MEALS AND MENUS: A STUDY OF CHANGE IN PREHISTORIC COASTAL SETTLEMENTS IN SOUTH AUSTRALIA

BY

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DECLARATION

To the best of my knowledge this Thesis is entirely the work of the author unless due reference has been made in the text.

Signed

Roger A. Luebbers

CORRIGENDA

p.19, line 23; "circumventing the island" should read "travelled around the shoreline of the island...."

p.20, line 3; "and by human predation itself" should read "and by the consequences of human predation itself".

p.52, line 36; (Campbell, 1946) should read (Campbell, Cleland, and Hossfeld, 1946).

p.57, line 3; (Langsford-Smith, 1970) should read (Langsford-Smith and Thom, 1970).

p.222, Plate 6.1, caption A, B; "Edge prepared core (no.2.0.6) from Inland Camps" should read "Edge prepared core (no number), from Plebidonax deposit 67, Canunda Rock".

p.293, line 3;"Since it has been established that occupation took place during the cooler parts of the autumn," should read "If the conclusion from the growth ring study is correct and occupation took place during the cooler parts of the year,".

p.297, line 28;"to have continued" should read "to have supported continued".

p.314 reference Thomas and Corden not in alphabetical order

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ABSTRACT

Current research into the causes of prehistoric coastal adaptation in southern Australia has emphasized the influence of the marine environment without considering other environmental or cultural factors which may also direct economic growth. The research described here considers the case of prehistoric settlement in swamps and coastal margins in South Australia in an effort to explain shifts in subsistence strategies in terms of the process of adaptation.

The 19th century ecology of the area is first reconstructed with reference to primary resources available in the sea, lagoon, and swamps. Against this information, the local ethnography is used to propose broad subsistence strategies by which the annual food quest may have operated during the late prehistoric occupation. The archaeological implications are considered in light of this information.

The archaeological record of settlement spans the last 10,000 years and can be divided into two cultural horizons. The first is an Early Holocene occupation which is distributed widely in association with swampside exploitation. The second horizon begins at 6000BP and can be divided into two primary occupation phases. The Early Phase (6000-1300BP) is represented in discrete monospecific middens of either Plebidonax or the mussel Brachidontes located mostly on hinddune surfaces. Both molluscs are locally extinct. The Late Phase by contrast is characterized by large deposits of several extant reef gastropods at a variety of localities throughout the coastal margin. Furthermore, a microlithic component flourishes during the Early Phase of occupation, but is absent later. This evidence indicates significant changes in occupation intensity and subsistence technologies which cannot be linked to Mid-Holocene sea level adjustments. Other explanations are therefore considered.

To resolve this problem, estimates are made of the size and organization of primary shellfishing groups operating in each of the two occupation phases. Growth rings of Plebidonax in single meals are examined to 1) determine contemporaneity of collection events represented by individual refuse heaps occurring in clusters, and 2) to estimate the pattern of seasonal occupation. This study concludes that successive rather than contemporaneous campsite visitations may have occurred during late winter. This pattern contrasts

with ethnographic documentation of a summer and autumn occupation during the late Phase.

Having isolated the contents of single meals within both phases, the size of the group dining has been estimated on the basis of standard human energy requirement with the conclusion that significant changes in group size have occurred between the occupation phases. The total number of shellfish meals consumed in the study area is calculated from survey and excavated data. These figures confirm a marked increase in consumption rates which correlates with increases in the duration of seasonal occupation, and further suggest that improvements in the marine biosphere and collection proficiencies are responsible. A biometric analysis of the food refuse reveals that shellfish collection in the Early Phase was exclusively intertidal, whereas subsequent use of marine resources could only have resulted from both inter- and subtidal exploitation.

Together, these data are considered to document sharp changes in consumer behaviour after about 1300BP, including longer duration of seasonal occupation of the coastal margin, an increase in resident population, an expansion of the menu, and the emergence of a more complex subsistence organization.

An explanation for this reorganization is seen in changes in swamp resources, whose importance to Holocene subsistence economies is firmly documented in ethnographic account and archaeological deposits. Pollen sequences from five dated peat deposits have been used to reconstruct Holocene water levels. From this information, increases in coastal exploitation are seen to correlated with a decline in water levels in the swamps and improvements in aquatic biota inhabiting the coast following blocked drainage there. The coastal adaptation is therefore seen as an attempt to maximize resources in the face of shrinking supplies in the swamps.

The subsistence technology is considered to account for the loss of microlithic component at a time economic growth is indicated by independent data. To accomplish this, manufacturing technologies of the Small Tool Tradition are traced from the Mid-Holocene settlement in order to identify possible adaptive advantages of the tradition. When this information is considered in light of an Early Holocene tool kit, which includes wooden and stone implements, the emergence of a microlithic component appears to reflect a major retooling to accommodate the introduction of the spearthrower and a redesigned

spear. The disappearance of the microliths is suggested to be related to attempts to increase hunting efficiencies following a period of regional stress in the environment. The marine economy is therefore seen as a final development in late prehistoric settlement of southeastern Australia.

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CHAPTER ONE

INTRODUCTION

The emerging picture of 18th century Aboriginal communities in coastal southeastern Australia reveals a remarkably successful adaptation to a marine setting. The first recorded observations of the settlement for instance (Cook, 1768-71), describe parties of women systematically combing beaches and reefs in search of the myriad shellfish, lobster, and fish which abound near the shore. With the use of a simple bark canoe capable of traversing short distances to offshore islands, Aborigines exploited the open sea as well as the more protected lagoons, bays, and river mouths for their daily fare. Perched on top of large accumulations of shells and other kitchen refuse near the water's edge, camps of small wooden huts and hearths marked the central focus of activities, giving testimony of a long cultural tradition in operation near the sea. Considered together with an informal census, the size of these camps suggests that late prehistoric populations reached comparatively high densities (Lawrence, 1971) which in certain localities may have equalled those in more productive subtropical settings to the north (Lourandos, 1977). This scenario of intensive use of seafoods described in New South Wales (Collins, 1798; Bradley, 1786-92), Victoria (Smyth, 1878), South Australia (Angas, 1847; Mountford, 1939; Edwards, 1972) and Tasmania (Labillardière, 1800; Péron, 1809; Robinson 1829-34 in Plomley, 1966) documents the capacity of prehistoric hunters and gatherers to maintain large, stable populations on a primary resource base over a wide area.

The purpose of the research described in this dissertation is to determine under what conditions this marine economy might have

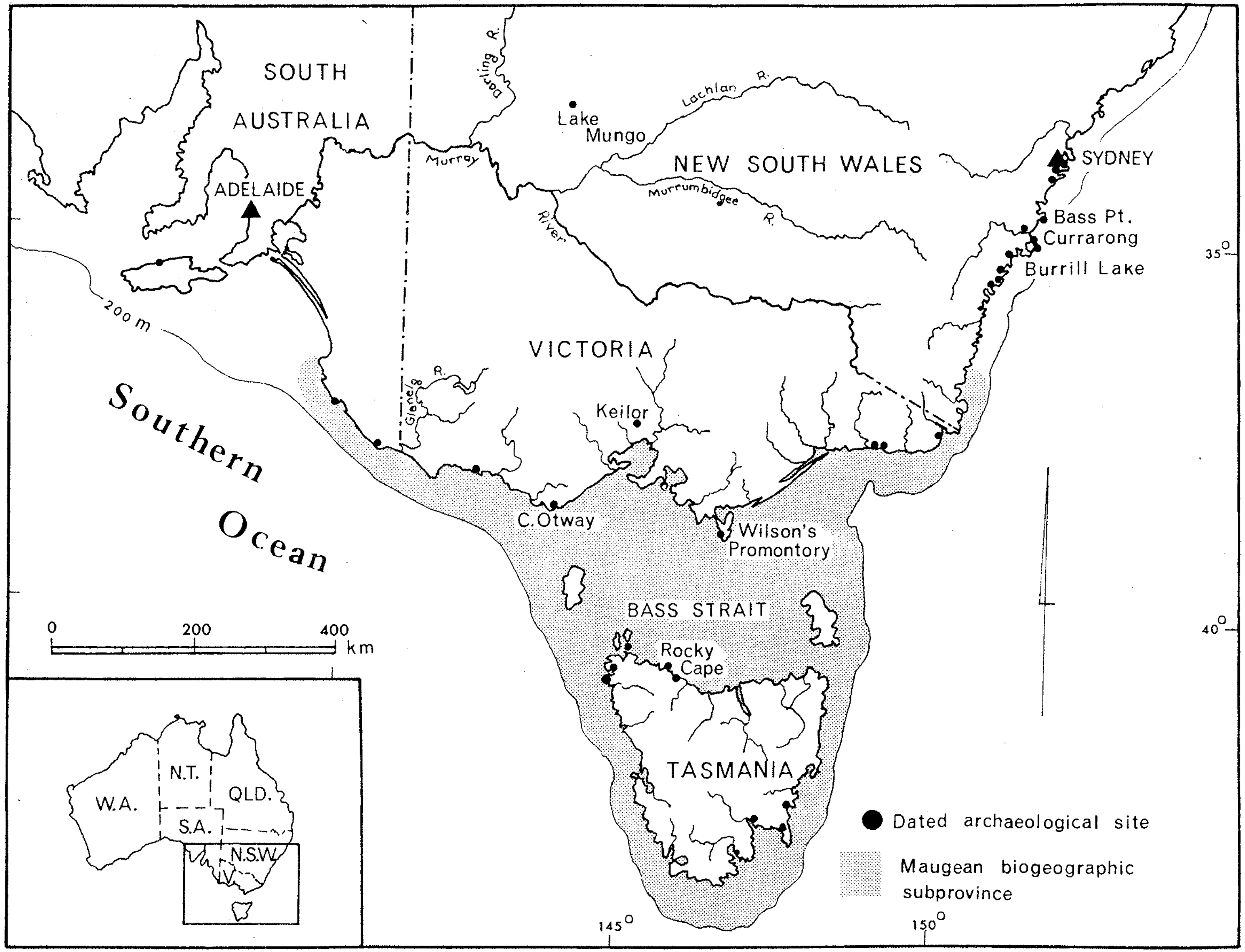


FIGURE 1.1 Map of South East Australia.

formed and, in doing so, to provide a time scale and explanation for its development. Past studies aimed at these objectives have relied almost exclusively on formal changes in stone tool assemblages to produce regional sequences for New South Wales (McCarthy, 1967) and scattered localities in Victoria and South Australia (Tindale, 1957a). Despite subsequent refinements in chronologies and later attention to the antiquity of critical dietary evidence, the implications these data have to adaptation remain unclear. Attempts to explain the underlying cultural significance of technological changes for example, are necessarily hampered by a limited understanding of the role of stone tools in the operation of local economies. Likewise, the emergence of a particular economic system is not necessarily revealed by the appearance of specific dietary remains. The difficulty with the existing interpretative frameworks is that the means of discovering when and how marine economies developed are not clearly discernible.

The issues to be confronted in improving this situation deal with the causes of and limitations to economic growth in prehistory. If it is assumed that changes in the physical environment or in the demographic structure of a region (Binford, 1968) are the causes for cultural disequilibrium, adaptation is seen as the process by which human populations react to these changes in order to maintain stable energy flow. The rate at which adaptation occurs will depend upon the magnitude and duration of these changes and the ability of the culture to respond through adjustments in population size, scheduling of subsistence activities, food collection techniques, and residence patterns, as well as in subsistence technologies. Of these mechanisms of adaptation, only the stone tools survive in quantity in the archaeological record, making recovery of the more definitive aspects of adaptation difficult to achieve. Partial resolution of this problem comes with the use of ethnographic information to establish the relationship between a specific Aboriginal population and its environment so that distinguishing characteristics may be identified archaeologically. A comparison of an Aboriginal settlement with its prehistoric antecedents will then reveal the nature of the adaptation and some of its causes. The first concern of such a study will then be the relationship between the environment and the economy.

As the ethnography reveals, the climate and physiography of the coastal belt in southeastern Australia has had a dominating influence on the shape of local economies. With wet, cool winters, and short, mild summers, marked seasonal changes give the region some of the most reliable rainfall and stable weather patterns in temperate Australia. Sweeping southwest into western Victoria close to the coast, the heavily forested Dividing Range confines oceanic moisture to the narrow coastal plain, making it the best watered ecosystem in southern Australia. A westward decline in surface runoff and estuary development beginning at Cape Otway is offset by the formation of vast swamp systems which maintain the aquatic character of the ecosystem as far west as Adelaide. The cold-adapted marine biota of the Maugean Biogeographic Subprovince, whose boundaries are shown in Figure 1.1, and which are centred around Tasmania and along the shores of Victoria, provide identical seafood menus on both sides of Bass Strait. In this fertile, temperate setting, it is reasonable to expect widespread similarities in subsistence activities to emerge despite uneven distribution of resources.

The coastal economy: its complex nature

The organization of late prehistoric coastal economies in this setting has only recently received attention. Employing ethnographic and ecological data ›iner (1976) has correlated broadly delimited seasonal movements of Aboriginal populations to the coastline with marked increases in the availability of certain plant and littoral resources on the central and south coast of New South Wales. The summer habitation is characterized by intensive use of a wide variety of resources with a more sedentary residency which may include co-operative interaction between neighbouring groups. Occupation dissipates inland in the leaner months of winter however, and groups revert to a nomadic way of life in response to waning supplies in the ecosystem generally. Archaeological evidence for the area (Lampert, 1971b; Bowdler, 1977) clearly indicates substantial use of non-littoral resources during occupation of the foreshore, a factor repeated in most archaeological records for the region.

