the tribe. When the news spreads, they come down in multitudes to enjoy the feast and for many days they may be seen . . . hurrying in and out of the body of the monster.

Robinson (1844:186) also noted a "... dead porpoise on the beach ..." near Twofold Bay, and observed "... the natives eat it."

The mammals common in coastal waters near Pambula at the time of European contact and still present are:

Baleen whales - humpback, noted commonly by Brierly (1844b) in the Twofold Bay area, and southern right whale, which although common in the area is seldom beached.

Toothed whales - dolphins, killer whale, (mentioned frequently by Brierly (1844a,b) in his journals) and sperm whale.

Seals - two fur seals (Arctocephalus forsteri and A. tasmanica) are common in the area, while two Antarctic migrants the leopard seal (Hydrurga leptonyx) and crabeater (Lobodon carcinophaga) are rare visitors which are occasionally beached on the New South Wales south coast (see e.g. Troughton 1967:251).
Mammals in the Diet

The small size of the sample of the total deposit investigated makes any reconstruction of minimum numbers of individuals inappropriate. If this sample however, is typical of the midden as a whole it appears likely that marsupials were a source of food throughout its period of use. Wallaby, potoroo, possum and other medium sized marsupials are present in all stratigraphic units throughout the deposit. In a compact shell deposit such as this it is unlikely that bone fragments have moved through the deposit (see Hughes and Lampert 1977), but rather they represent food remains from the time-stratigraphic level in which they are found. Sea mammals and large kangaroos occur more sporadically, and it is likely that this is a true reflection of irregular exploitation of such animals. Large kangaroo bones are distributed through four separate and distinct stratigraphic levels. They may reflect the occasional capture of a large kangaroo in the immediate area, or the return to the site of carcasses taken from further away. Bone incorporated into the deposit may reflect only a small proportion of the land mammals consumed by people using the site, as men may well have eaten such game elsewhere (see e.g. Meehan 1975, 1977).

Fish Remains

In terms of numbers of fragments most of the bone recovered from the excavation was fish bone and this made up almost half of the total weight of bone from the deposit. Of this only a small proportion (about 10% by weight) consisted of bones or fragments readily identified.

This study does not attempt to reconstruct diet, nor to determine the proportions of any food type to the total diet of the site's occupants. The analysis of fish remains was therefore carried out to identify as many of the species present as possible, not to systematically derive individual fish numbers. Identification of fish remains is a constant problem in the analysis of shell midden contents. If a systematic comparison of the proportion of the diet contributed by one fish species is
attempted, the problem of relative preservation must be considered, and identifications must be based on the systematic use of a limited number of body parts.

Several studies have been carried out on Australian coastal middens in which minimum numbers of fish have been estimated. Lampert (1966, 1971a) used jawbones, otoliths and specific characteristic bones and spines to identify fish species excavated from Durras, Currajong and Burrill Lake deposits. Bowdler (1970, 1976, 1979) used jawbones, otoliths and characteristic bones or spines at Bass Point in New South Wales and at Cave Bay Cave, Hunter Island, Tasmania to identify fish species and to calculate the number of individuals of any species recorded. Dyall (1978, 1979) used jawbones and otoliths to make minimum number determinations of fish from the Swansea and Birubi middens near Newcastle. Barz (1977) followed the method used in New Zealand by Shawcross (1967), and identified minimum numbers of individuals from the St. Georges Basin midden mainly from jawbones and otoliths. Coleman (1978) used otoliths, jawbones and specific headbones to identify fish species from the Stuarts Point shell midden, and to derive minimum numbers of individuals. Walters (1979) used a concept which he entitled "labcatch" to make use of the larger number of identifiable fragments which commonly occur in sieve residues to enable a statistical derivation of minimum numbers of individuals of any species from this larger amount of data.

In this study, given the nature of the test excavation and the questions being considered, it seemed most appropriate to identify as many species as possible in order to determine the source of the fish being consumed on the site, and therefore to identify all fragments possible, although it is likely that this method would bias a numerical analysis in favour of more robust species for which bone is better preserved.

**Fish Present in the Site**

Identification relied on two reference collections. I collected a number of common estuarine fish species caught on the south coast, and from these prepared a reference collection by
boiling the fish until soft, removing the flesh, and drying the bones in an oven. The weight and length of each fish was noted before cooking. For fish not represented in this collection, particularly large open ocean species, I used the reference collection held by the Department of Prehistory, R.S. Pac.S., ANU, comprising mainly fish caught by professional fishermen off the far south coast, and brought ashore at Eden or Bermagui.

My aim was to identify the species present in the excavated material and to obtain some estimate of their sizes as a guide to the habitats from which they were caught, rather than to calculate numbers of each species represented. I therefore used all identifiable fragments or body parts which could be matched against the reference specimens. This method undoubtedly biased the sample towards recording the more robust and resistant species, but as this is the nature of bone preservation it is a bias already inherent in any excavated archaeological sample. Although Barz (1977) and Walters (1979) justified various rigorous methods of ensuring lack of bias in fish identifications, no statistical procedure can overcome the effect of differential preservation. In this case, for determining the marine environments exploited from the site, as complete a listing of identifiable species as possible appeared more important than a statistically accurate sample.

Using the reference collections twelve varieties of fish were identified from the excavated material although for some varieties more than one species may have been represented. These are set out in Table 8-6, showing the details of the identifications, and are: snapper, bream, leatherjacket, wrasse, nannygai (redfish), mullet, mulloway (jawfish), Sergeant Baker, morwong, whiting, wirrah (rock cod) and flathead. All occur locally, either within the estuaries or offshore (Grant 1978, Pollard 1969). Biological classifications are given in Appendix 5.

Only two species of fish which are common in the estuaries on the south coast were not identified from the deposit. These are luderick (blackfish) and garfish. Each has a very fragile skeleton which would not be likely to survive well in a midden deposit, so preservation factors may be the determinant here, not
TABLE 8-6

Fishbones Identified from Excavated Sample of PLA mound

<table>
<thead>
<tr>
<th>Spit</th>
<th>Fish identified</th>
<th>Body parts used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Snapper</td>
<td>Otoliths, headbones, vertebrae</td>
</tr>
<tr>
<td></td>
<td>Bream</td>
<td>Dantary, teeth</td>
</tr>
<tr>
<td>3</td>
<td>Snapper</td>
<td>Dantary, headbones</td>
</tr>
<tr>
<td></td>
<td>Leatherjacket</td>
<td>Vertebra</td>
</tr>
<tr>
<td></td>
<td>Redfish</td>
<td>Otolith</td>
</tr>
<tr>
<td>4</td>
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<td></td>
<td>Wrasse</td>
<td>Pharyngeals</td>
</tr>
<tr>
<td></td>
<td>Mullet</td>
<td>Otolith</td>
</tr>
<tr>
<td>5</td>
<td>Snapper</td>
<td>Otoliths, dentaries, headbones, teeth, vertebrae</td>
</tr>
<tr>
<td></td>
<td>Leatherjacket</td>
<td>Spines, facial bones</td>
</tr>
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cultural ones.

There are changes in the species and sizes of the fish represented in the bones recovered from the deposit which correspond broadly to the three divisions based on the dominant shell species. In the lowest unit (dating from approximately 2,300 to 3,000 years B.P.) small to medium sized snapper, bream and leatherjackets, and at least one rock cod and one sand whiting were identified. All these fish could have been obtained from the Pambula estuary, probably from near its shores, with the exception of the rock cod which could have been caught from near the rock platforms of Haycock Point at the mouth of the estuary.

In the middle unit, dating from about 1,200 to 2,300 years B.P., the presence of very large snapper, leatherjackets and wrasse, a Sergeant Baker and a morwong, in addition to the smaller snapper, bream and leatherjackets which could have been caught in the estuary, indicate that during this time fish were also taken from deeper water off the rock platforms and further offshore. The claw tip of a southern rock lobster (Jasus novaehollandiae) was also found, and this crustacean was undoubtedly taken from the edge of the marine rock platform.

This unit thus represents a phase in which a wider range of marine environments was exploited. Fishing was apparently carried out both within the estuary and offshore from its mouth, suggesting the use of canoes to reach the deeper water from which large snapper were taken. Catching large leatherjackets either within the deeper parts of the estuary or from offshore would also have necessitated the use of canoes and possibly of fish hooks.

In the uppermost midden layer (spits 1-8) there is more variety in both the species and sizes of the fish than in the lower two units (spits 9-14 and 15-18), and this reflects an even wider range of marine habitats exploited. Mullet, nannygai, flathead and mulloway are present as well as snapper, bream, leatherjackets and wrasse of various sizes.

For the last 1,200 years of the site's use fishing was carried out near the estuarine shoreline, in deeper parts of the estuary, near the estuary mouth, off the coastal rock platforms.
and in deeper water further offshore. This would undoubtedly have involved the use of canoes, and is suggestive of line fishing.

Over time there was a widening of the range of fish resources being exploited. Despite this diversification in fishing there was no discernible corresponding change in the exploitation of mammals, as indicated by the proportion of mammal bones in the site (Fig. 8-12).

BONE TOOLS

Although this was a small test trench, representing about 5% of the volume of the PLA mound, and less than 0.001% of the entire Severs Beach site, bone tools were recovered from the excavation suggesting that these may be a relatively common component of the total assemblage in the site. These were:

One spatulate point in 3 fragments was recovered from spit 10. This ground and polished point (Plate 8-5) was constructed on a wallaby tibia. It is very similar to spatulate points from other sites in coastal and inland New South Wales, and was probably used as a sewing awl (Lampert 1966:107, 1971a:54, Flood 1980:56).

One piece of flaked bone with no diagnostic form, constructed from the tibia of a wallaby, was recovered from spit 11. This bone fragment (Plate 8-4) is severely corroded, and appears to have been passed through the digestive system of a dog (K. Aplin pers. comm.), resulting in pitting of the bone surface subsequent to flaking.

One small fragment of a broken point, was recovered from spit 6. It consists of a split wallaby or kangaroo fibula with a ground edge, but the fragment is too small to attempt any reconstruction of the original artefact (Plate 8-6).

One fragment, possibly part of a broken point, was recovered from spit 13. This is constructed on a long bone of a medium sized marsupial, but the fragment is too small to permit identification of the tool or the animal (Plate 8-7).
PLATE 8-4. BONE ARTEFACT FROM SPIT 11 WHICH HAS PASSED THROUGH A DOG.

PLATE 8-5. SPATULATE BONE POINT FROM SPIT 10.
PHOTOS BY DRAGI MARKOVIC. SCALE IN CM AND MM.
PLATE 8-6. SPLIT BONE POINT FROM 9.

PLATE 8-7. FRAGMENT OF A BONE ARTEFACT FROM SPIT 13.
PHOTOS BY DRAGI MARKOVIC. SCALE IN CM AND MM.
Fig. 8-12. Proportions of fish and other bone in PLA deposit, percentages in weight.
STONE

Stone made up approximately 0.45% by weight of the excavated sample. Much of this (91.5% by weight) comprised pieces of local sandstone and minor amounts of vein quartz, with a very small amount of locally occurring acidic volcanic rock. Many of these pieces of stone had oyster shells attached, or were blackened or fire marked, evidence of their having been used as hearth stones. This stone was weighed but not analysed further. The remainder of the stone (8.5% of the stone or 0.04% by weight of the deposit) was mainly quartz with some acidic volcanic rock and silcrete, the last two generally in the form of clearly struck flakes (see Table 8-7). Much of the stone likely to have been worked was quartz. It was examined by Peter Hiscock, then of the Department of Prehistory at the Australian National University, who had worked with a number of similar quartz dominated stone assemblages from southern New South Wales (Hiscock in press). Hiscock sorted out from the quartz chips pieces which showed definite evidence of human modification. The proportion of each raw material is shown in Fig. 8-13.