Lourandos (1977) has described Aboriginal spatial organization and population density in southwest Victoria at the time of European settlement. The picture there is one of regionally co-ordinated seasonal movements of bands between the coast and inland, with a competitive hold over resources in both areas. Convincing archaeological and ethnographic sources from the district document communal management of eels or other aquatic animals through large networks of earthen channels (Lourandos, 1976) and boulder-lined canals (Coutts, Witter, and Parsons, 1977). The eel, whose life cycle normally involves the sea, may have been one of several factors involving inland groups in the acquisition of marine resources and permitting large Aboriginal populations to thrive in the area. This evidence suggests that comparatively sophisticated regional organizational strategies developed of which marine economies may have been only one. This situation raises questions about the reasons for such a development, which seems to implicate either modifications of the carrying capacity of the ecosystem or an increase in population in order for these habitats to have been so intensively exploited.

The Victorian evidence is matched in the lagoons and freshwater swamps of South Australia, within the same drainage system. Travelling the length of a vast swamp, Angas (1847) observed intricate networks of low mud weirs near the shallows for catching small fish. Similarly, natural outcroppings of stone were used in the tidal backwaters of the Coorong lagoon, south of the mouth of the Murray River (Tindale, 1974), and these were manned during both summer and winter months. In both of these instances, the use of nonportable technology appears to signify strong commitment to certain types of resources and a sedentary way of life.

A review of 19th century ethnographic literature shows that only certain elements of the portable tool kit were specifically adapted for exploitation of the littoral. One correspondent (Hill, in Smyth, 1878:417) in eastern Victoria for example, noted two types of canoes: a simple one for crossing streams, and a more solidly built craft for more extensive use in the sea. Photographs and drawings from the period (Edwards, 1972; Massola, 1971: front endpaper) depict canoes on the Murray River made out of single sheets of bark formed into shallow, flat bottomed basins. The same forms were common on quiet waters of the Coorong (Angas, 1847) and various creeks in Victoria (Smyth, 1878:409). By contrast, watercraft used in estuaries and the open sea on the eastern seaboard (and around the shores of Tasmania - Jones, 1977:325) were fashioned with an up-turned, tightly bound bow and stern, presumably to withstand wave battering and to achieve maneuverability. Despite the frail, simple construction of these crafts, Aborigines were able to move skillfully and effectively across protected waters in search of fish, and to visit nearby islands for eggs, seals and other littoral resources.

The extractive technology reflects an enormous ability to adjust design to a particular requirement by way of blending different materials into a composite tool. Fishing tackle in particular received careful attention (Smyth, 1878;390-1). Hooks made in bone, shell, or wood, were attached to lines for angling for bream, salmon, eels or other fish close to shore. Sharpened bone prongs lashed to heavy wooden spears were effective in fishing over the side of canoes or along the shores. The most common type of spear in general use appears to have been the reed spear (Angas, 1847, Edwards 1972:46), which consisted of a hardwood foreshaft and a short, lightweight mainshaft, joined by resinous gum. Together with the spearthrower, boomerangs and clubs, these tools provided a versatility enabling exploiting the full range of resources near the water's edge.

When compared to complete tool kits used by Aborigines living on rivers and around lakes however (Angas, 1847; Beveridge, 1889), coastal technologies were almost indistinguishable from them. Fishing spears, spearthrowers, nets, boomerangs, throwing sticks, and other extractive equipment were as commonly used in subsistence activities by inland populations around, say the Murray River, as by those on the coast itself. The only distinctive implements used exclusively on the coast appear to have been the fish hook in its various forms, and the specific design of the sea-going canoe. Under these circumstances, little hope can be offered for tracing a marine economy archaeologically on the basis of purely technological criteria, especially in view of the perishable character of its main elements. The near absence of specialized forms adapted for littoral exploitation seems to suggest that non-littoral resources persisted as a critical concern in the subsistence organization of coastal economies.

We have seen from this brief look at the adaptation that these were not seafaring people participating in an exclusively Maritime economy, but rather were land based hunter-gatherers employing comparatively, sophisticated strategies and simple technologies to manipulate their environment. Seafoods were collected in the main from close to the tide mark or from the adjacent margins of the littoral. Inland retreats figured strategically in the food quest and presumably a versatile tool kit capable of exploiting several ecological niches proved more advantageous than one designed for each niche individually. The articulation of the economic system with non-littoral exploitation must alert the archaeological investigator then to the need to measure in some way the contribution of resources from and organization of the inland subsistence activities. To see if it is possible to trace these technologies and organization backwards in time, we may consider the archaeological evidence for coastal settlements.

Survival of evidence for prehistoric diets

The refuse most commonly associated with marine exploitation is certain fishing equipment and food remains. The oldest firmly dated shellmiddens are thinly distributed deposits of molluscs and small quantities of bone, suggesting low occupation intensity. For Victoria, the oldest is at Wilson's Promontory with an antiquity of 6550BP (Coutts, 1970) for South Australia it is 5-6000BP (Campbell, Edwards, and Hossfeld, 1963), and for southern New South Wales the oldest middens are at Currarong 2, with an age of 3740BP (Lampert, 1971b), and at Bass Point, with an antiquity of 2975BP (Bowdler, 1976).

The overwhelming majority of shellmiddens throughout the region however are younger than 2000 years, and in a number of these a full range of littoral and terrestrial fauna are preserved. Organic artefacts have a similar history. The oldest bone point associated with fishing is reported from basal shell layers at Bass Point (Bowdler, 1976:254), while less convincing evidence for a fourth millennium BP point has been described for Currarong 2 (Lampert and Hughes, 1974:229). In reviewing the dated evidence for New South Wales, Lampert and Hughes (1974) conclude that shell fish-hooks are less than about 600 years old for that coastline, although a stone file used to make fishhooks occurs in second millennium BP deposits at Currarong 2. The direct evidence for intensive marine economies in coastal southeastern Australia then appears within the last 1000 years.

This time depth may be more apparent than real however. The acid soils of the eastern seaboard have long been suspected (Lampert, 1971b:68) of being corrosive agents in the destruction of organic remains. Ambrose (1969) has examined this question empirically by exposing shell carbonate in a number of Australian and New Guinea deposits (1973) under carefully controlled test conditions. Weight losses were noted in most samples and decay rates were calculated on the basis of an exposure time of about 500 days. Ambrose concluded from these results that shell may be expected to survive anywhere from a few centuries to over a thousand years, depending upon the soil chemistry and other local factors. Hence, dates on shellfish, bone and other perishable material provide a minimal estimate for the emergence of littoral exploitation in the region.

If the mainland evidence for the antiquity of marine economies is ambiguous on these grounds, the Tasmanian case provides a provocative comparison. There, in the northwest of the island, Jones (1971, 1975) has excavated three large shellmiddens in precambrian quartzite caves, each located within a hundred metres of the foreshore. The antiquity of each deposit is slightly different, but the pattern is the same: bones of a large number of seal, fish remains, lobster, and other prime littoral resources are mixed in a heavy matrix of molluscs mostly rocky coast gastropods. In basal layers at Rocky Cape South, dated to 8120BP, this rich sea shore faunal assemblage is so predominant that Jones concluded that the contents of the first meal eaten at the shelter were collected by hunter-gatherers fully dependent upon littoral resources. Although relative proportions of these seafoods change through time at Rocky Cape, the emphasis continued unchanged through nearly 6 metres of deposit into the last millennium. The picture is similar at the nearby Sister's Creek midden and at several other large occupation sites on the island (Jones, 1975). By comparison, the mainland evidence looks nothing like the Tasmanian, suggesting that the contrast may be more an issue of different cultural adaptations than of soil chemistries. If this is the case, mainland economies relied less on littoral resources than did the Tasmanian island one, and their condition in the ground may be a truer reflection of this than is generally recognized.

Stone tools: sequence, elaboration and explanations

Having survived the ravages of burial, stone tool assemblages are the mainstay of Australian cultural reconstruction. Hayden (1977) has reviewed technological developments across the southeast Asian region and concluded that trends towards specialisation and regionalism occurred despite differences in environment. Seeing the succession of core to flake to blade tools as an indication of a growing need to manufacture more working edges from stone, Hayden characterizes the trend as increases in efficiency of use of raw material, increases in the variety of tools towards specialisation, and an advance in the general level of economic complexity in the local environment. Because these technological developments suggest attempts to increase subsistence efficiencies over a wide area of Australia, and are not confined to coastal settings specifically, they must be considered from a regional point of view.

Basal Pleistocene technologies are characterized by massive tool size and a narrow range of formal types. Originally described at Lake Mungo and named the Australian Core Tool and Scraper Tradition (Bowler, Jones, Allen, and Thorne, 1970), the assemblage contains large horsehoof cores, steep edge scrapers, and a variety of smaller robust scrapers. Bone artefacts are known from Pleistocene Tasmania (Bowdler, 1974), New South Wales (Flood, 1973), and South Australia (Lampert, 1972). Many of the large implements are believed to have been used for heavy woodworking tasks such as planing, pounding, and debarking, while the tools with lower edge angles may have been knives or scrapers for preparing flesh or soft plant tissue. The only convincing evidence for hafting are edge ground axes (White, 1971) from the northern margins of the continent, and waisted blades from Kangaroo Island and the adjacent mainland (Lampert, 1976b). Despite these regional variations then, Pleistocene horizons at Keilor, Burrill Lake, Lake Mungo and many other locations across Australia indicate that by about 20,000BP, Aborigines had adapted to almost all major ecosystems (Jones, 1973) using a simple, effective tool kit.

Around 6000BP, a noticeable elaboration of tool types and increase in design complexity appeared in a number of settings, suggesting an attempt at a more effective manipulation of local environments. First described and labelled the Australian Small Tool Tradition by Gould (1969), the tool kit featured a variety of backed microliths, stone points, polished axes, an assortment of scrapers, and woodworking adzes. To this list must also be added the array of fishhooks, files, and sharpened bone spear points, all of which emerge late in the archaeological record. Tools known to have been hafted include the tula and elouera (Mulvaney, 1975), the polished axes (Binns and McBryde, 1972), and all the various forms of microliths (Mulvaney, 1975:228; McBryde, 1974, plate 62). Although evidence that the Pirri and Kimberly Points were hafted is ambiguous (Mulvaney, 1975:221), these unifacial, lanceolate forms could have been used effectively as either sharp edged knives or projectile points. Despite local variations in the composition of this assemblage, the tradition is widely regarded as a major technological development in Mid-Holocene deposits in South Australia (Tindale, 1957a; Mulvaney, 1975), New South Wales (McBryde, 1974; Lampert, 1971a; Stockton and Holland, 1974) and Victoria (Mulvaney, 1975). Composed predominantly of smaller elements, the Small Tool Tradition is seen as a comparatively rapid graft onto the older industry. The innovations associated with the Tradition appear to highlight substantial adjustments in land-man relationships and a developing capacity to exploit specific habitats more successfully.

As a special element in composite tool construction and a hallmark of the Small Tool Tradition, the backed microlithic component may have particular relevance to the extractive capabilities of marine economies. Seen as a single industrial tradition despite differences in form and qualitative attributes (Pearce, 1973), the component appears across the entire southern half of the continent (Mulvaney, 1975:225-6). This raises the question of its origins and adaptive advantages. Towards this end, Pearce (1974) has shown that the oldest microliths occur in New South Wales between 5-6000 years ago, suggesting an Australian rather than external derivation. Although this antiquity may be an anomaly due to stratigraphic intrusion (Stockton, 1977), by the early part of the fourth millennium BP, the component appears virtually unaltered in Western Australia (Gould, 1969), New South Wales (Lampert, 1971a), South Australia (Tindale, 1957a), and Victoria (Coutts, 1970). This rapid dispersal throughout all ecosystems, along with other cultural traits, suggests that similar requirements are being met which are not related to specific economies, but rather pertain to fundamental advantages not required by previous technologies. The problem then is that of determining the cause of the development and the nature of the advantages to local economies in which it appears.

This question has added significance for the events following adoption of the Small Tool Tradition. At some time during the last 1500 years in southeastern Australia, microliths and certain other stone implements lost their popularity and in some regions disappeared altogether. Investigations in Victoria, (Coutts, 1970; Mulvaney, 1966; Coutts and Witter, 1977) for example, have failed to recover microliths from a number of foreshore deposits younger than about 1290BP (at Wilson's Promontory), but further inland, geometric microliths were still in use at the time of European settlement (Coutts, Witter, and Parsons, 1977). A similar pattern has been reported (Lampert, 1971a & b; Mulvaney, 1975) in southern New South Wales, whereas the component continued until near the 18th century further north in coastal settings (McBryde, 1966). In conjunction with this apparent devolution in coastal tool kits, specialized organic implements, of the type mentioned in the ethnography above, made an appearance. These include the first evidence for specialized fishing gear, in particular fishhooks and fishing spears. Was there a connection between the transition of the tool kit and the development of the marine economies?

Mulvaney (1969) seems to be saying that there was such a connection and, accordingly, divided the last 6000 years into two periods. The first 5500 years, which he termed the Inventive Phase, saw the development and dispersal of the Small Tool Tradition. The most obvious accomplishment of this period was the development of new hafting techniques and hafted equipment which Mulvaney interpreted to mean greater efficiencies in the hunt and in tool manufacture. The last five centuries or so before European settlement was designated the Adaptive Phase in recognition of what Mulvaney considered shifts towards greater use of organic materials in tool construction, with shell and bone forms replacing lithic counterparts. The Adaptive Phase then marked the advent of specialized elements in the tool kit which heralded new rates of adaptation to local conditions. Although Mulvaney later withdrew the terms of his phase (1975:124), his was the first attempt to integrate developmental themes reflected in the Small Tool Tradition with the picture of intensive occupation portrayed in most ethnographies of the area.

Lampert (1971b) on the other hand considered that subsistence technologies in southern New South Wales and South Australia show a much less dramatic transition than that proposed by Mulvaney. Three phases were recognized. Phase I represented the period up to 6000BP and pertained to the Australian Core Tool and Scraper Tradition. Phase II correlated with the emergence of the Small Tool Tradition, of which the most distinctive element was the Bondi microlith;

while Phase III was the final 2000 years during which microliths declined or disappeared from the sequence. Lampert regarded the Small Tool Tradition as evidence of a major retooling of the existing tool kit, accompanied by strong differences in local rates of adaptation. The persistence of some Bondaian traits into Phase III and the addition of such implements as the fishhooks were seen as a continuation of improvements in the exploitation capacity of Aboriginal populations within the ecosystem generally. The elaboration of certain cultural traits then, rather than the apparent demise of only a few, was the theme that Lampert emphasized in man's adaptation to Holocene Australia.

Lampert and Hughes (1974) have provided the only explanation for the timetable and development of coastal adaptations. Referring to the southern coast of New South Wales, they correlated growth of the marine economy with expansion and development of additional littoral habitats during the Holocene. Unstable sedimentary conditions, immature aquatic communities, and low habitat diversity in littoral communities arising from the Early Holocene Marine Transgression were seen as constraints on the carrying capacity of the marine biosphere. After 6000BP when the sea reached its present level however, environmental stress eased around coastlines and marine biota were able more successfully to colonize a wider zone in newly formed lagoons and foreshores. In response to the greater productivity of the sea, coastal societies adopted a specialized fishing technology to permit more efficient and wider ranging exploitation of this biota, and Aboriginal population increased as a consequence. According to this argument, technological development resulted from an increase in the carrying capacity of the marine environment and not from population pressure, implying that specialization is a prerequisite of marine economies and, in particular of intensive exploitation.

Although current archaeological evidence for coastal adaptation differs in local details, a common theme can be described. Coastal adaptation occurred some time after the Mid-Holocene in southeastern Australia under the influence of the development of the Small Tool Tradition. Elaboration of the tool kit is seen not only as a prelude to changes in both population structure and intensity of exploitation, but as a prerequisite to adaptation. Nevertheless, the specific causes of technological specialization are fundamental issues related to economic growth and the conditions under which it occurs. Without explaining tool kit elaboration for example, Mulvaney used it to infer changes in rates of adaptation to local habitats. Lampert and Hughes likewise correlated improvements in the marine environment with specialization without considering why tools should become increasingly more complex simply because food supplies expand. The case for coastal adaptation therefore rests upon the assumption that technological complexity is required for intensive exploitation of littoral resources, ignoring the source of the pressure exerted on coastal communities to formulate means of intensively and systematically exploiting marine resources. Why did they do it in the first place?

The argument that growth of the marine economies is regulated by stress on the marine environment has not been adequately demonstrated on empirical grounds. If the rates of adaptation depend on improvements in the marine biosphere as Lampert and Hughes suggest, one would expect to find shellmiddens on the eastern seaboard of a Mid-Holocene age. The fact that most shellmiddens are no more than 2000 years old and that fishhooks are younger still, makes the case for a correlation between sea level adjustments and marine adaptations less than convincing. Furthermore, the emergence of a marine economy in Tasmania 2000 years before the sea reached its present level casts doubts upon the limiting effect geomorphologically immature coastlines have on the development of marine economies. If anything, the existing evidence for Southeast Australia suggests that marine economies emerge independently of sea level rise. The only positive correlation to emerge in this hypothesis therefore is that the Small Tool Tradition, ie. technological elaboration, is related to sea level stabilization, but that coastal adaptations per se may not be.

Bowdler (1977) has presented a radically different explanation for coastal adaptation based on the assumption that the original settlers made their way to the continent in boats. Being already disposed towards a coastal existence and confronting unfamiliar terrain and fauna, the colonists settled on the shores of northern Australia, subsisting on the prolific supply of seafoods available near the foreshore. As the population increased in time, the settlement expanded around the coastline of Australia and penetrated the interior of the continent via primary water courses. As evidence of this, Bowdler saw parallels between the prehistoric diets in evidence in coastal settings and those containing fish, molluscs, and marsupials in the 26,000 year old deposits at Lake Mungo, which at the time formed a part of the Murray River drainage system some 400 km inland. She considered this a genetic connection and suggested the inhabitants of Lake Mungo possessed a "transliterated" coastal economy (Bowdler, 1977:223).

Underlying Bowdler's proposition is the premise that cultural tradition is an unwavering determinant of rather than merely an influence upon the adaptation of man to his habitat. This viewpoint calls for the donor economic system in transition to give rise to a daughter system by a process of cloning, in which successive generations emerge as identical copies of the original. Hence, the original settlers are seen to lack adequate behavioural mechanisms to adjust to their new habitats in Australia throughout the period the continent was being colonized. This position ignores the fact that coastal resources generally and littoral sources specifically are highly variable in space and in time and that even the most specialised Maritime economies worldwide (Drucker, 1965; Shawcross, 1975; Luebbers, 1972; True, 1975) adjusted to this ecological reality. They did so by incorporating non-littoral exploitation in their economic strategies, and, as has been shown above for Australia, this generally meant seasonal withdrawal from the coastline. It is likely then, that the first Australians made this adjustment and could have resided near the sea without substantial dependence upon its resources.

The Tasmanian problem

The adaptive significance of technological elaboration in the development of marine economies has recently been questioned by Jones (1978) who has been considering the evidence in Tasmania. There, isolated from the technological innovations of the mainland for the last 10,000 years, the Tasmanian population reached levels comparable to those across the Strait by exploiting marine resources using one of the simplest tool kits known in Australia. It did not contain barbs or specialized elements, nor was hafting of any description known to have developed on the island. Jones reasonably regards this achievement as paradoxical since Tasmanian communities subsisted on an identical diet and in an environment similar to that on the mainland. Taking this argument from the point of view of Pleistocene Australia, White (1977) asserted that the Australian Core Tool and Scraper Tradition was sufficiently effective for exploitation of megafauna and therefore the subsequent increase in complexity of stone tools was functionally irrelevant in an utilitarian way. This proposition was founded on the notion that there is no necessary relationship between stone tool morphology and efficiency of energy harnessing, and it must be stressed here that White was looking at the issue through lithic assemblages only.

The issues central to these arguments are too complex to be fully considered in this introduction, but two points need to be raised against them. The first is that technology is not the sole agent responsible in the regulation of energy flow in society, but is one cultural response along with those broadly identified as organizational. The Tasmanian adaptation is not known well enough to dismiss the possibility that substantially different subsistence strategies succeeded in exceedingly fertile maritime environment of Tasmania where they could not or did not succeed in adjoining mainland marine economies. Indeed, the character and time depth of the shell-middens in Tasmania suggest that this might be the case. Furthermore, Jones' reconstruction (1977:322-3) of the Tasmanian annual food quest at the time of European settlement shows groups circumventing the island in search of food, which is a pattern markedly different to the annual retreat inland described on the mainland. It is therefore premature to employ Tasmanian analogies towards an understanding of technological development generally until it is understood on the island itself.

White's argument on the other hand overlooks the pressure exerted on human populations by shifts in the availability of resources and by human predation itself. It must be assumed that human population densities have fluctuated and generally increased since colonization, and that competitive interaction under these conditions is likely to selectively favour individuals or societies capable of modifying procurement efficiencies. To challenge then the adaptive significance of more elaborate stone tools is to ignore the possible advantages gained from design modifications in existing technologies to accomplish objectives which were previously either unobtainable or unnecessary. In Australia, these changes certainly involved the increased use of hafted, or more precisely, composite implements and this included organic materials. In this light, stone tool morphologies alone cannot adequately reflect the nature of the energy harnessing capacity of composite tools. Obviously the method of examining this problem is first to identify the function of each tool and its relationship to subsistence activities. Correlations might then be sought between increases in technological complexity, population density, and simultaneous changes in the physical environment.

The menu and the meal

The following research proposes to do exactly that. It will be assumed that the development of a marine economy will involve increased consumption of seafoods and that for this to occur, Aboriginal populations must increase in size, or prolong the duration of residency at the coastline, or do both. As a result of intensification of littoral exploitation, economic organization is expected to increase in complexity with subsistence activities diversifying as ecological niches come under greater systematic exploitation. A measure of this adaptation will be expressed in changing consumption rates of primary seafoods, and in shifts in seasonal residence patterns. The emergence of complex subsistence organization on the other hand will be seen in the spatial relationship of archaeological debris to principal resources, as well as in the extent to which resources are transported away from their point of origin. It will also be expected that increased pressure of predation on littoral biota may disturb the local ecology, and that adjustments in subsistence strategies are likely to reflect this. Therefore, the effects of predation on resources must be considered in light of recovery rates under which stocks are replenished and the extent to which food collection methods are able to intensify exploitation. Technological efficiencies then become an essential concern to this study along with the effectiveness of group organization to exploit or manipulate the environment. These relationships when seen against changes in the physical habitat provide the basis for understanding when and how marine economies emerge.

While dietary remains are commonly used to characterize prehistoric economies, the practice has serious drawbacks frequently overlooked by prehistorians. In the same way menus from fine restaurants show the selection of foods offered by the chef, so the diet alerts the archaeologist to the choice of food available and the nature of the local ecology in the past. Menus however, are merely itemizations of a wide range of ingredients which may or may not be chosen at any one time. They fail to reveal, for this reason, the extent of economic dependence on any one resource or the expenditure of energy made to acquire the foods actually consumed. Presumably, the resources available within a habitat will be consumed regardless of the extent of economic resourcefulness on the part of the Aboriginal inhabitants. Barring special restrictions then, coastal peoples doubtlessly exploited seal, shellfish, and birds, since these are comparatively abundant and easy to acquire along many shorelines. The existence of a marine economy is therefore not necessarily demonstrated by the mere presence of seafoods in menus, nor has adaptation occurred simply because of residence near the sea.

It is in fact through the meal and its contents that the character of the subsistence economy is revealed. The size of the meal may reflect the number of people dining, and the number of meals is an indication of the frequency with which certain foods were consumed. The contents of the meal divulge the ecological niches being exploited, and, with biometric data as a guide, the extent to which niches are being exploited can be assessed. As a single event, the meal contains information relating to the time of death of the marine animals consumed, which when examined in a number of meals may define a seasonal pattern of exploitation of seafoods. If the meal can be isolated archaeologically, a quantification of its ingredients can provide a measure of the character and growth of the marine economy. It is then the conjunction of the meal and the menu which allows the dynamics of subsistence activities to be examined in terms of the options available and the choices made.

The major problem arising from interpreting seafood meals in this way however, is that they relate to only one aspect of an economy which, according to all evidence, involved significant non-littoral exploitation as well. The physical residues of inland exploitation rarely provide definitive clues to their contribution to the marine economy and are furthermore difficult to articulate with any given economic system. One method of overcoming this difficulty is to define the duration of visitation at the foreshore and assume that the remaining residency was spent elsewhere. It is the rate of consumption as revealed by the number of meals, rather than the contribution made by specific foods which determines the duration of residency.

The remainder of this text is devoted to a presentation of the research into the problem of coastal adaptations in the southeastern district of South Australia. The archaeological record there is well preserved and is expected to reflect many of the formal changes described for adjoining states to the east in respect to diet, subsistence technologies, and culture history. Because adaptation is a local issue involving adjustments of people to their habitat, the first topic discussed will be the ecology of this well watered district, with an eye for its Holocene history. Next, the prehistoric inhabitants and their settlement organization will be examined for the purpose of understanding late prehistoric adaptations. Following this, the results of a survey of surface deposits will be used to establish a working hypothesis relating past use of the habitat to the problem of coastal adaptation. This information is then examined by excavation and the data acquired by this means is fully described. The results of analysis of the subsistence technology, diet, meals, seasonality of collection, and population changes are finally discussed. The discussion will now turn towards the landscape of the research area.

CHAPTER TWO

THE LAND, THE SEA, AND THE SWAMPS

When G.F. Angas travelled through the South East of South Australia by horseback in 1844, he confronted an awesome, unique country which he described on April 20:

> ... little bays and miniature harbours, were formed by the waters of the Coorong (lagoon), into which jutted out headlands and peninsulas, often crowned with rocky eminences, or descending in limestone cliffs abruptly to the water. Beneath, on the circling silvery sand that lined these smooth little bays, red-legged gulls, plovers and sand pipers were for ever busy in search of marine insects, or paddling in the gentle ripple of the mimic waves, ... numerous limestone rocks and small islands, the resort of pelicans and shags, were scattered here and there over the blue surface, and when the sun shone on them in the evening, and threw a rosy tinge over the opposite sand hills, it seemed a fairy scene of birds and solitude. Further on, ... the cheerless hills of the desert, covered with inhospitable scrub, tell of a dreary region, as they rise away towards the blue distance, where the eye sees nothing but one vast rocky wilderness. (Angas 1847:135)

Even today, the motorist following Angas' route along the Princess Highway south to Victoria, finds the South East a land of solitary, cold drama. Despite elaborate drainage canals, vast sheets of water can suddenly blanket lowlying grazing land after a heavy rain, as if in defiance of man's attempt at manipulation of the environment. The weather too can be at once comforting and hostile, but the visitor cannot escape the stark isolation winter brings as the swamps rise and the temperatures drop, nor miss the vitality of the life cycles contained within. It has always been an immense landscape filled with boundless resources shifting from place to place, and a natural setting for man. It is only reasonable then to consider the region's environment and its possible influence upon prehistoric settlement.