Quartz

Two types of quartz were identified. One is derived from the immediate vicinity of the site and occurs as veins throughout the local Devonian sandstone and minor volcanic outcrops. It is opaque, milky white to pink, and is irregular in form as the result of having intruded through interstices in the rock mass. This quartz was present mainly as rounded or unmodified vein fragments, and to a lesser extent as chips with sharp fractured edges. Although many unmodified fragments were probably brought on to the site attached to shells or scooped up with shellfish (one fragment had an oyster shell attached to it), occasional fragments of this type of quartz were flaked.

The second type of quartz is derived from the Tertiary gravels within the lake catchment, and occurs as subrounded to subangular beach pebbles on the lake shoreline. It is clear to translucent white, glassy or crystalline, and it invariably
Fig. 8-13. Proportions of stone raw materials in the PLA sample.
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(*) shows number of pieces with retouch or edge damage.
occurs in the excavated deposit as broken fragments, only one piece having any clear pebble cortex preserved.

After examining the worked quartz, Peter Hiscock made the following comments. Very few of the quartz fragments showed bruising or spalling consistent with bipolar flaking (Plate 8-8A), however about fifty pieces had clear evidence of flaking in the form of bulbs of percussion, and one triangular piece had severe edge damage (Plate 8-8B). The quartz flakes are generally about 1-1.5 cm long.

Acid Volcanic Rock

This is the second most common raw material recovered from the excavated deposit. It varies from the equigranular uniformly reddish coloured material which occurs in minor outcrop immediately adjacent to the PLA site, to flow-banded, variously coloured rhyolitic and grey to green porphyritic examples. All such forms are present in the Eden Rhyolite which crops out in the Pambula Lake catchment, and can be found on pebble beaches on the lake shores.

About one third of the small fragments of acidic volcanic rock recovered comprised unmodified water-worn pieces, apparently collected with the shellfish. About twenty of the fractured pieces bear bulbs of percussion while a similar number of other fragments are split on planar surfaces and appear to have derived from fire-shattered pebbles. The flakes are generally 1-5 cm long, and some are elongated.

Silcretes

Fine (BII) silcrete fragments (Sullivan and Simmons 1979) were recovered from near the base of the excavation. These are invariably flaked and include 6 backed blades (Plate 8-8 C and D). Silcrete can be obtained within 4 km of the site in the lake catchment, and may be present among the lake shore pebbles. The flakes are elongated, and like the backed blades are generally
PLATE 8-8A. WORKED QUARTZ FROM SPIT 6, SHOWING MARKS OF BIPOLAR WORKING.

PLATE 8-8B. FLAKES FROM SPIT 16, TWO ELONGATED FLAKES OF ACID VOLCANIC (RYOLITE), ONE TRIANGULAR PIECE OF QUARTZ WITH EDGE DAMAGE. PHOTOS BY DRAGI MARKOVIC.

SCALE IN CM AND MM.
PLATE 8-8C. BACKED BLADES FROM SPIT 16. LOWER BLADE HAS RESIN NEAR BUTT.

PLATE 8-8D. FOUR BACKED BLADES FROM SPIT 17. PHOTOS BY DRAGI MARKOVIC. SCALE IN CM AND MM.
PLATE B-8E. FLAKES AND FLAKED PIECES FROM SPIT 17.

PLATE B-8F. CORE FROM SPIT 18.
PHOTOS BY DRAGI MARKOVIC. SCALE IN CM AND MM.
small, up to 3cm X lcm.

Glass

Slivers of glass were recovered from the upper 15 cm of the deposit. This is clear colourless glass, some with red-brown internal staining. All pieces are extensively chipped, and about ten pieces bear flaked margins. These may have been worked, or be the result of damage to the glass while it lay on the ground surface (for example by being crushed underfoot).

Nature and Distribution of Stone Artefacts

Table 8-8 shows the numbers of pieces of worked stone recovered from the deposit and the numbers of pieces showing no definite trace of human modification, but which were presumably carried onto the site for this purpose. Worked stone occurred throughout the excavated deposit. Most of this worked stone is non-diagnostic flaked quartz, with minor amounts throughout of acidic volcanic rock. In the upper 11 spits quartz makes up more than 70% of the worked stone (Fig. 8-13), and apart from a few glass slivers the remainder comprises acidic volcanic rock. In spits 12-15 there are too few pieces of stone to enable the industry to be characterised. In the lower levels of the deposit however the stone assemblage has the characteristics of Bondaian industries recognised in sites to the north (McCarthy 1948, Lampert 1971a,b) and, like these industries, it is based on silcrete and other fine grained siliceous rocks, including acidic volcanics (Hughes, Sullivan and Lampert 1973). The stone industry in the lowermost spits 16, 17 and 18 is characteristically Bondaian, with six backed blades occurring in spits 16 and 17, and resharpening flakes of silcrete (from which all the backed blades were made) and acidic volcanic rock in spit 18. The site was apparently first occupied during the Bondaian period, and this is consistent with the basal date for the occupation of the site of around 3,000 years B.P. (see Fig. 8-5).
The raw materials used and the sequence of radiocarbon dates from the deposit (Figs. 8-5, 8-13) indicate that the marked change to a stone assemblage dominated by quartz had occurred by 1,900 years B.P. If this change denotes the change to the post-Bondaian phase documented from sites to the north (Lampert 1971b, Hughes and Djohadze 1980), then it was manifested here much earlier than for example at Currarong shelter 1, where backed blades dropped out of the stone assemblage about 1,500 years B.P.

Tiny resharpening flakes, up to about 4mm across, were present in several layers of the deposit. Quartz, acidic volcanic rock and silcrete flakes of this type were recovered, consistent with working or rejuvenation of the stone artefact types present in the deposit having taken place at the site.

ARCHAEOLOGICAL CONCLUSIONS

The PLA mound was apparently used as an occupation site, rather than as a shell processing dump or a dinner-time camp, throughout the period of its use. Stone artefacts from throughout the excavated sample include implements, cores and flakes and resharpening fragments, indicating that stone working was carried out on the site. The proportion of stone implements is high relative to other shell middens. For instance there were 13 backed blades recovered per cu.m of deposit at Pambula compared with 0.18 per cu.m at Wombah (McBryde 1974:291) and 2 per cu.m at Currarong shelters 1 and 2 (Lampert 1971a:39). Substantial occupation is also suggested by the numbers and range of faunal remains present throughout the excavated material. There is no indication from this sample that the general function of the site changed through its period of use.

No shell fish hooks were recovered from the excavation, although bone points were, but the amount of fishbone in the site indicates that fishing was an important activity carried out by the site's users. Like Burrill Lake, Curracurang and Currarong, this mixed site can be explained as having been occupied "...by people with diverse economic interests occupying a varied environment" (Lampert 1971b:128). Analyses of the contents of the
site reveal close similarities with coastal/estuarine sites previously investigated in the Sydney Basin region to the north. The Pambula site is very similar in content to sites lying a few hundred metres back from the immediate coastline, particularly the deposits in Currarong Shelters 1 and 2 (Lampert 1971a:58), Burrill Lake Shelter (Lampert 1971a:11), Curracarrang 1005/-(Megaw 1968:326) and St. Georges Basin (Barz 1977:55). In this respect the Pambula site conforms to the pattern recognised by Lampert, as it also lies about 1km inland, and on the shoreline of the estuary. Like the Currarong Shelter 2 site, this deposit also indicates an increasingly wider use of the surrounding environment through time.

PLA is an especially important site of this type as it consists of dense shell midden throughout, in which shell and bone preservation is enhanced (see Hughes 1977:206-13). Faunal remains in this site are well preserved back to 3,000 years B.P. This is unusual, since in most shell middens excavated in southern New South Wales to date, shell and bone have not been preserved in levels dating beyond about 1,500 years.

From the nature of this test excavation it is not possible to offer definitive statements on the economy at the site. The fauna represented by the bone excavated are all available in the immediate locality, and the range of these fauna indicates that the occupants of the site used the forest and woodland behind the estuarine shoreline, the open sea and the seashore as well as the estuary to obtain food resources. The proportion of fishbone to the total bone content is high at about 50%, suggesting that fish were an important component of the diet. At Ballina fishbone made up about 30% by weight of the bone (Bailey 1975:56) and at Currarong shelter 2 about 20% (Lampert 1971a:58). The concentration of bone from the Pambula excavation however is high at 450gm per cu.m relative to Ballina (103gm per cu.m) and Currarong 2 (150gm per cu.m), and this difference is mainly due to the greater amount of fishbone in the Pambula deposit.

Cultural changes are demonstrated over the 3,000 years of occupation. Stone tools and raw materials typical of the Bondaiian tradition gave way to a less distinctive industry typical of the post-Bondaiian of the Sydney Basin coast (Lampert 1971b:127) at
about 1,900 years B.P. This change was associated with a change from silcrete or fine grained acidic volcanic rock to quartz as the major raw material used; this is also typical of sites on the Sydney Basin coast (Hughes, Sullivan and Lampert 1973) over this time span.

Changes in the main species of shellfish collected are pronounced. At about 2,300 years B.P. there was a change from the exploitation of mainly mud oyster, probably collected from the seagrass beds immediately adjacent to the site, to the exploitation of hairy mussel which would have been collected from rock platforms some hundreds of metres away within the estuary or 1km away at its mouth. At about 1,200 years B.P. there was another change, to the predominant collecting of edible mussel, also available only from the rock platforms, and this change co-incided with the taking of a wider range of fish.

Bowdler (1976) equated a similar change at Bass Point with the introduction of shell fish hooks and a change in women's food collecting strategy to one involving mainly line fishing. As no fish hooks were recovered from the Pambula site, this conclusion cannot be corroborated, although the increase in the range of fish species and sizes is consistent with a change to hook and line fishing. Shell fish hooks and fish hook blanks have been recovered from and observed on an open shell midden at Mimosa Rocks only 30km north of Pambula Lake (NSW archaeological site record, S.Bowdler pers.comm.) and it is likely that shell fish hooks were also in use at Pambula and simply not recovered from this test excavation.

Fishing Strategy

Blackwell (1980:Appendix 6) presented a table of species and size selection in the archaeological record which would derive from a range of fishing techniques. This was designed by Balme and Blackwell by modifying systems presented by Kefous 1977 and Coleman 1978. The essential difference suggested between the catches from hook and line fishing and those from netting or spearing, is a wider range of both species and sizes. Although Balme and Blackwell list spearing as non-selective for size, it
is certain that for hand-held spears larger fish presented better targets, and a change from primarily spearing to hook and line fishing should be accompanied by a change to a larger proportion of smaller fish as well as a wider range of species. Hook and line fishing would also have enabled a wider range of marine habitats to be exploited, and this should also be reflected in the archaeological record.