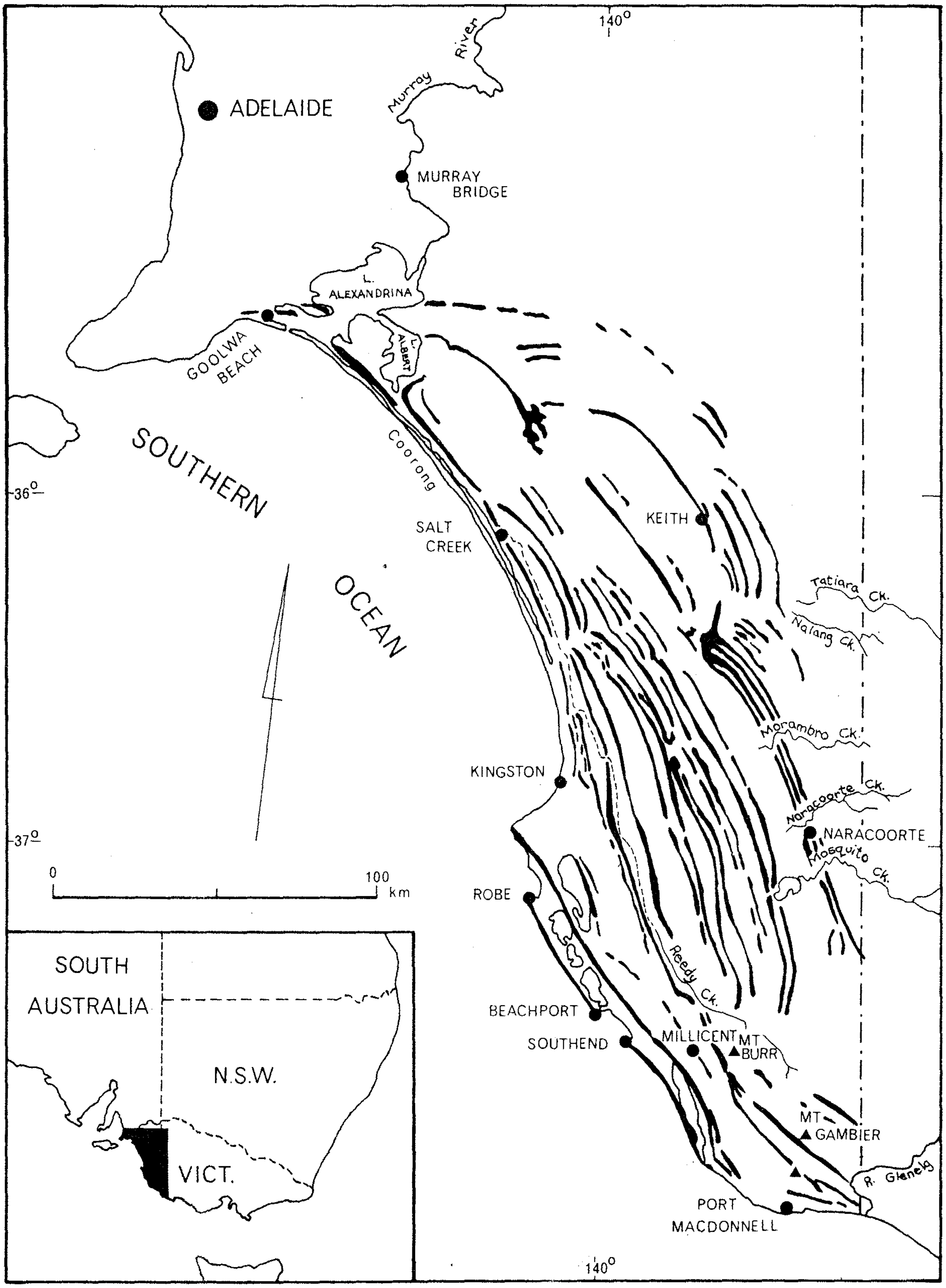


Figure 2.1 Map of Pleistocene dune ridges and coastline of the Lower South East of South Australia.

PHYSIOGRAPHY AND GEOLOGY

The South East Province, shown in Figure 2.1, is commonly divided into two districts; the Upper South East includes the area from Murray Bridge to Kingston, S.E., and east to the state border, while the remainder is known as the Lower South East. Together, these districts embrace about 15,400 square kilometers and share many features in common.

The area consists of a low subcoastal plain upon which marine processes have formed most prominent physiographic features. A remarkably well preserved series of subparallel aeolian dunes line the plain parallel to the coastline for a distance of 90 km inland and are the region's most distinctive landmarks. Low interdune flats, often under thick swamp growth, conduct surface runoff on a long, slow escape to the sea along a N.N.W. direction. The highest points in an otherwise flat terrain are volcanic peaks around Mt Burr and the Mt Gambier area, with elevations of 240 m and 190 m respectively. Within the coastal margin is a network of lagoons and swamps, the longest of which, known as the Coorong, is created by the backwaters of the River Murray. Remnants of tidal lagoons, now lakes and swamps, line the coastal margin south of Robe.

The area slopes gently seaward at a gradient of about one metre per 1.0 kilometres with elevations for the greater area rarely exceeding 50 metres. Figure 2.2 presents a typical altitudinal section. Interdune flatlands are invariably gently sloped, uncontoured surfaces of rich organic sediments formed under the influence of water.

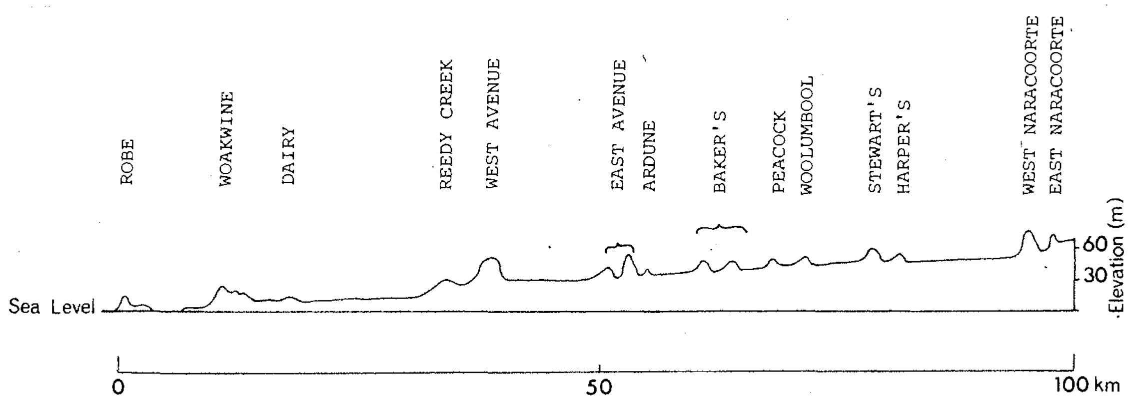


Figure 2.2 Altitudinal profile of region from Nora Creina Bay to Naracoorte. After Hossfeld (1950).

The region forms part of the Gambier Embayment of the Otway Basin centred in Victoria, and the Murray Basin of South Australia. The Embayment is an arcuate structure deposited on an elongate downwarp extending from the vicinity of Robe in a southeastern direction into the Otway Ranges of Victoria. Its main detrital components consist of igneous rock, feldspar and quartz which have limited surficial expression at two volcanic centres in the Lower South East. It is a distinct geological province separated from the Murray Basin by the shallow Padthaway horst which parallels the coastline northwest along the Coorong. The two structures are then stratigraphically unrelated until the Tertiary (Sprigg 1952), and for this reason, older events will not be considered in this discussion.

The structural geology and stratigraphy for the Province is known from numerous deep boreholes associated with oil exploration, seismic studies, magnetometer investigations and faunal correlations which have been summarized by Wopfner and Douglas (1971), Sprigg (1952), Firman (1973), and Parkin (1969). Major sediments are Upper Cretaceous and Cainozoic marine limestones exceeding 1200 m in thickness in the Embayment. These exhibit regional downwarping towards the Lofty Ranges away from the Mt Gambier volcanic region. In the opposite direction, downwarping from Mt Gambier into Victoria is apparent from altitudinal data (Sprigg 1952:36). Quaternary sediments formed under marine and estuarine conditions dominate the overlying sequence of mainly aeolian dunes and beach formations.

Firman (1973) describes the surficial geology for the Province and this information is presented in Figure 2.3 for the Gambier Embayment. Wedges of Gambier Limestone containing distinctive foraminifera extend into the Murray Basin and there are used to correlate stratigraphy between the two districts (Ludbrook 1969).

	OTWAY BASIN STRATIGRAPHY	DESCRIPTION
RECENT	Semaphone Sand	Loose coastal carbonate sediments; aeolian
	St Kilda Formation	Clay, colluvial
PLEISTOCENE	Bridgewater Formation Upper	Coarse-to medium-grained calcarenites, belonging to stranded dunes; aeolian
	Bridgewater Formation Lower	Relationship and extent unclear and variable
TERTIARY	Coomandook Formation	Fossiliferous sandy limestone; neritic-littoral
	Parilla Sand	Light grey, pale brown clayey quartz sand; fluvio-lacustrine
	Gambier Limestone (Miocene)	Bryozoal limestone, marls, and argillaceous limestones containing abundant flint bands, foraminifera, and molluscs.
	Knight Group	

Figure 2.3 Stratigraphy of sediments of the Lower South East. After Firman, 1973.

The marine sandy limestone of the Coomandook Formation overlies older Mt Gambier limestone at least as far northwest as Kingston, S.E., at the coast and strikes downwards beneath the seabed. The Bridgewater Formation, defined in Victoria (Boutakoff 1963) as calcareous dunes, in South Australia pertains to the series of subparallel aeolian dunes described above. Semaphore Sand has loosely consolidated following fixation of the Pleistocene dunes and contains abundant debris resulting from human habitation during its accumulation. The Bridgewater Formation is eroding from below tide mark from Guichen Bay to the Victorian border as prominent low cliffs lined by extensive platform reefs.

The dating of the recent aeolian dune series is uncertain. Tindale (1933: 1947) correlated the system with North American eustatic movements using accurate ground levelling data furnished from drainage records. Sprigg (1952) further considers correspondence with predictions of the Milankovitch Astronomical Theory (1938). Both have accepted, on the basis of stratigraphy and levelling data, that age increases from the coastline inland and that gentle uplift and tectonic movement are associated with formation. Blackburn, Bond, and Clarke (1965) conclude that progressively greater depths of profile development in soil also occur with distance from the coast and may be related to age. A number of radiocarbon dates exceeding 24,000 BP (Blackburn 1966) on extinct marine and estuarine molluscs from the flats behind the Woakwine Range are believed to mark one of several Late Pleistocene transgressions. In any event, radiocarbon dates associated with the human exploitation of a Holocene lagoon require a great antiquity for all stabilized aeolian dunes in the area.

The formation of travertinous soil profiles and rapid vegetation colonization have been responsible for consolidation of the dunes, especially in the Mt Gambier area. Despite this crustal cover however, water and wind have eroded calcarenite around the closed lakes between Beachport and Robe, producing overhangs and cavities suitable for human habitation. These features seem to have formed only on the seaward side of the lagoon and many contain occupation debris. Otherwise, protected shelters in weathered calcarenite are rare, probably due to frequent collapse of the exposed faces. An exception occasionally arises at foreshore localities as seacaves, and in the form of sinkholes common throughout the Mt Gambier district.

Extensive deposits of flint, eroded from the Gambier Limestone, strew the beaches south of Cape Banks and are known from older beachlines in more weathered states further inland. Coloration ranges from blue black to caramel, and usually each beach contains flints of similar colour. Willington (1956) has described some of these deposits. The nodules range in weight from a fraction of a kilogram to several kilograms and are occasionally irregular in shape, although always rounded and smoothed by water action. Some shingle beaches at the current seafront are too weathered to provide suitable material for tools.

Nodules and veins of flint also occur in sinkholes and underground solution caves in the Mt Burr Peninsula, where clear evidence of Aboriginal quarrying may be seen. Quarried flints exhibit a wide range of colour including oranges, browns and greens in distinctive banded or mottled patterning. Unlike worn, rounded beach cobbles which have lost much of their cortex, flint quarried from veins retains a deeper cortex and may display greater angularity in its surface contour. In these ways, the two sources of flint can often be distinguished in the field.

Two periods of volcanic activity have been identified for the Lower South East. The earliest occurred during the Pliocene and Early Pleistocene and is believed to be related to the formation of basalt plains in Western Victoria (Hills 1940) which resulted in the emergence of the Mt Burr Peninsula near Millicent. Sprigg (1952) has identified sixteen eruptions along fissure lines extending across the state border. Eruptions were followed by microporphyritic olivine basalt flows which have been subsequently covered by aeolian deposits. Ash, tuff, and agglomerate are common to many cones, and most exposures of volcanic material indicate that vitrification is complete. Mt Burr at 260 m and Mt McIntyre at 200 m above MSL are the two highest peaks in the Province.