From the three units of the Pambula deposit there is a change which may be interpreted as representing the exploitation of a wider environment through time. This is similar to the change noted at Currawong Shelter 2 (Lampert 1971a:56). Hughes and Lampert (in press) have argued on general geoarchaeological grounds for an increased rate of population growth on the south coast over the last 1,000 to 1,500 years. Such an increase in population should have placed a stress on locally available resources, and some change might be reflected in the archaeological record. To date, of all excavated deposits in the area, only the shelter deposit at Currawong 2 has faunal remains preserved back beyond that time, so there has been no opportunity to detect patterns of change. The exploitation through time of a widening range of environments from which to collect food may however reflect an increasing pressure of population at the Currawong site. The pattern of resource use at Pambula is also consistent with this interpretation.

Associated with the extension of the resource base may have been a change in fishing strategies. During the time of accumulation of the lowermost unit of the site fish were probably caught by spearing or netting from the banks of the estuary or from the nearby marine rock platforms. Canoes may have been used to fish within the estuary. Over the next 1,100 years as the middle unit accumulated while there was a continuation of spearing and netting within the estuary, fish were taken from within the estuary, from off the marine rock platforms and from further offshore using canoes. During the phase of accumulation of the uppermost unit, the fishing strategies used previously were continued and it is likely that hook and line fishing was also introduced.
Seasonality

There are now broad seasonal differences in the abundance and range of species of fish in and near Pambula Lake. While individuals can be caught at any time of the year there are seasonal spawning runs during which particular species of fish are most abundant and most easily taken. Although the small number of fish remains identified from the Pambula site does not allow detailed patterns of exploitation to be established, it is worth considering the seasonal availability of the most commonly represented species (Pollard 1969).

Small snapper (squire) are present in the estuaries for 2 - 3 years before sexual maturity. They migrate in late winter to early summer to deep ocean waters, and adult snapper come inshore between August and October to spawn.

Sea bream gather near the bars at estuary mouths to spawn during winter.

Mullet gather in large shoals near the estuary mouths from late summer to early winter, then travel in schools northward along the coast.

Whiting gather in large shoals near estuary mouths and coastal sandbars during summer.

Flathead move from the rivers downstream to estuary mouths to spawn in late summer.

Fish normally present off rock platforms such as wrasse, morwong and rock cod are present throughout the year but are generally more plentiful in summer, while carnivorous fish such as mulloway tend to follow schools of spawning fish, and enter estuary mouths when mullet or bream are spawning.

From the fish identified in the deposit there are some indications of seasonal variations in resources. As only small numbers of identifiable fragments from several fish species were recovered, no systematic use of particular skeletal fragments (such as the otoliths from a single fish species used by Mellars and Wilkinson, 1980) could be used to assess seasonal use of this site. Whiting were probably taken during summer, flathead during
late summer and mullet from late summer to early winter. Small bream were probably taken in winter and small snapper from late winter to early summer. There is thus some indication for the year-round use of the site, and seasonal indicators are distributed evenly throughout the deposit, suggesting use of the site at various times throughout the year over the period that it was used.

ETHNOHISTORICAL INFORMATION FOR THE PAMBULA LAKE AREA

Archaeological evidence from the Pambula Lake midden indicates that the site continued to be used until the time of European contact. Chipped glass is present in the surface 5 cm of the deposit, and a radiocarbon date for shell from the top spit gave a corrected age of about 200 years B.P. It is therefore relevant to consider the ethnohistorical information available for the locality. This information can be used to indicate the numbers of people living in the area at various seasons during the year, and to provide some evidence of the forms of landuse at those times.

Two sources are of greatest importance. Oswald Brierly, while employed by Benjamin Boyd, visited the whaling stations which had been established between 1800 and 1828 in Twofold Bay (a term used to describe most of the coastal strip between Goalen Head and Cape Howe) and at Nulliça (Nulliça) during 1842, 1843 and 1844. During these visits he also journeyed inland with Benjamin Boyd (who was already both a whaler and grazier) to inspect cattle pastured on the Monaro Tablelands. Brierly made numerous journal entries describing the appearance and customs of the local Aborigines, many of whom were by then at least casually employed in whaling or cattle farming enterprises and whose lifestyles had therefore changed somewhat from those in pre-contact times.

George Augustus Robinson travelled through the area in June and July of 1844; he commented specifically on the Aborigines occupying the area between Gippsland Lakes in Victoria, and Goalen Head in New South Wales, including those of the Pambula area. He noted that he:
felt assured a certain communication (could I but cross the Alps before the Commencement of the Snow) might readily be effected through the Two Fold Bay natives with whom the Gipps Land Aborigines were in communication (Mackaness 1941:11).

In a footnote he commented that this proved to be the case. Of the GippsLand Lakes he noted that:

fish are abundant, and the Aborigines may be termed Ichthyophagist;... Their mode of taking fish is by net, spearing and line and hook the latter ingeniously made from bone their Canoes a sheet of bark from the straight part of a tree folded at the end (Mackaness 1941:17).

Brierly (1843c) likewise indicated that fishing appeared overwhelmingly to provide most of the food of the Aborigines on the coast. In a sketch from Twofold Bay he described a "bright brown ... Cockatoo Fish", which he noted was important in the local diet. This fish, from his sketch, is almost certainly a parrot fish or wrasse (Cheilinus sp.).

Robinson provided also some descriptions of the coastal areas through which he walked, and referred to other probable food resources:

Between Cape Howe and Two Fold Bay the Coast (with the exception of the sandy beach bottom of False Bay and Granite at the Ponebina (Wonboyn) River) consists chiefly of abrupt cliffs and red and grey sandstones known to Mariners as the Iron Bound Coast. Cape Howe or Harregano as called by the Natives is an Island of Red Granite a Mile and a half North and South and half a Mile East and West with rather high land having good waters and grass upon it. A low Island of loam and sand a quarter of a Mile around inhabited by Mutton Birds (Gabo Island) is contiguous to the extreme point (Mackaness 1941:17).

The Gipps Land Natives as I had anticipated were in communication with the other Tribes of the Coast east to Twofold Bay Tomahawks with Dr. Imley's mark were in use among them (Mackaness 1941:17).

Perhaps it was also to steel tomahawks that Brierly (1843a:7) referred when he stated of the "natives":

... most ... carry a small tomahawk ... to mark notches ... to climb trees ... and to hunt the opossum.

as his journal sketches frequently show metal tomahawks.

In the report of his journey Robinson also gave an indication of the distribution of tribal groups through the area and the differences he noted between groups of Aborigines:

The Nallekotang (from Nallekoter, the Large Lake near Cape Howe) Mittong are the Original Inhabitants of the Country at Cape Howe.... The Tinnon, Kyrerkong, Poneyyang and Horarer Mittong are Tribes inland. The extensive tract of Country
between Buckan (Buchan) and Twofold Bay is very thinly inhabited by Aborigines.

The Twofold Bay or Nulliker Blacks are an industrious and intelligent race but diminutive compared with the Aborigines of the interior. Their huts like the other natives of the Coast are simple and rude being a mere sheet of Bark in a trigonal shape with barely sufficient room to sit under. Their Canoes like the Gipps Land Natives are folded at the Ends and though buoyant are very frail. The Natives occupy a kneeling position in their Mudjarras or Canoes and may be seen like floating Specks off the Coast spearing Salmon; they are expert Fishers (Mackness 1941:19).

Briely (1844a:9th Aug.) also commented on the "gunyas...made of bark and brushes" near the whaling station at Twofold Bay, and at the same time offered an insight into the cultural change which had already occurred by this time. He described attending "... a Corroboree of Moneroo Blacks" (1844a:14th Aug.) but commented that he had walked that evening from where he left his boat near the whaling station on the coast. This would suggest that by 1843 upland Aborigines were already living near the whaling station on the coast. Briely also provided sketches of bark huts behind which the "gins" retired whilst the men danced in three parts and the dogs howled.

Robinson similarly noted that people were gathered near the whaling stations in winter to obtain work and food, in his account of his journey some distance inland along the Brogo and Bega Valleys and his description of the Aborigines and their food:

...I proceeded Northward and conferred with a large party of Brogo and Biggah Tribes; they are tall (some upwards of six feet) and well made and in this respect superior to the piscatory people of the Coast (Mackness 1941:12). The language of the Biggah Tribe is dissimilar to the Natives at Twofold Bay....The Phascomolyca (Wombat) and Fish are the chief support of the Natives, the latter are taken in Weirs, Eels and other fish in ponds are stupefied by an infusion of Bark. Of the fruits eaten by the Coast Natives the Solanum Laciniatum (Kangaroo Apple) Nesembryanthemum Equilaterale and Astraluma Humifusa (Native Cranberry) are the most Common (Mackness 1941:23).

...Proceeded over wooded sandstone Ranges to Pambuller (Pambula) a fine alluvial Tract and well adapted from its soil and climate for purposes of Agriculture; the River which is navigable for small Craft passes through a Lake in its course to the Sea. On the Ranges the first plant of the Zamia was observed.

He noted that Biggah (Bega) meant plain.

The Dendrobium was common on the Rocks and the Zamia on the Ranges; the nuts of the latter hang in clusters and are delacerious if eaten in a raw state: in preparing them for food the Natives bruise the kernel to a pulp and soak them
in water; the nuts are collected in large quantities and by the Blacks called Bunggow. The Cabbage Palm unknown in the Port Philip District is another article of sustenance, the largest near the Coast measured forty feet in height and four feet in circumference. The Biggah River is the farthest south they have been seen (Mackaness 1941:22).

Brierty (1843b:58) also gave some indication of the method of preparation of animal food, in his description of "natives of Twofold Bay cooking a wild dog".

Having scooped out a circular place in the Earth, about a couple of feet in diameter and perhaps six inches deep, a fire is made onto wh. the bodie's are thrown, for a few moments and ... constantly turned about. The hair is thus so singed that a rub of the hand leaves the dogs skin quite clear of any hair.

Stones were then heated in the fire, and the dog "slit with a tomahawk". The brains and entrails were removed, and the heated stones placed in the body of the dog, which was laid on hot stones and covered with a "rubbed bark tow".

Robinson's account continued (Mackaness 1941:23) until:

Forty Miles by the Coast North of Twofold Bay was the farthest point reached. Some of the Huts in the locality resembled a beehive and others half a Cupola.

As is apparent from the map accompanying Robinson's report and from Mackaness' editorial notes, this point along the coast is Goalen Head.

Robinson's description of the northern part of this journey is for the most part compatible with the archaeological evidence. Certainly the importance of fish as a source of food is indicated by both archaeological and ethnographic evidence as is the use of tree-dwelling marsupials. "Salmon" might refer to any fish found in the waters offshore, or it may in fact refer to the schools of Australian salmon (Arripis trutta) which move along the nearshore reaches of the New South Wales coastal waters, but it is significant that at least at the time of Robinson's journey the Aborigines of this part of the coast were spearing fish from canoes in the open waters offshore. It is possible that the continual references to fish as a food source reflect a certain preoccupation with male activities or with this more dramatic aspect of Aboriginal behaviour (Plate 8-9), and that the more mundane aspect of shellfish collecting went unnoticed.
PLATE 8-9. A sketch by W.A. Cawthorne 1844 of a fishing scene on the south coast. No location is given, but scenes like this must have been common at Pambula Lake.
Photo courtesy of the Mitchell Library.
In any case it is clear that in 1844 there was still a thriving coastal community practising an economy at least in some respects similar to that which seems to be represented by the faunal assemblage of the Pambula site. It is questionable that the economy had remained totally unchanged. It is likely that the fishing lines referred to by then had changed to European string lines with metal hooks, and that the technological advantages of this type of hook and line allowed ocean fishing in a way that was not feasible in prehistoric times. It is also possible that the subtle changes this might have caused in the archaeological record were not noticeable in the small sample excavated at Pambula, however the increase in the proportion of cockles in the midden at this time may reflect some change in overall economy. Perhaps they were easily collected by people whose time was spent mainly in other activities (see e.g. Bowdler 1976:255).

There was a clear local knowledge of whale behaviour. Brierly (1844a:10th Sept.) noted that in the Kiah River area as the weather became warmer blowflies appeared. "Black fellows say no whale after Big fly come" and only a single whale was taken after that date.

Fishing was undoubtedly important in the prehistoric economy of the Twofold Bay area. Ethnohistorical accounts have also stressed the importance of fishing. It is possible that Robinson mistook the smoothly filed shell fish-hooks for bone. Bone fish-hooks are not recorded archaeologically for the New South Wales south coast, although Enright (1939:195) stated that they were used in the Clarence-Richmond area of northern New South Wales. Brierly (1843a:7) also sketches Nulliker (Nullica) Beach with five people, one of whom is apparently towing a fishing net (Plate 8-10). Was net fishing from the beach used in pre-contact times to trap schooling fish such as mullet or salmon in their run along the coastline? Or was this behaviour learned from European fishermen?

The observations relating to the use of the Mallacoota and Gabo Island areas is borne out by the archaeological evidence. In a survey of the area around Mallacoota, carried out in January 1980, the Victoria Archaeological Survey recorded several sites on Gabo Island and numerous sites in the shoreline zones of the
PLATE 8-10. Sketch by Brierly of Aborigines fishing at Nullica Beach. One is towing a fishing net, but as all are wearing European clothing the net may also be a European artefact. Photo courtesy of the Mitchell Library.
Mallacoota Lakes. All the sites were shell middens or scatters of stone artefacts, and the indications are that the shellfish eaten were those obtained locally - estuarine species for the sites within the lakes complex, and rock platform shellfish on Gaba Island. A site excavated at Mallacoota apparently contained flaked glass and porcelain in the surface spits, and had been occupied at the time of European contact. Gaba Island is still known to become attached to the mainland by a sand tombolo, although at present there is a deepwater crossing of about 100 to 150m from the mainland. At times, access to the mutton birds of the Island would not even have required water craft.

Although working in the area much later, Anderson (1890) also made several pertinent observations on the material culture of the Aboriginal people still living along the coastline in this part of New South Wales. He noted that Aboriginal relics were common, consisting of:

- Stone weapons and implements... often ploughed up in the field by settlers; skeletons laid bare by the action of the sea and creeks; and artificial accumulations such as the shell heaps or 'Kitchen-middens'... along the shores of the... lakes. Relics of a more perishable nature, such as the various wooden implements and weapons used by the aborigines, including the boomerang, waddy, etc., and the grass-tree spears, tipped with a short length of hardwood, or barbed with sharp fragments of shells, are rarely met with in any of the recent deposits. The remains of canoes formed of a wide strip of bark have, however, occasionally been exposed on the beach. The two ends of the strip of bark, after having been made pliable by heat, were caught up in plaited, which were held in position by a short wooden pin inserted through them, and permanently fixed by a mass of dried grass-tree gum (Anderson 1890:53).

It is perhaps significant that for these coastal fishing people the last example of their "more perishable" material cultural relics which survived to be described in such detail was the bark canoe, which was apparently a mainstay of their fishing economy.

It is also interesting to note that Brierly's journals record encounters with Aborigines on the coast in summer, from December 1842 through to March 1843, and in winter and spring, from August through to October 1844. As well on visits to the Monaro Tablelands in summer, he encountered apparently large numbers of "well built natives" (see e.g. 1843a:41-42) near Manfra, Ingebyra and Candelo in December 1842 and January 1843.
From this description it may be assumed that these inland people showed no sign of food stress, but were apparently well fed. Robinson similarly seems to have met up with Aborigines both on the uplands and right along the coast between Goalen Head and Gippsland Lakes in mid-winter, during June and July of 1844. Nothing in either account would suggest that strongly seasonal differences in patterns of coastal or inland occupation existed, at least by the 1840's.

Brierly's accounts also raise another question; that of the size of residential groups. He described (1843a:10) at "Oman", Dr. Imlay's settlement at Twofold Bay, a "native village", which consisted of nine bark huts each about one metre high at the centre, open at both ends, and which he sketched as being about six metres apart (Plate 8-11). This visit was made in mid-summer, and he described the leaning walls as being designed to protect the occupants from the prevailing northeasterly breeze. He noted that "Each fire has its party of men Women and Dogs". His sketch shows a bark slab lean-to with a man, his spears and boomerang, two women and a dog (Plate 8-12).

The women are wearing blankets, and in his account of a funeral ceremony some months later (1843b:59 and 1844a:19th Aug.), he commented that before burial the body was wrapped in the "blanket worn when alive", then in sheets of bark to form a cylinder. If European goods such as blankets had replaced items of the pre-European material culture (such as possum skin rugs) it is possible that occupation patterns and social and economic practices also had been altered by this time.

A sketch of the burial scene (Brierly 1843b:60) shows a camp on a headland at Pambula Lake (Plate 8-13). The scene could have been at any of the twenty or so mound sites recorded around that lake and described in Chapter 7. Certainly in January 1843 "About twenty natives belonging to the Twofold Bay tribe were camped here" (Brierly 1843a:55), when Brierly walked from Canelo back to Pampoola (Pambula) which he described (1843a:56) as "...a beautiful fertile flat about 15 miles from the Bay". It is doubtful to what extent this reflected the pre-European contact pattern of land use however, since Brierly also noted (1843a:56) that Dr. Imlay's "station" and "house...are...about a mile from
Plate 8-11. A BRIEFLY sketch of a 'Native village' at Oman, Dr. Imlay's property at Thofold Bay.

Plate 8-12. A BRIEFLY sketch of a camp scene at Thofold Bay, with a family group near dark shelter, and fishing and hunting spears and a boomerang displayed. Photos courtesy of the Mitchell Library.
PLATE 8-13. A BRIEFLY SKETCH OF A BURIAL CYLINDER AT PAMBULA LAKE.
The camp in the background is on a headland location similar to many sites, including the PLA mound.
Photo courtesy of the Mitchell Library.
Pampoola... near the Yowaka River...". This encampment may have reflected the advantages of being near the source of blankets, tomahawks and whaling station discards or handouts rather than a continuation of a long established tradition of land use. This seems especially likely if the reports of population from Lambie to Gipps (Walters 1931) are considered. For Pambula, persons counted and blankets issued were in 1841, 17; 1842, 17; 1843-45, 14; 1846, 15; 1847-48, 17. These census counts seem to indicate that a permanent adult population of around 18-17 people was based near Pambula during this period. Brierly's "village" sketches however would suggest an adult population of more than 30 people in the area. It seems likely that these sketches represent the groups which gathered around the whaling stations and associated centres, and in fact relate to members of more distant Aboriginal communities attracted to the area by the whaling activities.

Robinson encountered 701 Aborigines between Goalen Head and Mallacoota (1844:91,235), most of these at Twofold Bay. The largest number he met with in any other area was 160 in the Bega Valley (1844:260), suggesting that by 1844 whaling had markedly changed the patterns of Aboriginal settlement in that area, and that large numbers of people had moved close to the whaling stations.

Perhaps Robinson's journal provides part of the answer to the question of changes in the coastal population. He commented (1844:88-96) on a gathering of what he estimated to be 100 to 200 Nulliker Blacks in Twofold Bay: "...large numbers were congregating as the whaling season had commenced...". Unfortunately his journal does not indicate whether this might have been what Robinson understood to have been the normal winter (whaling season) pattern of population movement, but as he was generally explicit in such observations it is much more likely that his causal statement should be taken at face value, and that by 1844 whaling settlements were a major attraction to the Aboriginal population of southeastern New South Wales. Although it is likely that the population on the coast during winter might always have been high (Chapter 5), the large numbers of people observed by Brierly and Robinson at Twofold Bay were almost
certainly a phenomenon of European culture and its effect on Aboriginal lifestyles.
CHAPTER 9

CONCLUSIONS: A REVIEW OF A LANDSCAPE APPROACH TO COASTAL ARCHAEOLOGY

THE NATURE AND DISTRIBUTION OF SITES

This study of shell middens within the coastal landscape of New South Wales has ranged widely over several aspects of the nature and distribution of such sites. It is concerned initially with an overview of patterns of distribution, and concentrates on specific characteristics of middens particularly in the southern part of the coastal zone. Little concluding commentary is necessary for the broad overview since Chapters 3 and 4 in this thesis are in themselves summaries describing patterns of site distribution. Aspects of the more detailed investigations arising from the overview do however require concluding themes to be drawn from them.

The introductory chapter and part I of this study, Chapter 2, were concerned entirely with setting a background for the study. In Chapter 2 definitions of coastal regions and landscape units were put forward as a framework in which the distribution of coastal shell middens could be considered. A framework based on structural and geologic criteria was used as an independent method of dividing the coast into four regions, and of classifying landforms within these.

In Part II of the study, Chapters 3 and 4, statistical analyses of the site data collated were carried out, and the implications of the results assessed. At the broadest level appropriate variables describing the nature and locations of the shell middens were defined for each of the four structural regions, and these were used to demonstrate that there are close relationships between shell midden contents, midden locations, and landscape characteristics.

These patterns of site contents and distribution reflect closely the way in which prehistoric people used the landscape. The nature and locations of archaeological sites confirmed that exploitation of
coastal resources such as fish and shellfish was important everywhere, and that in general, locally available resources were used. Features of the physical landscape which particularly influenced site locations included proximity to fresh water, specific landform types rich in food resources (e.g. granitic and sandstone rock platforms), and degree of "site comfort" (e.g. sand to sit on, shelter from wind provided).

From Part III, Chapter 5, it is apparent that people occupied the coastal zone during long periods when the landscape underwent considerable changes brought about through rising sealevel, barrier and dune construction and infilling of deltaic floodplains. Differences in the nature and location of sites through time reflect adaptations made to these changes in landscape.

In Part IV, Chapters 6, 7 and 8, consideration was given to characteristics of shell middens in relation to their landscape setting in the southern part of the coastal zone. In particular a number of relationships between patterns of prehistoric land use in the far southern part of the coastline were identified, and related to similar patterns recognised from further north. Specific aspects of change, such as the widespread change to edible mussel in the southern part of the coastal zone were also followed up. In addition a survey was carried out along the banks of two estuaries in the south of the coastline, and the results of this have implications for the rate of site destruction and the quality of the surviving archaeological record. An excavation of a shell midden recorded during that survey was carried out, initially to fill a gap in the archaeological record for southern New South Wales. The results of this excavation however had wider reaching implications, for instance in assessing the change to mussel.