The second period of volcanism occurred at Mt Gambier and Mt Schank during the Holocene. Radiocarbon dates on plant remains buried by ash place the eruptions at 4830 BP and 1410 BP (Blackburn 1966). Aboriginal legend is believed to record this volcanism (Hossfeld 1950). Sprigg (1959) has described submarine lava flows located about 12 km from Beachport and has speculated upon their relationship to Holocene volcanism.

Despite the general notion of tectonic stability for Australia as a whole, the Lower South East has experienced two known earth tremors. The first disturbance occurred on May 10, 1897, and the second on 8th of April, 1948. Both quakes are believed to be centred off the coast of Beachport and were felt 150 km away. An eye-witness to the earlier quake has related escaping "two feet of water over the floor boards of the diningroom" as water swept across the flats near Robe (Bermingham 1972, pers. comm.).

CLIMATE

The Province receives its precipitation from anticyclonic airmasses which move in an easterly direction across the southern part of the Continent at an average speed of 800 km/day (Specht 1972). North/South migration of the centre of these masses results in longer winters and shorter summers. Over 70 percent of the precipitation falls in the province between the six months of April to October, with less than 20 percent variability from the mean annual rainfall (Specht 1972:41). The annual mean fall for the area is 600 mm, but pronounced heavy falls exceeding 890 mm/yr occur within the volcanic hills at Mounts Burr and McIntyre. The measured precipitation-to-calculated evaporation ratio for the Lower South East exceeds 1.0 between April and October, is between 0.5 and 1.0 in November, and is less than 0.5 for the remaining four summer months. Rainfall distribution for the southern parts of the Province is presented in Figure 2.4.

Table 2.1 lists climatic data for four recording stations in the Lower South East, calculated from measurements published by the Bureau of Meteorology (1956) and compiled in this form by Dodson (1975a). Explanatory notes are as follows:

Line 1	average daily maximum temperature (^{o}C)
Line 2	average daily minimum temperature (^{o}C)
Line 3	average daily mean temperature (^{o}C)
Line 4	average index of mean relative humidity (percentage of saturation)
Line 5	average monthly and yearly rainfall (mm)

From the above information, it can be seen that a south to north decline in rainfall occurs, the lowest appearing at Keith (425 mm; see Fig. 2.1). Higher precipitation around Mt Burr, and presumably Mt Gambier, are due to orographic effects. Frosts have occasionally been recorded and snow has fallen at least once in the past 20 years. Strong winds are prevalent year round for considerable distances inland. In brief, the climate of the Lower South East is characterized by wet, cool winters and mild, dry summers.

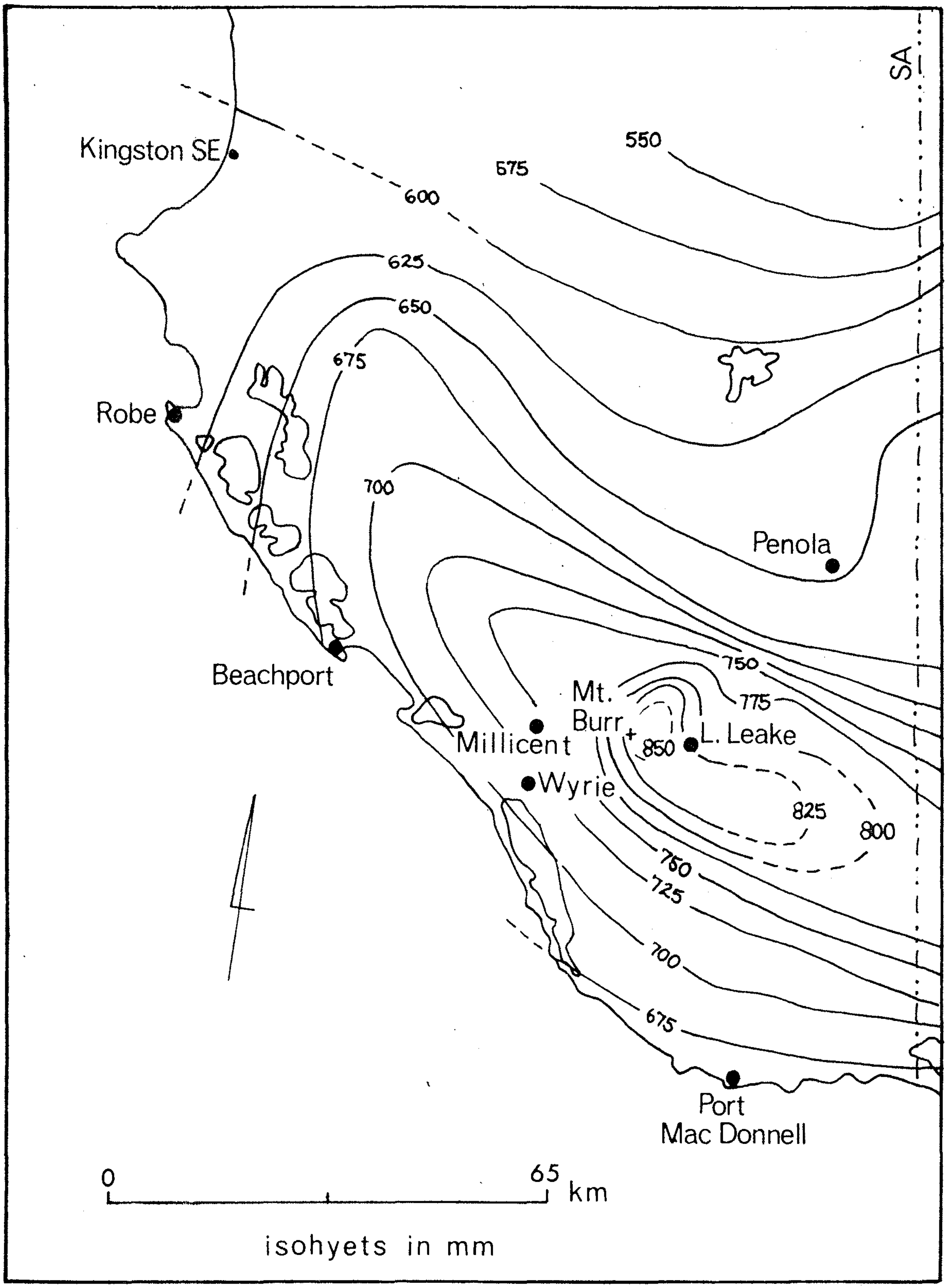


FIGURE 2.4 Rainfall distribution for the Lower South East, South Australia.

TABLE 2.1

Climatic data for centres in the Lower South East

Line No.	Years	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Year
CAPE NORTHUMBERLAND 38° 05'S 140°E 38 m MSL														
1	30	20.8	21.1	20.3	18.2	16.1	13.9	13.5	13.9	15.5	17.2	18.1	19.7	17.4
2	30	13.1	13.8	12.8	11.1	9.4	7.6	7.0	7.3	8.4	9.5	10.8	12.2	50.3
3	30	17.0	17.4	16.5	14.7	12.7	10.9	10.3	10.9	12.0	13.3	14.4	16.0	13.7
4	30	73	74	75	78	80	80	80	80	79	77	77	76	77
5	30	21.5	31.3	27.2	54.1	83.2	91.7	102.3	93.5	68.1	47.7	36.6	38.6	694.8
MOUNT BURR 37° 33'S 140°S 24'E 64 m MSL														
1	11	23.4	23.0	22.0	18.5	15.6	13.5	12.8	13.9	15.8	17.0	19.0	22.5	18.1
2	11	10.9	11.2	10.6	8.6	7.7	5.4	5.2	5.0	6.3	7.1	8.7	10.5	8.1
3	11	14.6	14.7	14.8	14.1	13.5	13.5	13.6	13.4	14.3	14.2	14.2	14.6	14.1
4	11	63	64	67	73	83	82	84	81	77	76	74	63	73
5	11	34.8	37.1	35.6	67.1	83.1	92.2	112.1	95.6	80.0	65.1	44.0	38.9	785.6
MOUNT GAMBIER 37° 50'S 140° 50'E 42 m MSL														
1	30	23.5	24.4	22.4	19.2	16.4	13.9	13.5	14.5	16.2	18.3	20.2	22.2	18.7
2	30	12.0	12.6	22.6	9.7	9.1	6.4	5.9	6.2	7.3	8.3	9.7	11.1	9.1
3	30	17.7	18.5	17.0	14.4	12.2	10.2	9.6	10.3	11.8	13.3	14.9	16.7	13.9
4	73	65	65	70	76	80	81	79	79	77	74	71	67	73
5	30	23.6	31.0	29.7	54.4	73.7	90.2	88.7	87.5	74.0	53.4	39.6	36.8	682.6
ROBE 37° 10'S 139° 45'E 6 m MSL														
1	65	22.2	22.4	20.9	18.5	16.1	14.1	13.3	14.0	15.4	17.3	19.3	21.2	18.0
2	65	13.5	13.6	12.6	11.5	10.2	8.7	8.1	8.5	9.3	10.3	11.5	12.6	10.9
3	65	17.9	18.1	16.8	14.9	13.2	11.4	10.8	11.2	12.4	13.7	15.4	17.2	14.4
4	59	67	69	72	76	79	82	81	79	78	74	71	68	74
5	30	18.8	24.4	21.1	41.4	75.8	102.0	97.4	79.8	59.5	42.4	27.2	32.8	622.6

HYDROLOGY

Accounts of European settlement of the South East in the 19th century tell of man's struggle to exploit the fertility of the district and reveal the magnitude of the aquatic character of the environment. A life-long resident remembers that seasonal downpours caused such extensive local inundation that families could be isolated for days or even months whenever winter falls were especially long (Barrowman, pers. comm.). Travel was so interrupted by this pattern that surveyed and sign-posted trails were required before regular southward communication links could be established (Tolmer 1847). These trails, which sometimes followed those of Aboriginal travellers, traced the ridges and passed stations which today bear the designation "Island". The particular alignment of the ancient dunes parallel to the coastline meant that travel to inland destinations either was scheduled to coincide with dry periods or followed circuitous routes to avoid the swamps. This was especially true nearest the coastal tract, where permanent water stood against the Woakwine Range. This situation will be described in greater detail below.

In 1865, the first drain was cut through the Woakwine Range to relieve waters backed up against the Narrow Neck overlooking Lake Frome. A newspaper report describes the scene:

> It has long been known that the ridge of land, of which the Narrow Neck forms a portion, has been the means of damming back the surface water of an immense extent of land. Owing to this barrier being in the way the water accumulates to a great depth and floods many hundreds of square miles of country, and eventually the back-water works its way up towards Lacepede Bay (Kingston). (*The South Eastern Times*, May 5, 1864; as quoted from Richards and Towers, 1974)

Once the 6 m wide, one metre deep channel was completed in 1865, the water flowed into Lake Frome at 10 km/h.

Today, a highly articulated network of drains conducts surface waters from great distances inland, directing them straight through the dune ranges to Lake Bonney or elsewhere on the coastal margin. Their construction has relied upon accurate ground surveys throughout the district, providing levelling data for every interdune corridor. More recent work by the South Australian Geodetic Survey has related the local Mean Sea Level used in earlier surveys with the Australian Height Datum. The previous datum is found to be in the order of .50 m above the AHD as measured from a limited number of points (B. Randle, pers. comm.).

The hydrology of the South East has been described by Ward (1941) and Solomon (1952) and the following discussion draws upon their work. Regional physiography, underlying limestones, and high precipitation-to-evaporation rates play important roles in the regional hydrology. A cavernous karst topography conducts immense volumes of water underground, emptying either into the sea or onto the corridors. The discharge of two conduits, Eight Mile Creek and Ewen Ponds, flows into the sea. Their combined output, measured in 1939, was 390 x 10^6 litre/day (Ward 1941). The South Australian Department of Mines estimates that about 100 x 10^6 m^3/year (260 x 10^8 gallons/year or 100 x 10^9 litres/year) enters the sea between Cape Northumberland and Cape Banks at present. These rates are likely to be influenced by the area's thirsty pine plantations, which were absent last century.

Smaller springs occur in numerous localities below the Mt Burr Peninsula and are known to have disgorged millions of gallons per day. Many of the smaller ones are identified locally as "native wells".

The only significant water courses in the Province are Mosquito, Naracoorte, Morambro and Reedy Creeks of the Naracoorte Plain (see Figure 2.1). Reedy Creek formed the major conduit to the sea through a winding passage along the dune by that name. According to Woods (1862), Dismal Swamp developed a current for two months of the year, flowing towards the Glenelg River. Other sources of flow into the coastal margin are described in early survey sketches and this information is discussed below in detail. Bayly and Williams (1966) and Dodson (1975a) consider that lakes formed in the volcanic area of Mt Burr are the accumulation of local catchment, whereas those at Mt Gambier and Mt Schank expose the regional water table.

It is worth noting the presence of stranded dunes overlying the impervious volcanic detritus of Mt Burr and its adjacent slopes. These effectively conduct large quantities of surface water underground to the foot of the slopes. The effect of this is to concentrate water from the highest rainfall area into the swamplands with a minimum of loss.

The South Eastern Drainage Board has summarized groundwater behaviour as follows (Sprigg 1952):

1. There is movement of groundwater from the western portion of Victoria into South Australia.

2. The highest flow occurs in late winter (September), and the lowest occurs at the close of summer (April).

3. A lag in the change of groundwater compared with rainfall occurs as a result of the westward migration into the area.

4. A convergence of groundwater around the volcanic highlands is experienced, causing steeper gradients in the groundwater table to occur locally.