CULTURAL IMPLICATIONS OF THE PATTERNS IDENTIFIED

Patterns of Movement

It was suggested in Chapter 2 that the wide northern rivers, with their high flood discharges, may have formed a barrier to the movement of people along the coast. The possibility was also raised that if
people in the north depended more heavily on watercraft than those to the south, this may be reflected in the distribution of estuarine or riverine sites inland from the coast at points where north-south access was easier. In fact there appears to be no such concentration of shell middens along the upper tidal reaches of estuaries or rivers in the north. Although generally smaller than the wide floodplain estuaries of the north, the bedrock controlled estuaries of the southern part of the coastal zone were just as much a focus of Aboriginal activity, and there is no indication that the patterns of use of the estuaries differed between the two parts of the coastal zone. It is likely both from the distributions of sites predominantly close to the estuarine shorelines, and the presence of bones of large numbers of deep water fish species in many estuarine sites, that canoes were used widely on estuaries in both parts of the coastal zone. Although differences in the patterns of resource use in the two parts of the coastal zone can be identified, these do not appear to reflect barriers to movement or lack of equipment to travel over water.

**Seasonal Patterns of Site Use**

Virtually the only conclusion relating to seasonality that can be drawn from the archaeology of the New South Wales coastal zone is that all of the sites investigated may have been occupied in summer at least. Many of them have definite indicators of summer occupation as outlined below. Definite indicators of winter occupation are sparse, and those which potentially can occur are generally fragile and subject to rapid decay. Fish are the most predictable seasonal indicators likely to occur in shell midden deposits, and the presence of large numbers of estuarine bream or mullet is generally the best indication of winter use of the site.

Muttonbirds, penguins and other seabirds generally breed in summer, and are available in rookeries or are washed ashore following storms, only at that time. These are clear indicators of summer use of sites, but their absence does not necessarily indicate winter occupation.
Ethnohistorical evidence suggests that for both the north and south of the State, Aborigines used the coastal zone at all seasons of the year, although not generally in a sedentary fashion. It seems likely from ethnohistorical and archaeological evidence that there was a greater emphasis towards the south on the use of the coast during winter, and that this correlated with a trend southwards to increasing year-round mobility.

There is not a great deal of evidence for sedentism on the New South Wales coast, but it appears from ethnohistorical sources that if any coastal populations approached sedentism it was those on the north coast. Whatever their mobility however, Aborigines on the north coast throughout the period of known prehistory based their coastal economy on estuaries, where they relied for animal food on fish, shellfish and terrestrial fauna. Beach shellfish were also an important resource. Aborigines on the south coast congregated both near rocky headlands, where they exploited the platforms and offshore waters, and to a lesser extent, terrestrial environments, and on the estuaries where there was a greater use of terrestrial fauna in addition to the estuarine resources. Shellfish, fish and terrestrial mammals or birds formed their main sources of animal foods.

Future Research Deriving From an Overview of Shell Middens

A project to elucidate the relationships between the use of offshore islands and mainland sites has been described in Chapter 5. This is now one of the few fundamental questions remaining in coastal archaeology in New South Wales in that the basic data from islands to enable an understanding of this relationship, do not yet exist.

Nowhere does there appear to have been real pressure on coastal resources. There is good evidence from the southern coastal zone (Hughes and Lampert in press) and from hinterland areas such as the Mangrove Creek catchment (Attenbrow 1981) that there has been an intensification of site occupation during middle to late Holocene times, especially over the last 2,000 to 1,000 years. Superficially there is no evidence for pressure on resources, although the increasing use of a wider range of local resources at both Currarong Shelter 2 (Lampert 1971a:57) and Pambula (Chapter 8) may reflect this intensification.
A detailed examination of shell remains from a number of excavated shell deposits from coastal New South Wales may reveal that shell sizes have indeed decreased over time, although at this stage there is little evidence for this. If shell sizes do decrease this may reflect population pressure in a way which is not apparent from the superficial observations made to date. An exception is the observation made by Campbell (1982:145) for the Wombah midden in the Clarence-Moreton region, that there was a decrease in the average length of oyster shells (*Crassostrea commercialis*) in level II towards the surface, compared with deeper levels. She suggested this was more likely to reflect a local increase in silt being deposited in that part of the river than over-predation of the oysters.

The Change to Edible Mussel

Questions raised in Chapter 6 concerned the nature and timing of the change to edible mussel in shell middens in southern New South Wales. Bowdler (1976:255) suggested on the basis of evidence from Bass Point that the change to edible mussel was abrupt, and that it co-incided with a cultural change to the use of shell fish hooks. Evidence from the Pambula excavation can be combined with that presented in Chapter 6 to re-assess the implications of this change in shellfish exploitation, and the discussion which follows is long in proportion to the remainder of the conclusions, as it involves drawing the data together. The nature of the changeover has not been described in excavation reports from other sites.

Given the range of error for any radiocarbon date, and the unlikely situation that each changeover event could be dated precisely, the main questions concerning the timing of the changeover to be resolved were the correlation of the changeover dates from a number of sites, or the limits of time within which the changeover occurred, and any trend in this change along the coastline. Nine shell middens have now been excavated in southern New South Wales from which direct evidence of the nature and timing of this changeover is available, and four other excavated middens provide additional evidence on the timing of this change.
Middens from which there are radiocarbon dates to indicate the timing of the change to mussel have been dated using either or both charcoal and shell. Marine shell is a suitable dating material (Gillespie and Temple 1977, Gillespie and Polach 1979), but shows a marine reservoir effect which increases the apparent age of the shell relative to charcoal. The relationship between shell and charcoal dates was investigated by Gillespie (Gillespie and Temple 1977, Gillespie and Polach 1979), mainly by using paired shell/charcoal samples taken from coastal shell middens. It has been suggested (Hughes and Djohadze 1980:18) that for the south coast of New South Wales the environmental correction factor applied to shell dates to derive an equivalent charcoal age, may be about 270 years rather than 450 years. This is very close to the 280 years which Gillespie and Temple (1977) noted was a common difference between shell and charcoal dates from southeastern Australian sites.

In this study two sets of charcoal-shell paired dates were available for the Pambula site (Fig. 8-5, Table 8-1). The average difference in this site is about 350 years, with the shell dates being older. Paired dates are also available for Cemetery Point (Fig. 6-2) and Bass Point. The difference between charcoal and shell dates in these sites is 340 years at Cemetery Point (Gillespie and Temple 1977: Table 8) and 270 years at Bass Point (Hughes and Djohade 1980:18). Thus for southern coastal New South Wales it appears that the environmental correction factor may indeed be lower than the recommended 450±30 years. This has implications for the interpretation of the chronology of the Nundera Point site, where all three dates were on shell. Although these shell dates have been corrected by subtracting 450±35 years, the corrected dates could be as much as 150 years older than the values stated.

From a consideration of the excavation results from the sites shown in Fig. 9-1, it is apparent that the nature of the changeover was not everywhere as abrupt as at Bass Point. Sites at Birubi, Daleys Point, Cemetery Point, Nundera and Pambula show a gradual increase in the proportion of Mytilus planulatus. At Birubi and Daleys Point Mytilus increased over a midden depth of about 10cm. At Pambula, where more detailed information is available, it is apparent (Fig 8-11) that Mytilus initially became important in the shell assemblage at about 1,200 years B.P., but reached maximum proportions within the
Fig. 9-1. Excavated sites with Mytilus planulatus dominant or significant □□□□□□ or not significant □□□□□□
(?) indicates best estimate on radiocarbon dates or cultural evidence (??)
assemblage only at about 600 years B.P. A more abrupt change in that site was the almost total disappearance of the hairy mussel *Trichomya hirsutus* at the time when *Mytilus* first became important. In the Daleys Point deposit however, *Trichomya* did not decrease as *Mytilus* increased, but made up an appreciable proportion of the upper midden layers. At Cemetery Point an increase in the proportion of *Mytilus* occurred between about 900 and 300 years B.P. In the nearby site on Bowen Island however, the change to *Mytilus* was abrupt, similar to that at Bass Point.

Fig. 9-1 shows the best estimated dates of the changeover to edible mussel within the shell middens, with shell dates corrected to an equivalent charcoal age by subtracting 450±35 years. Accepting that at Nundera this date should perhaps be 150 years earlier, there is a suggestion from Fig. 9-1 of a trend northwards to a somewhat more recent timing of the changeover to edible mussel. This trend is also based on the best estimate from Pambula of a changeover at about 1,200 years B.P., although it was acknowledged in Chapter 8 that it is possible the site was virtually abandoned from between 1,600 and 1,800 years B.P., until about 800 years B.P., in which case the changeover could have occurred as recently as 800 years B.P. The proportional change in both the amount of edible mussel and the relative proportions of raw materials for stone artefacts in that site (Figs. 8-11 and 8-13) however, favours a slow but continued accumulation between 1,600 and 800 years B.P., and a changeover date of about 1,200 years B.P. most likely.

In summary therefore it is apparent that the change to edible mussel, while not synchronous, generally occurred over a relatively short period of time in the recent prehistory of southern New South Wales, between about 1,200 and 700 years B.P. Sites abandoned before 1,200 years B.P. do not appear to have contained *Mytilus*, and the excavated site at Durras North which was first occupied after 700 years B.P. contained *Mytilus* throughout the depth of the shell column sampled. The change to mussel appears to have occurred first in southern New South Wales, possibly as early as 1,200 years B.P., and to have occurred further north, towards the Sydney region, between 700 and 800 years B.P. The Bowen Island site in which the changeover occurred somewhat later at about 600 years B.P. could reflect a particular phenomenon of island exploitation, or a particular example
of the establishment of an edible mussel colony only recently on that island. Additional dates from this midden would also be needed to ensure that this apparently aberrant changeover date does not simply result from inadequate chronologic control.

The overall change to edible mussel was a gradual one, such that mussel had become important in a number of sites by about 800 years B.P. Although it is likely that the changeover to edible mussel was culturally determined, and although the changeover generally co-incides with the use of shell fish hooks, the two phenomena may not be causally linked. In the absence of other likely explanations however, Bowdler's hypothesis that the use of shell fish hooks caused a change in the patterns of shellfish exploitation, is the most convincing argument so far suggested. The change however was by no means the simple result of a sudden technological change, and it may be related also in some way to recent intensification of resource use on the coast.

Such intensification need not imply pressure on resources, and in itself a change in resource exploitation does not imply population pressure (see Hassan 1981:173-5). Cohen (1977:49) provided fourteen criteria by which an assessment could be made of the likelihood of pressure on resources due to human population increase in prehistoric times. Although a shift in the food sources exploited was one of the fourteen criteria proposed, taken alone it does not indicate pressure due to population increase, and in coastal New South Wales no evidence has been identified to indicate such pressure on food resources. If Cohen's fourteen criteria are considered for the New South Wales coastal zone, there is too little convergence of these to imply population pressure. Nevertheless the use of a wider range of foods and environments through time in at least some of the sites investigated, may reflect, along with other criteria, an intensification of use of coastal resources over the last 1,500 to 1,000 years of prehistory.

**Future Research**

This study has brought together the information so far available on the change to edible mussel in south coastal sites in New South Wales. Questions of the nature, exact timing and the cause or causes
of the change have not yet been resolved. These could form the subject of a major research project, or could be answered progressively if future archaeological investigations in southern coastal New South Wales are carried out with these questions in mind.

There is a need for detailed information on the nature of the change to edible mussel in more sites, the chronology of the change in these sites and thorough descriptions of accompanying changes in the faunal and artefactual material. In particular detailed analyses of the fishbones from the deposits should be carried out to examine correlative changes in fish numbers, sizes or habitats exploited. Such changes could then be considered along with the nature of the change in the shellfish. Detailed faunal analysis involving mammals and birds as well, might provide additional information on seasonality of use of these sites.

Another facet of south coast prehistory which could be resolved at the same time is the nature of the environmental reservoir effect in charcoal and shell dating. Sites within which careful chronological control is required could be usefully dated using shell/charcoal pairs. Not only would this provide a better estimate of the local environmental correction factor, but it might provide information on the degree to which charcoal moves in shell middens, relative to the less mobile shell fraction.

All of these inter-related research themes would require detailed field investigations involving the recording and recovery of a wide range of archaeological and environmental information. There is a need for archaeological authorities issuing permits for research, salvage or ameliorative works on south coast shell middens to ensure that relevant information is not overlooked. Large excavations or test columns should be accompanied by thorough descriptions of changes in shellfish species, and spits excavated in a way which would be compatible with extracting information on these changes. Such spits or columns could later be used to provide samples for radiocarbon dating if layers containing shells of different species or sizes were removed as separate units. In addition shell, sediment and bone from such excavations should all be retained as all may contribute usefully to future analyses.
There are also sites which do not show the change to edible mussel, but which show other changes in shell species exploited. A change in the upper horizons from large to very small gastropods for instance, occurs in a shell midden near Batemans Bay. Sites of this type should also be investigated in a programme of data collection to define this cultural change.

**Other Cultural Patterns**

A clear change was identified which allowed the coastal zone to be divided into a northern and a southern section. This division was based not only on landscape change, but on a change in the nature and distribution of shell middens in those landscapes. Although these cultural differences may not have been caused by environmental constraints, differences in the way these varied environments were exploited may reflect other cultural differences.

This division of the coast near Newcastle is also identified in other cultural traits not related to coastal exploitation, and not so far considered in this study. In a thorough analysis of the distribution of Aboriginal mortuary practices for instance, Meehan (1971: maps 4-8, 31, 53, 80) showed that there was similarly a break in this same area in these practices. North of the Newcastle area more complex disposal of the dead occurred. Secondary disposal was common, as was burial in bark cylinders, in hollow logs, platform burials and grave mounding. South of the Newcastle area simple burial or cremation was the normal means of disposal of the dead. To what extent this major break in landscape character was a real boundary for a number of cultural traits in prehistory is not known. It may be however that the response of people in dealing with resources in these contrasting landscapes reflected other differences which left no archaeological traces.

**MANAGEMENT IMPLICATIONS OF THIS STUDY**

In order to manage archaeological sites it is necessary to have as thorough a knowledge as possible of the range, features and distribution of those sites.
This study has contributed to widening this information base by describing systematically and completing information for sites where previous records lacked detail, and by ensuring that there is an overall cover of the coastal zone. It is possible from this analysis to identify typical, unusual, large and rich sites, all of which are of interest in making management decisions regarding salvage or protection of sites. Additional data concerning the positions of sites in the landscape are presented in this study. Such information is necessary in designing appropriate physical methods to protect sites, especially sites threatened by erosional processes.

All systems of assigning a rating value to archaeological sites in fact take into account the potential of any site in terms of future research. Questions which are asked by researchers develop and change through time, so the directions of future research cannot be known when decisions regarding site protection are made. It is likely however that high research value will continue to be placed on culturally rich sites. Shell middens by their nature tend to preserve cultural material better than do most other archaeological deposits. Those which are best able to be protected are those which occur on stable landforms or in stable landscapes. In seeking to protect culturally rich shell middens within stable landscapes, and sites which are likely to contain a long record of use in prehistoric times, the two southern regions of the coastline are most important. Shell middens in the two northern regions commonly rest on recent and unstable depositional landforms; those to the south occur more commonly on older bedrock features. The far south coast of New South Wales, which contains many such sites, has not yet been subjected to intense modification by housing, agricultural or industrial programmes. As a research area, the far south coast of New South Wales is therefore an invaluable and important archaeological landscape worthy of special protection.
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APPENDIX I

COMPLETE SITE DATA FILE

03401CTH676501281215133404SFSXNGCX1202351211526BXXXIFSIAFXXXINDSANX03402SAIIFSLLH02SWHA0050CRKBIF00400001JBPXLRAIFXXX
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...
# APPENDIX 2

**Coding System used with Data Recording Sheets**

## SITE DESCRIPTION

No. 0001 etc. - a four figure system in order of recording

<table>
<thead>
<tr>
<th>Region</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>The Clarence-Morton Basin</td>
</tr>
<tr>
<td>N</td>
<td>The New England Fold Belt</td>
</tr>
<tr>
<td>S</td>
<td>The Sydney-Bowen Basin</td>
</tr>
<tr>
<td>M</td>
<td>The Molong-South Coast anticlinal zone of the Lachlan Fold Belt</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grid Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TH</td>
<td>Tweed Heads</td>
</tr>
<tr>
<td>MN</td>
<td>Maclean</td>
</tr>
<tr>
<td>DR</td>
<td>Dorrigo</td>
</tr>
<tr>
<td>CH</td>
<td>Coffs Harbour</td>
</tr>
<tr>
<td>HS</td>
<td>Hastings</td>
</tr>
<tr>
<td>NC</td>
<td>Newcastle</td>
</tr>
<tr>
<td>SY</td>
<td>Sydney</td>
</tr>
<tr>
<td>WG</td>
<td>Wollongong</td>
</tr>
<tr>
<td>UL</td>
<td>Ulladulla</td>
</tr>
<tr>
<td>BG</td>
<td>Bega</td>
</tr>
<tr>
<td>ML</td>
<td>Mallacoota</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Description</th>
</tr>
</thead>
<tbody>
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<td>A six figure reference (in degrees, minutes, seconds)</td>
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</tbody>
</table>

<table>
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<th>Longitude</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>A seven figure reference (as above)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Site Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A three figure code to represent the type of deposit</td>
<td></td>
</tr>
<tr>
<td>SOM</td>
<td>stratified open midden</td>
</tr>
<tr>
<td>DOM</td>
<td>deflated open midden</td>
</tr>
<tr>
<td>BOC</td>
<td>buried occupation layer(s)</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>SHD</td>
<td>shelter/cave deposit</td>
</tr>
<tr>
<td>SFS</td>
<td>surface scatter of shell, not deflated</td>
</tr>
<tr>
<td>SFC</td>
<td>surface campsite, i.e. shell + stone or bone, not deflated</td>
</tr>
<tr>
<td>SWS</td>
<td>surface scatter of worked stone</td>
</tr>
<tr>
<td>BWS</td>
<td>buried layer of worked stone</td>
</tr>
<tr>
<td>QRY</td>
<td>quarry</td>
</tr>
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</table>

**QUALIFYING FACTORS**

### Art present

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>A</td>
<td>Art associated with the site</td>
</tr>
<tr>
<td>O</td>
<td>Ochre in site</td>
</tr>
<tr>
<td>X</td>
<td>Art not present</td>
</tr>
</tbody>
</table>

### Reworking

<table>
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<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>none</td>
</tr>
<tr>
<td>P</td>
<td>partial reworking</td>
</tr>
<tr>
<td>T</td>
<td>deposit totally reworked</td>
</tr>
</tbody>
</table>

### Preservation

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>good</td>
</tr>
<tr>
<td>F</td>
<td>fair (some disturbance, but at least some deposit intact)</td>
</tr>
<tr>
<td>P</td>
<td>poor (most of the deposit disturbed, destroyed)</td>
</tr>
</tbody>
</table>

### Rating

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>an excellent example of this site type, unique, should not be destroyed</td>
</tr>
<tr>
<td>B</td>
<td>a good example, should be studied before disturbance</td>
</tr>
<tr>
<td>C</td>
<td>site typical of many, not particularly worthy of detailed study</td>
</tr>
</tbody>
</table>

### Mounding

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>deposit mounded or distinctly hooped</td>
</tr>
<tr>
<td>X</td>
<td>deposit not mounded</td>
</tr>
</tbody>
</table>
SITE PARAMETERS

Aspect

three figure bearing, perpendicular to long axis of site

999 used to indicate no specific aspect

Dimensions

length given by two figures to indicate in cms

width the upper limit of the decile and

depth the power of 10 to which this must be raised

area

volume

e.g.

1 0 = 1cm (1cm², 1cm³)

1 5 = 1km

9 9 = 9,000,000,000 units

CONTENTS OF DEPOSITS

Shell

Dominant suite(s) listed in order in three figure combination

P rock platform species

B open beach species

E estuarine species

X none (of one, two or three of above)

Bone

A single figure to indicate presence of:

M mammal bone

B bird bone

F fish bone

U mixed or undifferentiated or unidentified bone

X no bone

Stone

A three figure symbol to indicate lithology

SST sandstone (arenaceous sedimentary)

SHL shale (fine sedimentary, including those with glacial erratics)

HFS hornfels

LST limestone (including calcarenite, dolomites)
<table>
<thead>
<tr>
<th>Abbr.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNG</td>
<td>conglomerate, agglomerate</td>
</tr>
<tr>
<td>BIF</td>
<td>fine textured basic igneous</td>
</tr>
<tr>
<td>BIC</td>
<td>coarse textured basic igneous</td>
</tr>
<tr>
<td>AIF</td>
<td>fine textured acidic igneous</td>
</tr>
<tr>
<td>AIC</td>
<td>coarse textured acidic igneous</td>
</tr>
<tr>
<td>SHT</td>
<td>schist</td>
</tr>
<tr>
<td>HMT</td>
<td>high grade unspecified metamorphics</td>
</tr>
<tr>
<td>LMT</td>
<td>low grade unspecified metamorphics</td>
</tr>
<tr>
<td>QTZ</td>
<td>quartz</td>
</tr>
<tr>
<td>QIT</td>
<td>quartzite</td>
</tr>
<tr>
<td>SLC</td>
<td>silcrete, porcellanite, silicified fine grained material</td>
</tr>
<tr>
<td>CDY</td>
<td>chalcedony, agate</td>
</tr>
<tr>
<td>CHT</td>
<td>chert</td>
</tr>
<tr>
<td>PMC</td>
<td>pumice</td>
</tr>
<tr>
<td>XXX</td>
<td>no stone</td>
</tr>
</tbody>
</table>

Up to three stone types may be listed in decreasing order of abundance.