5. Abnormally heavy rains have a marked effect on the water table.

VEGETATION

The flora of the Lower South East belongs to part of the Temperate Floristic Zone of Australia (Burbidge 1960) and consists mainly of savannah woodland and heath lands. Close affinities can be drawn with neighbouring communities in Western Victoria in similar climatic conditions. In the face of rapid drainage and land clearance in the 19th century, the original composition and ecology of plant communities have disappeared almost completely (Dodson 1975a) and only a generalised description of pre-European conditions can be offered.

Inquiries into the area's botany were made soon after settlement by Baron Von Meuller (n.d.) and Woods (1862), and later studied more systematically by Black (1943) and Wood (1937). In 1943, Eardley described a coastal fen formation at Eight Mile

Creek near Cape Northumberland. It was not until 1944 (Crocker) that the relationships between soil and vegetation in the district were examined comprehensively. Since then, Welbourne and Lange (1968) have distinguished four main vegetation groups on the dune ranges according to association with other species, but stress the need for further study to determine their correlation with soil formation. Ecological relationships in South Australian plant communities and relevant nomenclature have been defined (Specht 1972) and are used in this discussion. Dodson and Wilson (1975) have described the modern vegetation on the Mt Burr Peninsula, and Dodson (1975b) has reconstructed the nature of plant cover for the area around Mt Gambier at the time of European settlement on the basis of pollen analysis. Only a summary of this information is presented here.

The Coastal Complex of the modern dunes at the coastline has not been fully described, but a general picture can be compiled from personal observation and Specht (1972). The use of the asterisk (*) with the common name denotes plants known to be consumed by Aborigines (Campbell, Cleland, and Hossfeld 1946; Cleland 1957). Most associations are influenced by the harsh conditions of salt spray and migrating sand. Consequently the cover is open, growth is stunted, and distributions are likely to be variable. The most common plants at the foreshore include Atriplex cinerea (Saltbush), Spinofex hirsutus (Hairy Spinofex), Salsola kaki (Saltwort), and Cakile spp. (Sea-rocket). Behind the foreshore, Lepidosperma gladiatum (Sword Rush), the succulent Carpobrotus aequilaterus (Pigface)*, and the fruit-bearing Kunzea pomifera (Muntries)* are abundant where soil nutrients accumulate. Still further away, Solanum aviculare (Kangaroo Apple)*, and Sambucus gaudichaudianna (Native Elder)* are found close to the lagoons and lakes between the sandhills and the Ranges. Acacia ligulata (Umbrella Bush)* is sparse in the same area. In the Lake Robe vicinity, Melaleuca halmaturorum (Salt Water Tea-Tree)* circles the brackish lakes, while the Mallee association of Eucalyptus diversifolia is present in isolated pockets. The Low Woodland formation, Casuarina stricta (Drooping Sheoak)* - Melaleuca lanceolata is sparse near the coast at Cape Banks but may have been almost impenetrable to within one kilometre of the cliffs last century. The association Leucopogon parviflorus (Native Currant)* -

Olearia axillaris is well represented in the southern portion of the district as well, along with the Umbrella Bush. Of the plants consumed by Aborigines, the bulrush, muntries, the kangaroo apple, Pigface, the umbrella bush, and the native currant are abundant even today.

Further inland, the *Casuarina stricta*-*Melaleuca lanceolata* association occurs northward along the Woakwine Range, mixing with *E. diversifolia* scrubland communities which dominate the Upper South East at similar positions to the sea. Open heathlands of *Xanthorrhoea australis* (Grasstree) - Hakea rostrata (Needle Bush)* are presently interspersed in this northern region with sand heathlands of *Xanthorrhoea australis*-*Banksia ornata* of the Upper South East. The first description recorded of the area between Kingston and Robe depicts dense foliage of *Casuarina* and *Banksia* (Honeysuckle)* stretching to Rivoli Bay 20 km away (Angas 1847:150).

The main forest formation for the study area is *Eucalyptus baxteri* and its associations, which dominate the dune Ranges. It occurs on the Reedy Creek, Avenue, and portions of the Woolumbool Ranges, and is taken over north of Robe by *E. diversifolia* scrub land. On dry and shallow podzols it forms pure stands while on normal podzols it occurs with *E. obliqua*.

Savannah woodlands of *Eucalyptus camaldulensis* (River Red Gum) are the dominant tree cover north of Mt Gambier beyond Penola. The association thrives well on the meadow podzols of the Kalangadoo Sands, which are naturally flooded in the winter.

Low woodland stands of *E. baxteri* and the low open-forest formation, *E. ovata* fill the main canopy of the uncleared portions of the Mt Burr peninsula. In about 1880, clearing in this area began for the planting of *Pinus radiata* and *P. pinaster* forests, and today these cover most of the volcanic highland. Heath species of *Leptospermum juniperimum*, *Xanthorrhoea australis*, *Banksia marginata*, *Acacia oxycedrus* are among the most common under more open conditions. The underscrub contains *Gahnia rudula*, and *Lepidosperma laterale* in the open forest formation, and at its margin, *E. viminalis*, *Leptospermum juniperinum*, *Acacia melanoxylon* and *Acacia verticillata* may occur as emergents (Dodson and Wilson 1975). Many undrained swamps appear in the area and two of these have been described in detail (Dodson and Wilson 1975). Pine plantations have replaced original vegetation east of Mt Gambier into Victoria, and these consume inc[illegible] amounts of water.

Tussock grasslands, Gahnia trifida-G. filum, are common throughout most of the interdune corridors in association with groundwater rendzinas. Banksia spp. may occur in number, and wet habitat species are abundant today. In many areas close to the Woakwine Range, the absence of drainage has lead to the accumulation of peat or peaty deposits occasionally exceeding 2 m in thickness. The installation of the drainage network has destroyed the original ecology of these lowlands and its not possible to provide details of their original cover.

PALAEOBOTANY

In 1972, John Dodson expanded his efforts, begun in Western Victoria (1974a), to reconstruct the Late Quaternary vegetation history of the area by studying the sediments of five South Australian deposits. Enrolled in a PhD programme in the Department of Biogeography and Geomorphology (Research School of Pacific Studies), he developed his research in conjunction with the archaeological investigation of the Lower South East and in particular set out to describe the palaeo-environment of Wyrie Swamp in relation to its prehistoric occupation (1975a). The results of that study, when combined with vegetation histories from other deposits (Dodson 1974b; 1975b), provide an independent basis for understanding prehistoric settlement of the swamps for the entire Holocene. A brief summary of this information will now be presented.

The sediments examined by Dodson are situated in two distinct hydrological regimes which represent the full cross-section of local water catchment. The first is the high rainfall area of the Mt Burr Peninsula and includes the sites of Blue Tea-Tree and Mt Burr Swamps (known collectively as Marshes Swamp), and Lake Leake. The second group is nestled against the Woakwine Range in the peatfields south of Millicent and includes Wyrie Swamp and Pompoon Swamp 800 m away. Water in these swamps is derived from a vast area including the volcanic highlands, and it is reasonable to expect sediments in the two regimes to reflect regional vegetation histories. Figure 2.4 shows the location of each area. They will be considered separately.

Marshes Swamp contains peat or peaty sediments 2.5 to 3.3 m thick in a basin spreading across one half of a square kilometre, and forms a part of a still larger marshy area. Local catchment appears to be the only source of water, and large seasonal variation in water stand has been recorded in historic times. Lake Leake is in a volcanic crater and receives its water from the steep slopes of the crater. Its organic sediments are more than 7 m thick and present a record of alternating dry and wet periods spanning the period 30,000 BP to the Present.

Wyrie Swamp also contains over 7 m of sediments and likewise represents accumulation during alternating wet and dry periods beginning more than 30,000 years ago. Buried in basal peat layers dated to the Early Holocene is a remarkable assortment of wooden spears, boomerangs, and digging sticks, and these appear to be associated with other shoreline camping debris. The discovery of this evidence has made it possible to relate archaeological data of swampside exploitation to the larger question of coastal adaptation during the Holocene. Pleistocene sediments will not be discussed at this time. One kilometre away, at Pompoon Swamp, a single basal peat sample has been dated and the pollen sequence from the open peatfield has not been analysed. In the 1950s, a fire in Wyrie Swamp destroyed most of the final 7000 years of organic sediments, but Pompoon Swamp seems to have escaped damage.

Table 2.2 itemises relevant radiocarbon ages derived from peat samples collected from each deposit's Holocene history. Sample number ANU-1017 from Lake Leake was collected in an outlying lagoon basin whereas others in the sequence were taken from the lake itself. Details of techniques employed, stratigraphy and chronology, and pollen analysis for Marshes Swamp appear in Dodson, 1975b, and for Lake Leake in Dodson, 1974a. Results of the climatic reconstruction at Wyrie Swamp appear in Dodson, 1975a.

Radiocarbon Sample No.	Depth from surface (cm)	Age in years B.P.
	Lake Leake	
ANU-1016	420-425	8350±100
ANU-1017	400-405	9470±120
ANU-1142	365-370	7860±110
ANU-1143	255-260	2960±80
ANU-1144	170-175	2030±160
ANU-1145	80-85	1360±140
	Mt Burr	
ANU-1018	315-320	7460±100
ANU-1157	215-225	7160±70
ANU-1158	85-90	5240±100
	Blue Tea-Tree Swamp	
ANU-1159	240-245	8620±100
	Wyrie Swamp	
ANU-1159		10,200±150
ANU-1192a		9010±120
ANU-1306		7280±100
	Pompoon Swamp	
ANU-1343		9520±120

Table 2.2 Holocene Chronology from Five Fossil Pollen Sites examined by Dodson.

Generalised conclusions reached by Dodson (Dodson 1975a:273) indicate climatic changes have occurred in the research area during human occupation; these are listed below.

26,000 BP - 11,000 BP	Cold and arid with sparse open vegetation. Driest period in the last 50,000 radiocarbon years.
11,000 BP - 8,000 BP	Conditions approach that of today.
8,000 BP - 3,000 BP	Wetter than today and any time in the last 50,000 years.

3,000 BP -	60 BP	Climate similar to today with small fluctuations in temperature probably controlling hydrology. Driest about 2000 BP and at 500 BP.
60 BP - Present		Similar to today.

The question of Late Quaternary climates has been considered recently (Bowler, Hope, Jennings, Singh, and Walker 1976) in conjunction with evidence amassed across the continent, including Dodson's. In Southern Australia, the Holocene pattern described above is shared by several independently studied sites in Victoria, New South Wales, and Western Australia. In particular, lacustrine and vegetation data from Lakes Keilambete and Gnotuk, and from Wilsons Promontory indicate that from 7500 until 5000 BP, relatively humid conditions prevailed in the region. From the point of view of the historic description of the Lower South East, and sensitivity to climatic control of the local hydrology, the consequences of these Holocene climatic changes will strongly bear upon the stability of local biota and its biogeography.

SOILS

Soils in the study area were first described and related to vegetation in 1944 (Crocker), whereas more recent work has been aimed at detailed classification of soils (Blackburn 1959;1964). Soils developed in association with the Pleistocene dune ranges have been divided into four main groups (Blackburn, Bond, and Clarke 1965). These are from estuarine and lacustrine deposits (groundwater rendzina and solodized solonetz). Local variation in each of these soil types occurs in the area in accordance with moisture regime, biological agents, parent material, and time interval for soil formation. In addition erosion, deflation, and reworking of sediments at various times in the past imposes a necessary constraint upon the use of soil formation time as an indicator of absolute antiquity of the soil and its contents. Nevertheless, a relative chronology derived from general soil stratigraphy can be useful in an archaeological framework and for this reason a description of the soil groups follows.

The podzols are all deep sandy soils in which the iron-organic B horizon is highly sandy. Their low acidity is believed to have resulted from small amounts of wind-borne calcium carbonate or underlying limestone recirculation associated with biological activity. Organic material is lower than for most podzols and this feature is consistant with heavy leaching imposed by the humid conditions of the area. Podzols are not known to occur on the seaward faces of the Woakwine, Reedy Creek, or Dairy Ranges, but rather are widespread further inland.

The terra rossa soils, which are the most common type in the study area, are derived from carbonate parent material and possess a uniform red, earthy colour. On the Pleistocene dunes, the typical profile involves a distinct lower boundary on a secondary carbonate, or kunkar layer, which in turn overlies a soft, uncemented calcareous sand showing separate shell fragments and quartz grains. Thickness is highly variable within the same locale, ranging from a few centimetres to a few metres. The terra rossa is derived from calcareous beach sands and also influenced by aeolian accessions of fine material, apparently from estuarine or lacustrine sediments. These impart a sticky quality in the presence of excessive water.

Solution pipes, often to depths of 3 m, are common features of the soil overlying limestone in the Mt Gambier district. Terra rossa is exposed extensively along the Robe and Woakwine Ranges, although it is particularly thin nearest the sea, presumably due to removal by wind blasting and water action. The charred remains of tree stumps and branches, charcoal, marine molluscs, and stone tools can be found on the surface of the soil, and in certain instances are buried in it. In almost every case I have witnessed, tools retrieved from the soil bear the red staining, and in many instances appear to have been chemically altered such that the flint crumbles like chalk. In fewer instances, certain flint tools included in the soil surface retain pale colouration and display less staining. This inconsistency in staining, plus the inclusion of foreign objects in the soil underscores the possibility of mixture between unrelated material.