**Implements**
A three figure symbol to indicate the type of implements apparent:

- PRE: pre-bondaian industries
- BND: bondaian industries
- PST: post-bondaian industries
- IND: indistinguishable flakes, etc., or combinations of above

**Matrix**
A three figure symbol to indicate the matrix of the deposit:

- SAN: sand
- GVL: gravel
- ALL: alluvium
- EST: estuarine sediments
- ASH: ashy, or organic material
- OTH: other

**Date**
An indication of whether a $^{14}C$ date is available for the deposit:

- D: site dated
- X: site not dated
LOCATION DESCRIPTION

Immediate substrate Material directly underlying the deposit

General substrate Locally occurring bedrock
Both as listed using categories specified for in stone types and matrix

Landform A three figure symbol to indicate:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRH</td>
<td>headland crest</td>
</tr>
<tr>
<td>SLH</td>
<td>headland slope</td>
</tr>
<tr>
<td>FTH</td>
<td>headland foot</td>
</tr>
<tr>
<td>PFB</td>
<td>platform back</td>
</tr>
<tr>
<td>PFM</td>
<td>platform</td>
</tr>
<tr>
<td>CLT</td>
<td>cliff top</td>
</tr>
<tr>
<td>ESC</td>
<td>escarpment</td>
</tr>
<tr>
<td>SLP</td>
<td>hillslope, ridgeslope</td>
</tr>
<tr>
<td>TOP</td>
<td>hilltop, ridge top</td>
</tr>
<tr>
<td>BCI</td>
<td>beach</td>
</tr>
<tr>
<td>FDN</td>
<td>foredune complex</td>
</tr>
<tr>
<td>BDN</td>
<td>backdune complex</td>
</tr>
<tr>
<td>SSH</td>
<td>sandsheet, including cliff-top accumulations</td>
</tr>
<tr>
<td>BRG</td>
<td>beachridge system</td>
</tr>
<tr>
<td>IBR</td>
<td>inner barrier deposit</td>
</tr>
<tr>
<td>EST</td>
<td>estuarine shoreline</td>
</tr>
<tr>
<td>ESX</td>
<td>former estuarine shoreline</td>
</tr>
<tr>
<td>RBK</td>
<td>riverbank</td>
</tr>
<tr>
<td>FPN</td>
<td>floodplain</td>
</tr>
<tr>
<td>LVE</td>
<td>levee</td>
</tr>
<tr>
<td>TCE</td>
<td>terrace</td>
</tr>
</tbody>
</table>

Slope Measured in degrees (two figures)

Position Relative to shelter from prevailing winds, offered by a dune, headland or cliff. A three figure symbol, two figures representing eight directional co-ordinates in combinations of N, S, E, W, and one representing

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>dune</td>
</tr>
<tr>
<td>H</td>
<td>headland, cliff</td>
</tr>
<tr>
<td>XXX</td>
<td>if this factor not applicable</td>
</tr>
<tr>
<td>Floods</td>
<td>A single symbol to indicate the position of the deposit or site relative to normal tide or flood levels</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>A</td>
<td>above the reach of highest floods/tidal levels</td>
</tr>
<tr>
<td>R</td>
<td>reached by extreme floods, highest spring tides</td>
</tr>
<tr>
<td>N</td>
<td>covered by normal high tides, bankfull floods</td>
</tr>
<tr>
<td>X</td>
<td>not applicable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water</th>
<th>The distance in metres from drinkable (fresh or slightly brackish) water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The value 9999 = more than 10km</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>A three figure symbol indicating the local source of drinking water</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRK</td>
<td>creek, surface runoff</td>
</tr>
<tr>
<td>SWP</td>
<td>swamp, ponded water</td>
</tr>
<tr>
<td>RKH</td>
<td>rockhole, spring</td>
</tr>
<tr>
<td>SPG</td>
<td>seepage through sand, alluvium</td>
</tr>
</tbody>
</table>

**PLATFORM DESCRIPTION**

The nature of rocky platforms or reefs nearby.

<table>
<thead>
<tr>
<th>Area</th>
<th>The surface area of the platform uncovered at normal low tide, estimated or measured from maps or airphotos, in m²</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Slope</th>
<th>The surface slope on the platform in degrees</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Form</th>
<th>A single figure symbol to indicate the surface erosional form of the platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>smoothly eroded</td>
</tr>
<tr>
<td>J</td>
<td>jointed, cracked, etched, exfoliating, honeycombed, etc.</td>
</tr>
<tr>
<td>L</td>
<td>lumpy, differentially eroded to discrete surfaces</td>
</tr>
<tr>
<td>XXXXX</td>
<td>etc. if this does not apply, with 999 for area &amp; slope</td>
</tr>
</tbody>
</table>

**SHELLFISH**

The species locally available at present, as listed in midden contents. XXX if not applicable.
Size

S   small
M   medium
L   large

Availability

R   readily available, plentiful
F   few, none readily available

QUARRY

A listing of any quarry or stone source immediately adjacent to the site. Stone type listed as in midden contents.

FILM

Note of the film number on which the site is recorded
## APPENDIX 3

**Shellfish Referred to in Text or Recorded in Pambula Excavation**

<table>
<thead>
<tr>
<th>Common name</th>
<th>Biological name</th>
<th>Authority</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipi</td>
<td>Plebidonax deltoides</td>
<td>Lamarck 1818</td>
<td>Beach</td>
</tr>
<tr>
<td>Sydney cockle</td>
<td>Anadara trapezia</td>
<td>Deshayes 1840</td>
<td>Estuary</td>
</tr>
<tr>
<td>Rock shell</td>
<td>Cleidothaerus albidus</td>
<td>Lamarck 1819</td>
<td>Deep water, incl. estuary</td>
</tr>
<tr>
<td>Basket shell</td>
<td>Corbula stolata</td>
<td>Iredale 1930</td>
<td>Deep water, incl. estuary</td>
</tr>
<tr>
<td>Mud oyster, dredge oyster</td>
<td>Ostrea angasi</td>
<td>Sowerby 1871</td>
<td>Estuary</td>
</tr>
<tr>
<td>Hercules club whelk, mud whelk</td>
<td>Pyrazus ebeninus</td>
<td>Brugière 1792</td>
<td>Estuary</td>
</tr>
<tr>
<td>Small mud whelk</td>
<td>Velascumans australis</td>
<td>Quoy and Gaimard 1834</td>
<td>Estuary</td>
</tr>
<tr>
<td>Mussel drill</td>
<td>Bedeva paiva</td>
<td>Crosse 1864</td>
<td>Platform, estuary</td>
</tr>
<tr>
<td>Rock oyster</td>
<td>Crassostrea commercialis</td>
<td>Iredale and Roughley 1933</td>
<td>Platform, estuary</td>
</tr>
<tr>
<td>Mulberry shell, oyster borer</td>
<td>Norula marginata</td>
<td>Quoy and Gaimard 1834</td>
<td>Platform, estuary</td>
</tr>
<tr>
<td>Edible mussel</td>
<td>Mytilus planulatus</td>
<td>Lamarck 1819</td>
<td>Platform, estuary</td>
</tr>
<tr>
<td>Hairy mussel</td>
<td>Trichomya hirsutus</td>
<td>Lamarck 1819</td>
<td>Platform, estuary</td>
</tr>
<tr>
<td>Chitons</td>
<td>Tychichiton elongatus</td>
<td>Blainville 1825</td>
<td>Rock platforms</td>
</tr>
<tr>
<td></td>
<td>Poneroplax albida</td>
<td>Blainville 1825</td>
<td>Rock platforms</td>
</tr>
<tr>
<td>Barnacles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tiny rock barnacle</td>
<td>Chamaesipho columna</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surf barnacle</td>
<td>Catophragmus polymerus</td>
<td></td>
<td>Exposed rock platforms</td>
</tr>
<tr>
<td>Rock barnacles</td>
<td>Tetracita purpureascens</td>
<td></td>
<td>Rock platforms</td>
</tr>
<tr>
<td></td>
<td>Tetracita rosea</td>
<td></td>
<td>Rock platforms</td>
</tr>
<tr>
<td>Sea urchin</td>
<td>Heliocidaris erythrogramma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limpets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variegated limpet</td>
<td>Cellana tramosorica</td>
<td>Sowerby 1825</td>
<td>Exposed rock platforms</td>
</tr>
<tr>
<td>Chapman's limpet</td>
<td>Patellanax chapmani</td>
<td>Tanison Woods 1876</td>
<td>Rock platforms</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Common name</th>
<th>Biological name</th>
<th>Authority</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaly limpet</td>
<td>Patellinae peroni (patelloides)</td>
<td>Blainville 1825</td>
<td>Rock platforms</td>
</tr>
<tr>
<td>Tall-ribbed limpet</td>
<td>Patelloida alticostata</td>
<td>Angas 1865</td>
<td>Rock platforms</td>
</tr>
<tr>
<td>Ribbed top shell</td>
<td>Austrocochlea constricta</td>
<td>Lamarck 1822</td>
<td>Sheltered rock platforms, upper littoral zone</td>
</tr>
<tr>
<td>Tent shell</td>
<td>Bellastrea kesteveni</td>
<td>Iredale 1824</td>
<td>Sheltered rock platforms</td>
</tr>
<tr>
<td>Striped-mouthed conniwink, small tent shell</td>
<td>Bambicium nanum</td>
<td>Lamarck 1822</td>
<td>Sheltered rock platforms, upper littoral zone</td>
</tr>
<tr>
<td>Jewelled top shell</td>
<td>Calliostoma armillata</td>
<td>Wood 1828</td>
<td>Sheltered platforms, deep water</td>
</tr>
<tr>
<td>Nerite</td>
<td>Nerita atramentosa (Melanerita melanotragus)</td>
<td>Smith 1884</td>
<td>Sheltered rock platforms, upper littoral zone</td>
</tr>
<tr>
<td>Conical top shell</td>
<td>Thalotia conica</td>
<td>Gray 1827</td>
<td>Sheltered rock platforms, upper littoral zone</td>
</tr>
<tr>
<td>Triton, Spengler's rock whelk</td>
<td>Cabestana spengleri</td>
<td>Perry 1811</td>
<td>Exposed rock platforms</td>
</tr>
<tr>
<td>Carrot shell</td>
<td>Picathais orbita</td>
<td>Gmelin 1791</td>
<td>Exposed rock platforms</td>
</tr>
<tr>
<td>Elephant snail</td>
<td>Scutus antipodes</td>
<td>Montfort 1810</td>
<td>Exposed rock platforms</td>
</tr>
<tr>
<td>Australian rock whelk</td>
<td>Kylene australasia</td>
<td>Perry 1811</td>
<td>Exposed rock platforms</td>
</tr>
<tr>
<td>Turban shell</td>
<td>Turbo (Ninella) toquata</td>
<td>Gmelin 1791</td>
<td>Exposed rock platforms</td>
</tr>
<tr>
<td>Warrner, small turban</td>
<td>Turbo (Subninella) undulata</td>
<td>Solander</td>
<td>Exposed rock platforms</td>
</tr>
</tbody>
</table>