Groundwater rendzinas are formed from limestone parent material under conditions of imperfect drainage. They occur throughout the length of the interdune corridors of Reedy Creek, the Avenues, and other ranges further inland, and in each case display considerable variation in thickness and morphology. The greatest spread, usually with neutral-to-slightly acid clay above limestone or marl and showing yellow staining of the limestone, is noticeable south of the Millicent area. Excess sodium chloride accumulation is common.

The solodized solonetz soils are most common east and inland from the Naracoorte Range in varying alkalinities and salinities. They are rare on the Kingston-Millicent plain and do not occur on the Woakwine Range.

The peats of the district are formed under conditions of impeded drainage and are derived from the debris of sedentary plant communities. Drain channels expose extensive peat fields close to the Woakwine Range from the vicinity of Benara Creek at the southern end of Lake Bonney (see Figure 2.5) to Kingston and again in swamps of the volcanic highlands. Thickness often exceeds 2 metres south of the town of Millicent. Peat also occurs in thin layers near the shallows of Lake Frome (McCourt, pers. comm.), behind the beach ridges of Guichen Bay, and at depth in Lake Hawdon (Dodson, pers. comm.). Submarine peat has been located in Robe Harbour (Sprigg 1952).

A nutrient deficiency exists in the soils of the Woakwine Range caused by the absence of cobalt and copper. The condition results in sudden death, known as "coastal sickness" in stock grazing in the area for long periods of the year. Yearly dusting today replenishes the supply and is responsible for reclaiming large tracts of the sandhills in the Upper South East for cattle and sheep grazing.

THE COASTAL ENVIRONMENT AND ECOLOGY

The South Australian marine environment belongs to the Transitional Warm-Temperate waters of the Flindersian Biogeographic Province, which extends from southwest Western Australia to eastern Victoria, including Tasmania (Womersley and Edmonds 1958). Sea temperatures within this Province generally range between 12° to 20°C (Knox 1963). Bennett and Pope (1953;1960), along with Guiler (1954) have called attention to faunal and floristic affinities between Victoria and Tasmania which fall into a temperature regime 2-3 degrees lower than in neighbouring waters. The term Maugean was used to distinguish these more southerly associations from the Flindersian Province. Following a study of the intertidal ecology of South Australian coasts, Womersley and Edmonds (1958) observed the influence of Maugean affinities as far north as Robe, where it terminated abruptly. Finding that more faunal and floristic similarities than differences existed across the whole of southern Australia, the authors recommended that the Maugean be regarded as a subprovince and aligned the marine fauna of the Lower South East with that of Tasmania and portions of Victoria. The presence of this cold water interface within the research area attracts special attention in reconstructions of past environments, and a review of the modern inshore ecology assists in clarifying this point.

An uninterrupted sand beach stretches for 150 km from Goolwa Beach at the Murray mouth to Kingston and parallels a brackish-to-saline lagoon originating from blocked exit of the Murray River to the sea. Known as the Coorong, the coastal tract supports immense flocks of migratory aquatic birds during the summer and autumn months. The only mollusc inhabiting the beachfront in any quantity is Plebidonax deltoides (Goolwa Cockle), and it is distributed only as far south as Salt Creek. Heavy wave action, a gentle offshore gradient, and proximity to seasonal floodwaters are important habitat requirements of the animal met in the Coorong. The distribution of Plebidonax middens however, extends beyond Salt Creek by at least 25 km and this indicates that a more southern distribution of the bivalve existed in the past. The crab Ovipales bipustulatus and the snail Polinices are the only other invertebrates residing in the Coorong beach.

The Maugean subprovince begins south of Robe coincident with low, calcareous cliffs and associated flat, wave-cut reefs, which dominate the coast to beyond the Victorian border. Characteristic form and morphology of these coarse-grained reefs have been described (Womersley 1948; Edmonds 1948). Of importance here is their extensive span into the sea, covering tens of metres into waters up to 3 or 4 metres deep and paralleling the beach for many hundreds of feet at low tide. Pools in the reefs tend to be small and wave action over the platform is fierce. Under these conditions, life atop the reef is generally sparse (Bennett and Pope 1953) and more abundant in more protected regions, such as the pools or the lower littoral fringe. Consequently the supralittoral may be fringed with sand or small accumulations of flint nodules, but is otherwise unatttractive to an unfamiliar visitor. Tidal range is 1-1.3 metres.

The most prominent molluscs on the reefs as identified by Womersley and Edmonds (1958) include Cellana tramoserica, Patelloida alticostata, Siphonaria diemensis, S. baconi, Notoacmea septiformis, Austrocochlea adelaidae, A. torri, A. concamerata, Melanerita melanotragus, Subninella undulata, Neothais textilosa, and Bembicium melanostana. Other molluscs observed on the reefs today include several species of Haliotis, the chiton Poneroplax albida, and Austrosipho sp. Although all of these occur in middens nearby, Subninella undulata and Cellana tramoserica are by far the most common molluscs eaten.

South of Canunda Rocks to near Cape Banks adjacent to Lake Bonney, the aeolian cliffs are replaced by a course-grained, loosely organised sandy beach known as Canunda Beach. This sandy stretch is sedimentologically unstable from one year to the next as is seen in rapidly changing beach morphology and sand texture. Shallow reefs and rocks are alternately exposed and buried. Under these conditions, molluscan settlement would be extremely difficult and an inspection of storm beaches failed to encounter evidence of colonisation. The hinddunes in this area are however strewn with numerous monospecific deposits of Plebidonax deltoides and the mussel Brachidontes rostratus.

The absence of live communities of these two animals is noteworthy. The mussel occurs on the manmade breakwater at Robe in small numbers (Womersley and Edmonds, 1958; and personal observation), and I have located sparse colonies south of Cape Buffon populated by tiny individuals. The nearest known established colony appears east of Portland in Victoria (Bennett and Pope, 1952); hence for all practical purposes, the species is unsuccessful in the Lower South East today. Except for Salt Creek, as mentioned above, the nearest known Plebidonax population is in the vicinity of Wilsons Promontory where the waters are 1-2^{o}C warmer.

Behind the aeolian cliffs of the Robe Range is a system of lakes and swamps representing the remnants of a tidal lagoon which once opened to the sea at Guichen and Rivoli Bays. Cessation of tidal exchange occurred at some time in the past, resulting in a decline in aquatic resources in the lagoon. These changes in the distribution of molluscs or their disappearance suggests that substantial changes have taken place in the marine environment during human occupation which are likely to have influenced economic activity. In the Coorong, the change involves a northward adjustment of Plebidonax distribution, and in the southern part of the state, the species disappears altogether. The magnitude of the events would suggest that important environmental factors control the direction of the shift and that the species affected are chronological indicators of that fact.

THE MARINE ECOLOGY

In an economic analysis of molluscan foods, it is significant to observe that the ecological relationship between littoral and sublittoral communities is poorly understood generally (Morton and Miller 1973:591-609) and that this is particularly so in the case in the Lower South East (Womersley and Edmonds 1958:247). The full distribution of major organisms within their habitat for example is rarely stated, nor are their size-frequency distributions, or movements across their range known from observation. In stressing the need for this information, Phillips (1969) considers that the littoral has traditionally been discussed in isolation from the sublittoral in marine studies, and that this situation arises from limitations on personal observations and the physical burden of sampling adequately. It might also be fairly said that the interests of intertidal ecologists have not extended below the tide where zonation is not strong.

This deficiency is acutely felt in reconstructions of past economic activities based on an analysis of food remains. The consumption of large, mobile gastropods such as Subninella undulata, Ninella torquata, Dicathais spp., and Cabestana spengleri in prehistoric diets around southeastern Australia is a case deserving more attention from the point of view of prey-predator relationships. To establish this relationship, knowledge about recruitment mechanisms, migration, and reproductive behaviour is required.

The observations of individuals personally familiar with South Australian marine ecology through their diving experience have provided valuable information for this study. These include R. Lewis, fisheries biologist investigating Rock Lobster populations in the Lower South East; B. Hart, professional fisherman and abalone diver; and M. King, fisheries biologist investigating Plebidonax communities at Goolwa Beach, South Australia.

The reproductive cycles and geographic distribution in southern Australia of the gastropods Subninella undulata, Austrocochlea constricta, Cellana tramoserica, and Patellanax peroni have been described (Underwood 1974). These species display a wide variety of pattern and timing of reproductive cycle at one locality which does not correlate with overall geographic distribution, zonation pattern on the shore, or phylogenetic relationships. The ecology, habitat, movement and feeding behaviour of five sympatric species of Haliotis have been studied in South Australian waters with the conclusion that water movement is an important environmental factor affecting position and feeding behaviour (Shepard 1973; Shepard and Laws 1974). While several species of this sedentary animal may occur together, there is little microhabitat overlap. The most common species, H. ruber, prefers caves in calm water to rough water localities. Five species of marine mussel, including Mytilus edulis planulatus and Brachidontes cf. variabilis, in Western Australia have been shown to exhibit different breeding cycles, and a distinction is drawn between the season of gametogenic activity and the much narrower season of actual spawning (Wilson and Hodgkin 1967). Factors other than temperature are thought to govern season of spawning or the number of spawning peaks. M. edulis in Western Australia occur on jetty pilings or on rocks and are densest near low tide level or a few feet below (Wilson and Hodgkin, 1967), and this pattern of zonation applies to New South Wales (Maclean 1972) and Victorian populations (Macpherson and Gabriel, 1962), although specimens are found to a depth of 20 metres (Maclean 1972:4; Cotton 1961). Brachidontes cf. variabilis is a mat-forming species occurring in great numbers on intertidal rocky shores and sometimes in beds on the sea floor a few feet below tide. Brachidontes rostratus establishes narrow bands as colonies on rocks in Victorian waters (Bennett and Pope 1953), and as a sessile, fast growing animal, competition for space can result in colonies dominated by age mates. Austrocochlea constricta and Cellana tramoserica populations which are abundant on rock surfaces in the intertidal zone have been shown to vary diurnally and seasonally in three environments in the vicinity of Sydney (O'Gower and Meyer 1971).

A study of the population ecology of Dicathais aegrota in Western Australia (Phillips 1969) provides information on the dynamics of a large mobile gastropod on a platform reef in strong surf. Over a 3 year period, the adult population sustained a 70 per cent mortality rate per annum and was still able to remain viable on the reef due to a large supply of recruits residing at the edge of the reef. During this time, the population ranged from 77 to 372 animals. Shoreward and upward movement occurs before the spawning season in winter, and there is a general year round migration of juveniles and a small proportion of adults. Once on the platform, individuals do not move quickly or range widely during life, but space themselves evenly over the surface of the reef. A more permanent population of Dicathais resides in the sublittoral and provides the recruits necessary to sustain the intertidal population and protect it against extinction. Compensation for sudden loss of large adults therefore could not occur quickly, nor is it likely that the replacements will be nearly as large as those lost.

The life history of Donax denticulatus is known from two environments in the West Indies (Wade 1968) and from Algeria (Moueza and Renault 1971) where dense populations and tolerance to seasonal floods have been described. Donax gouldi growth rates over a three year period have been calculated for California populations (Coe 1955), while the same investigator has recorded massive fluctuations of the clam population over 70 years. These cyclical population explosions in California are attributed to changing ocean currents and loss of larva at sea.

Subninella undulata attracts special interest in this study because it represents a major food to prehistoric shellfish gatherers. Lewis has devoted many days to tagging and monitoring the movements of inshore lobster populations in the Lower South East, and observes that :

> Subninella are common on shoreline reefs below low tide and could be collected by shallow diving or scooping up. Live Subninella are found in the same locality as Rock Lobster (Jasus) and large numbers of shells are found in front of caves sheltering Rock Lobsters. Depth of water close inshore ranges from 0-20 feet (6 m). No definite age grading appears to occur although I have not taken any length measurements - larger specimens appear to be more common but whether this actually occurs or that small specimens are harder to observe I have not gone into. (Lewis 1976, pers. comm.)

Hart (pers.comm.) has described "whole carpets" of large Subninella living below the front apron of the reefs along with large numbers of abalone. Others place the snail in the lower and sublittoral (Underwood 1974; Cotton 1961). Its relatives (Turbinidae) in the Indo-Pacific region share similar habitat preferences for life below the tide as adults (Morton and Miller 1973:81 and 598), and some are deep water inhabitants (Habe 1964).

The most important characteristic of Subninella is the fact that it is locally mobile. As a grazing herbivore, it inhabits a variety of microhabitats and is therefore tolerant of a range of temperatures and wave action intensities. Bennett and Pope have observed upward migration during warmer months, presumably in search of better breeding conditions, and this behaviour is confirmed in New Zealand relatives (Morton and Miller, 1973), with the low littoral marking the animal's highest ascent. A study of a cousin, Turbo cornutus, in Japanese waters concludes that "...habitats preferred... are rocky bottoms where sun's rays are shut out.... Small shells occur in tide pools and between tides, and they migrate from these regions to offshore water with growth." (Uno 1962: English summary). The high density below the tide observed in Subninella populations in the Lower South East seems to follow this pattern with some adults and many juveniles residing on the reef platform, while the bulk of the population inhabits the foot of the reefs below the tide.

It is clear from this information that the most attractive segment of the Subninella population resides below the tide mark, and it is this portion which is most capable of withstanding prolonged predation. While movements upward do occur, the severe turbulence across reef surfaces hinders the migration, especially in the case of the less streamlined adults. For this reason, overnight replenishment of depleted reeftop communities would not be possible and the time required for full recruitment may require some weeks or longer.