**Seaweed Adherents, Floating Snails, Bottom Dwellers in Shell Beds**

<table>
<thead>
<tr>
<th>Common name</th>
<th>Biological name</th>
<th>Authority</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slit limpet</td>
<td>Amblychilepas nigrita</td>
<td>Pilsbry 1890</td>
<td>Shell beds</td>
</tr>
<tr>
<td>Mitre shell</td>
<td>Austromitra scalariformis</td>
<td>Tenison Woods 1975</td>
<td>Deep water</td>
</tr>
<tr>
<td>Kelp shell</td>
<td>Bankivia fasciata</td>
<td>Menke 1830</td>
<td>Weed adherent</td>
</tr>
<tr>
<td>Granulated creeper</td>
<td>Cacoxenea granaria</td>
<td>Kiener 1842</td>
<td>Weed adherent</td>
</tr>
<tr>
<td>Cantharidus</td>
<td>Cantharidus ramburi</td>
<td>Crosse 1864</td>
<td>Weed adherent</td>
</tr>
<tr>
<td>Flamed limpet</td>
<td>Chiazacmea flammea</td>
<td>Quoy and Gaimard 1834</td>
<td>Shell beds</td>
</tr>
<tr>
<td>Common name</td>
<td>Biological name</td>
<td>Authority</td>
<td>Habitat</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------------------</td>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Warted sand whelk</td>
<td><em>Cymatiella verrucosa</em></td>
<td>Reeve 1844</td>
<td>Bottom dweller</td>
</tr>
<tr>
<td>Common violet snail</td>
<td><em>Ianthina ianthina</em></td>
<td>Linne 1758</td>
<td>Floating shale</td>
</tr>
<tr>
<td>Southern kellia</td>
<td><em>Kellia australis</em></td>
<td>Lamarck 1818</td>
<td>Wood adherent</td>
</tr>
<tr>
<td>Spotted triton</td>
<td><em>Maculotriton australis</em></td>
<td>Rease 1872</td>
<td>Shell beds</td>
</tr>
<tr>
<td>Blemished nassarius</td>
<td><em>Parcanassa jonasi</em></td>
<td>Dunker 1846</td>
<td>Shell beds</td>
</tr>
<tr>
<td>Conical sand snail</td>
<td><em>Polinices (Conuber) conicus</em></td>
<td>Lamarck 1822</td>
<td>Bottom dweller</td>
</tr>
<tr>
<td>Sand snail</td>
<td><em>Polinices sordidus</em></td>
<td>Swainson 1821</td>
<td>Bottom dweller</td>
</tr>
<tr>
<td>Elongated thracia</td>
<td><em>Thracia elongata</em></td>
<td>Stutchbury 1835</td>
<td>Bottom dweller</td>
</tr>
<tr>
<td>Notched limpets</td>
<td><em>Tugali cicatricosa</em></td>
<td>Adams 1857</td>
<td>Bottom dweller</td>
</tr>
<tr>
<td></td>
<td><em>Tugali parmophoidea</em></td>
<td>Quoy and Gaimard</td>
<td>Bottom dweller</td>
</tr>
</tbody>
</table>
APPENDIX 4

METHODS OF SEDIMENT ANALYSIS

The laboratory analytical methods used to determine the composition of the less than 2mm matrix of the PLA deposit were basically those described by Hughes (1977, 1980, in press). These methods were developed by Hughes for the analysis of sites in southern coastal New South Wales, including open shell middens such as PLA.

A. GRAIN SIZE ANALYSIS AND MINERALOGY

Most of the sediment sampled from the deposit and from the surrounding landscape was sand and the samples were size-analysed by sieving 50gm of shell and organic matter-free sediment through a set of nested Endecott 20cm screens at 0.5 phi ($\phi$) intervals for 15 minutes on a mechanical sieve shaker. Any shell in the sample was first removed by digesting it in acid and then rinsing the residue by decantation. Much of the organic matter such as charcoal and humus was also lost in the decantation process but if appreciable amounts still remained, this was removed by digesting the sample in concentrated hydrogen peroxide and then washing away the sludge by further decantation.

The sediments were examined under 10 times magnification using a binocular microscope, to observe the mineralogy and nature of the sand grains.

B. SHELL CONTENT DETERMINATION

The percentage of shell in each spit of the column sample was determined using a modification of the method described by Bauer, Beckett and Bis (1972) for use in soil carbonate determination (see Hughes 1980). This rapid gravimetric method is based on the fact that when acid is added to shell carbonate carbon dioxide is produced by
the reaction. The carbon dioxide is emitted as a gas, and allowed to escape from the reaction container, and the proportion of calcium carbonate initially present is calculated from the weight loss due to carbon dioxide emission. Excess acid is used to ensure that reaction is complete, and the final weighing is not carried out until effervescence has totally ceased - this time varying between 3 and 30 minutes.

Method

1. Pour about 15-25ml of 5N HCl (50% concentration) into a 50ml beaker.

2. Place an empty porcelain crucible bottom-down on top of the beaker and weigh the combination (i.e. beaker, acid and crucible) to the nearest 0.05gm on a top-loading balance (W1).

3. Add about 2gm of less than 2mm matrix to the crucible and re-weigh the combination (W2).

4. Gently tip the sediment into the acid and allow to stand until the reaction is complete. Re-weigh the combination (W3).

The percentage of calcium carbonate is calculated as follows:

\[
\% \text{ CaCO}_3 = \frac{(W2 - W3) \times 227.4}{(W2 - W1)}
\]

Duplicate sub-samples were analysed, and the determination was repeated until duplicates varied by less than 0.5% of the percentage value obtained. The method is accurate to within 5%, and gives a good estimate of the proportion of finely divided shell making up the matrix.

C. LOSS ON IGNITION METHOD

The simplest method of determining the content of other organic matter (humus and charcoal) is that of loss on ignition. Duplicate samples of approximately 2 gm of sediment were fired in a muffle furnace at 650 degrees Centigrade for one hour. This temperature is not sufficiently high to cause calcium carbonate in the shell to break
down to calcium oxide, but ensures the complete oxidation of other organic matter to gaseous oxides. The content of other organic matter is calculated as follows:

\[ \% \text{ organic matter} = \frac{\text{weight loss on ignition} \times 100}{\text{sample weight}} \]
## APPENDIX 5

**Fish from Excavated Site at Pambula Lake**

Data Sources: Grant, 1978; Pollard, 1969

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Biological Name</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snapper</td>
<td><em>Chrysophrys auratus</em> (Block and Schneider)</td>
<td>Estuary→ocean</td>
</tr>
<tr>
<td>Silver bream</td>
<td><em>Acanthopagrus (Mylio) australis</em> (Gunther)</td>
<td>Estuary, ocean</td>
</tr>
<tr>
<td>(sea bream)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black bream</td>
<td><em>Acanthopagrus butcheri</em> (Munro)</td>
<td>Estuary</td>
</tr>
<tr>
<td>Leatherjacket</td>
<td><em>Fam. Aleuteridae</em> incl.</td>
<td>Estuary, ocean</td>
</tr>
<tr>
<td>Yellow-finned</td>
<td><em>Cantherines (Menschenia)</em> trachilepis (Gunther)</td>
<td>Estuary</td>
</tr>
<tr>
<td>leatherjacket</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parrot-fish, wrase</td>
<td><em>Fam. Labridae</em> incl.</td>
<td>Off rock platform</td>
</tr>
<tr>
<td>Maori wrasse (groper)</td>
<td><em>Ophthalmolepis lineolatus</em> (Ruppell)</td>
<td>Off rock platform</td>
</tr>
<tr>
<td>Nannygai (redfish)</td>
<td><em>Centroberyx affinis</em> (Cuvier)</td>
<td>Ocean, estuary</td>
</tr>
<tr>
<td>Mullet (sea mullet)</td>
<td><em>Mugil cephalus</em> (Linnaeus)</td>
<td>Estuaries, along coastline</td>
</tr>
<tr>
<td>Whiting (sand whiting)</td>
<td><em>Sillago ciliata</em> (cuvier)</td>
<td>Estuaries, offshore sandflats</td>
</tr>
<tr>
<td>Flathead (Dusky flathead, mud flathead)</td>
<td><em>Platyccephalus fuscus</em> (Cuvier and Valenciennes)</td>
<td>Offshore sandflats, estuary</td>
</tr>
<tr>
<td>Wirrah (rock cod)</td>
<td><em>Acanthistius serratus</em> (Cuvier)</td>
<td>Off rock platform</td>
</tr>
<tr>
<td>Mulloway (jewfish)</td>
<td><em>Seicna (Johnius) antarctica</em> (Castelnau)</td>
<td>Ocean, estuary, routh</td>
</tr>
<tr>
<td>Morwong (mowong)</td>
<td><em>Chelodactylus (Nematodactylus)</em> (Ramsay and Ogilby)</td>
<td>Off rock platforms, in weed beds</td>
</tr>
<tr>
<td>Sergeant Baker</td>
<td><em>Aulopus purpurissatus</em> (Munro)</td>
<td>Off rock platform</td>
</tr>
</tbody>
</table>

* In these Families species other than the single species listed may also be represented in the site.
APPENDIX 6

WHALES FOUND IN AUSTRALIAN COASTAL WATERS

The distribution of whale species is still not well known, however Frost (1978:228 ff.) noted that the following are present in Australian coastal waters. Although any of these may occur off the southeastern coastline those indicated (*) are common off southern New South Wales, and are the species most likely to have been beached near Twofold Bay or Pambula.

**Whales**  
Order Cetacea

**Baleen Whales**  
Sub-order Mysticeti

- *Balaenoptera acutorostrata* minke whale to 9m
- *B. borealis* sei whale to 18m
- *B. edeni* Bryde's whale to 15m
- *B. musculus* blue whale to 30m
- *B. physalus* fin whale to 25m
- *Megaptera novaeangliae* humpback whale to 14m
- *Eubalaena australis* southern right whale to 16m
- *Caperea marginata* pygmy right whale to 5m

**Toothed Whales**  
Sub-order Odontoceti

- *Physeter catodon* sperm whale to 18m
- *Kogia breviceps* pygmy sperm whale to 4m
- *K. simus* dwarf sperm whale to 2.5m
- *Berardius arnuxii* Arnoux's beaked whale to 11m
- *Hyperoodon planifrons* southern bottlenose whale to 9m
- *Ziphius cavirostris* Cuvier's beaked whale to 6m
- *Mesoplodon mirus* True's beaked whale to 5m
- *M. hectori* Hector's beaked whale to 5m
- *M. layardi* strap-toothed whale to 6m
- *M. novaeangliae* Camperdown whale to 4m
- *M. bowdoini* Andrew's beaked whale to 4.5m
M. densirostris  Blainville's beaked whale to 4.5m.
Indopacetus pacificus  Pacific beaked whale to 6m
Lissodelphis peronii  southern right whale dolphin to 2.3m
*Delphinus delphis  common dolphin to 2.3m
Lagenorhynchus obscurus  dusky dolphin to 2m
L. cruciger  hour-glass dolphin to 1.8m
Tursiops truncatus  Atlantic bottlenose dolphin to 3.5m
*Grampus griseus  Risso's dolphin to 4.3m
Lagenodelphis hosei  Sarawak dolphin to 2.5m
Feresa attenuata  pygmy killer whale to 2.5m
*Orcinus orca  killer whale to 9m
Pseudorca crassidens  false killer whale to 5.5m
Orcaella brevirostris  Irawaddy dolphin to 2.1m
Globicephala melas  longfin pilot whale to 6m
G. macorynchus  shortfin pilot whale to 6m
Pepenecaphala electra  broad-beaked dolphin to 2.8m
Steno bredanensis  rough-toothed dolphin to 2.5m
Sonsa borneensis  Borneo white dolphin to 2m
S. lentiginosa  freckled dolphin to 2.5m
S. plumbea  plumbous dolphin to 2.4m
*Stenella coeruleoalba  blue or striped dolphin to 2.7m
S. longirostris  spinning dolphin to 2.1m
S. attenuata  bridled dolphin to 2.1m
S. plagiodon  spotted dolphin or many-toothed blackfish to 2.2m