Other mobile molluscs may be considered in a similar light. The population dynamics and migratory behaviour of the carnivore Dicathais textilosa is likely to closely resemble that described for its Western Australian cousin, D. aegrota. In the Lower South East, its intertidal population would have to compete for space with larger mobile gastropods under conditions of continual stress from the physical environment. Austrocochlea spp. are most abundant in rock pools, where as mobile aggregate communities, their habitats include protective foliage and crevices which are always submerged.

The more stationary molluscs are especially susceptible to the effects of sustained predation. Brachidontes forms extensive, narrow (30-50 cm) bands above low tide in easy access to man. Densities of the adult mussel may exceed 4000 individuals per square metre (Bennett and Pope, 1952) on solid substrate in Victoria, but these figures could not be obtained on the loose aeolian substrates of the Lower South East, and must be taken as a maximum limit. Haliotis strongly competes for space below the tide, and although it may range to some depth, its sedentary habits and slowness to reach sexual maturity prevent rapid recovery under conditions of large losses to its inshore communities. A similar condition may prevail with the many intertidal limpets, although incomplete evidence makes this possibility less certain.

Details of the ecology of Plebidonax deltoides are unavailable, although a general description of this filter feeder is helpful at this juncture. The clam inhabits fine to medium-coarse sandy beaches a few centimetres below the surface at mid-tide to about one metre below tide. A maximum length of 60 mm has been reported from Goolwa beach and densities may range from 100-500 individuals per square metre. Local lateral drift of the community occurs consistant with currents. Settlement of the larva follows a pelagic stage during which the spat are influenced by warmer sea temperatures, and the activity of the animal is further stimulated by increased phytoplankton bloom in the summer months. Fishermen who use Plebidonax for bait report the decline of populations along the Coorong over recent years, and King has observed fluctuations in population (pers. comm.), but a cause has not been identified nor have the changes been as dramatic as those witnessed by Coe in California.

A list of lagoon molluscs has been compiled by Kathy Conover from collections made of fossil shellbeds (Table A2.1), and these assemblages are identical to one described from a mangrove mud-flat near Adelaide (Cotton 1949). In order of abundance, the more common molluscs include Katelysia cf. peronii (Mud Cockle), Ostrea angasi (Mud Oyster), Hormomya erosa (Rough Beaked Mussel), Mytilus edulis planulatus (Port Melbourne Mussel), and Equichlamys bifrons (Common Scallop). The picture is very typical of protected marine settings (Poore and Rainer 1974) in which a wide array of shallow water habitats is represented ranging from fine mud and sand sediments, to rocky substrate. Subninella is present in very small numbers as small individuals. Zeacumantus diemenensis (Sandy Creeper), Clanculus dunkeri (Top Shell), and Gazameda iredalei (Screw Shell) inhabit shorelines under calm conditions and are the clearest indicators of the lagoon setting.

The bivalves are extraordinarily large and prolific and could have provided astonishing quantities of food close to the tide mark. In embayments, some Katelysia spp. exceed 60 mm in length, and that may be a record in South Australia. Scallop and oyster are exceptionally large closer to the centre of the lagoon, and the mussels Mytilus and Hormomya are uniformly large and robust. This evidence clearly testifies to the fact that optimal growth conditions existed in the lagoon for a considerable time and that the setting is ideal for shellfish collecting.

A detailed survey of the freeswimmers in the sublittoral is not available for the South East. Scott, Glover, and Southcott (1974) have described and illustrated the marine and freshwater fishes of the state. Campbell (1946) has compiled a list of possible marine fish available in the Lower South East and these are presented in Table 2.3 below, revised according to Scott *et al.*

The Rock Lobster supports a primary fishing industry from Robe to Melbourne and is known to have been eaten in great numbers by the Aborigines during the summer months. It can be easily caught under rock ledges in one fathom near the shoreline and occurs several kilometres offshore. Campbell, Cleland, and Hossfeld, (1946:485) have reported finding one 4 kilogram lobster. Details of behaviour are not available at this time.

Marine Fishes : speared

Gummy Shark	*Mustelus antacticus*
Blue Pointer Shark	*Isurus glaucus*
Wobbegong	*Orectolobus maculatus*
Skate	*Raja* spp.
Smooth Sting Ray	*Dasatis brevicaudata*
Short Finned Eel	*Anguilla australis occidentalis*
Conger Eel	*Leptocephalus wilsoni*
Barbed Rock Cod	*Physiculus barbatus*
Slimy Cod	?
Mulloway	*Sciaena antarctia*
Flounder	*Rhombosolea* spp.

Marine Fishes : caught in nets

Garfish	*Hemiramphus melanochir*
Sea Mullet	*Mugil argenteus*
Spotted Whiting	*Sillaginodes punetatus*
Tommy Rough	*Arripis georgianus*
Australian Salmon	*Arripis trutta*
Snapper	*Chrysophrys unicolor*

Crustaceans:

large Crab	*Plagusia chalcus*
Sand Crab	*Ovalipes bipustulatus*
Reef Crab	*Ozius truncatus*
Rock Lobster	*Jasus novaehollandiae* (Holthuis)

Table 2.3 List of fish and crustaceans known to exist in the Lower South East

THE PALAEOENVIRONMENT OF THE COASTAL MARGIN

The formation of a striking series of beach ridges across the mouths of the lagoons at Rivoli and Guichen Bays progressively changed the coastal environment while man camped on their shorelines. The following discussion attempts to reconstruct the nature of these changes as a framework in explaining Man's responses.

A line of saline and brackish lakes and ponds (Figure 2.5) has formed in the interdune corridor between Beachport and Robe after the beach ridges closed the mouths of the lagoon. Recent studies of some of these lakes have shown that they are derived from local runoff under conditions of high evaporation, and that they are essentially non-marine (Bayly and Williams 1964; Bayly 1970). Ground surveys along the 30 km corridor have determined that land surfaces are more than 1 m *below* MSL, except for a strip separating Lakes George and St Clair, which is no less than +1 m *above* MSL. The beach ridges however, are 7-8 m *above* MSL. Lake George, which drains into the sea after high winter rains, is known to contain estuarine fish (whiting and mullet) and attracts numbers of swans during the fall and winter months. In the absence of adequate flushing of the system by freshwater and by stream discharge, the lakes cannot maintain stable biological communities.

A southern group of lakes between Cape Buffon and Cape Banks is maintained by both rainfall and creek discharge, although drainage has been severely altered artifically during the last two decades. Lake Frome is a shallow (2-6 m) swamp situated behind Rivoli Bay and is known locally as a permanent body of water rich in game and aquatic plants (Angas 1847; Smith 1880). Lake Bonney is the largest of the lakes (30 km) and is maintained by rainfall and waters from Stony and German Creeks, as well as by numerous small springs at its southern end. An immense number of aquatic fowl, plants, and fish lived in the lake last century, and residents of the district report the persistance of some of these communities until industrial effluent destroyed the environment 10 years ago.

The possibility that artificial drainage has exaggerated these ecological differences between the two systems seems to be quite low. A ground survey of the major lakes was conducted in 1882, and the results were plotted as a sketch map appended by tabulated elevations and notations (1883, Drainage Rack G/17; South Eastern Drainage Board). Presented below in Table 2.4, this information reveals that separate hydrological conditions prevailed at the time drainage began, and that the present picture is not substantially different from the original situation.

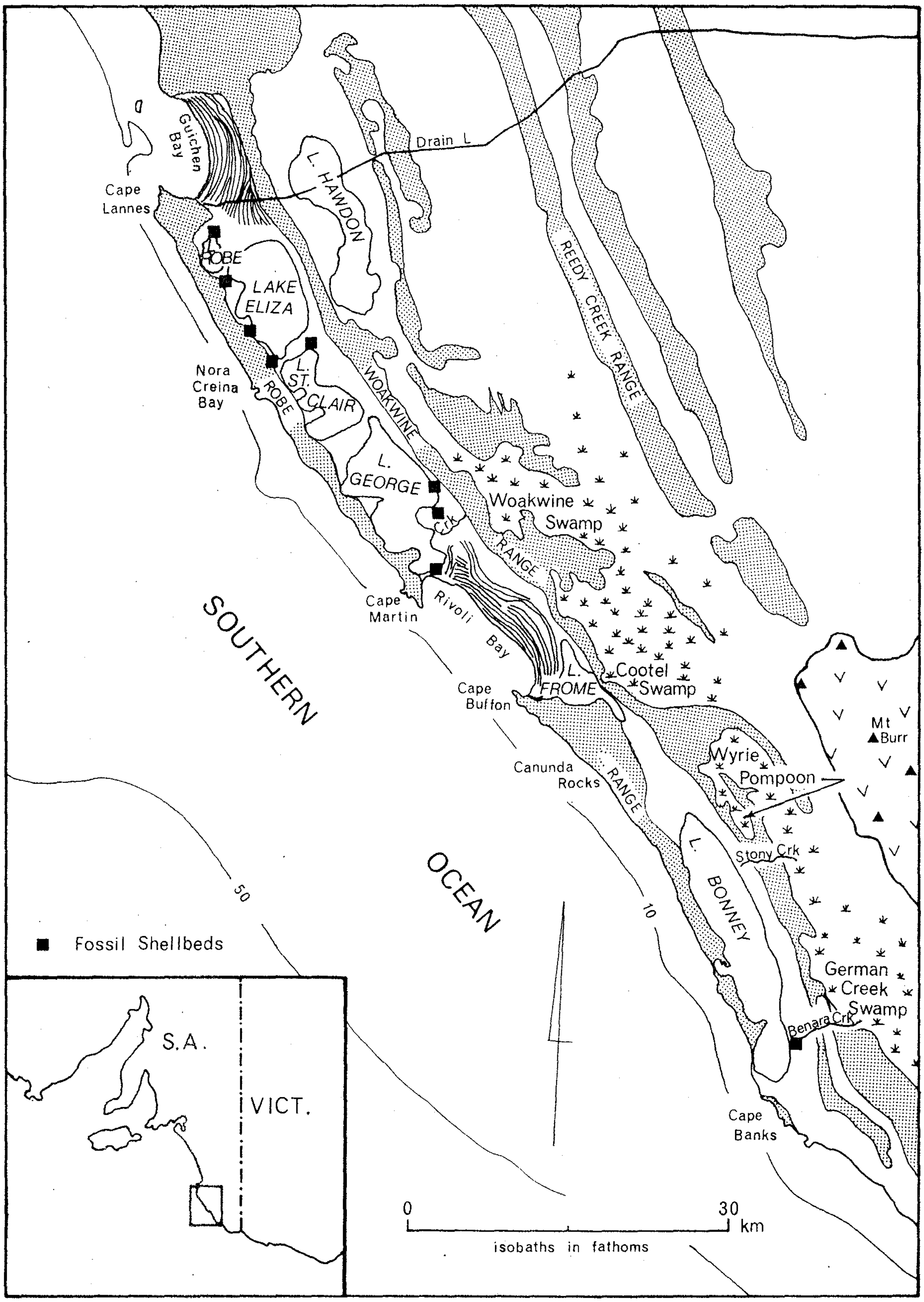


Figure 2.5 Map of prominent swamps and lakes at the coast in the Lower South East. Fossil shellbeds contain only marine fauna.

Lakes	Winter Level (relative to High Tide)
Robe (brackish)	-7.73 feet
Eliza (salt)	-14.39
St Clair (salt)	-11.59
George (brackish)	-0.35
Frome (fresh)	+7.46
Bonney (fresh)	+4.89

Table 2.4 Lake elevations acquired in 1882

The hydrology of the district is likely to have played a substantial role in supporting aquatic wildlife on the coastal margin. Precise levelling data acquired during drain construction, show that a gradual slope beginning at 16 m above MSL exists from the foot of Mt Burr along a line SW to the base of the Woakwine Range, where depressions as low as 9 m above MSL are recorded. As a consequence, extensive permanent swamps have formed against the steep inland face of the Woakwine, and these have been identified (Campbell 1934; Smith 1880) as important to Aboriginal groups. Cootel Swamp, at Narrow Neck, was the first to be drained and was from 3 to 5 m deep at the range. Mayurra and Wyrie Swamps were equally deep prior to drainage (Towers, pers. comm.). Other swamps are German Creek, Pompoon and the Woakwine Swamp near Lake George. Mayurra Swamp adjoins Wyrie Swamp to the northwest and is not shown, while the other swamps are illustrated in Figure 2.5. Given the tremendous quantities of subterranean waters flowing into the Lake Bonney and Mt Gambier area as excess from the permanent swamps, it is likely that the coastal margin south of Cape Buffon was extensively endowed with aquatic resources for most of the year.

Geomorphic processes have had a strong influence upon the coastal environment, especially north of Cape Buffon where beach ridges have formed across the lagoon exits. Sprigg (1952) has counted 80 and 120 ridges at Robe and Beachport respectively and has commented upon the mechanism of their formation and its periodicity. At Robe, Drain L dissects a portion of these beach ridges revealing organic sediments buried in an overlapping fashion towards the sea, occasionally covering small shell middens. Beach ridges of this sort are common products of coastal processes (Davies 1957; Bird 1964; Langsford-Smith 1970) which have had a complex history in Holocene Australia (Thom 1974). In the Lower South East, these structures have altered local ecology and the availability of resources of use to Man. The history of these changes is reflected in the well-preserved biostratigraphy of the lagoon and can be considered at this time.

Massive, stratified fossil shellbeds of lagoon molluscs span the width and length of the lagoon floor and are exposed in numerous barrow pits, drains, road cuttings, and watering ponds. Permanent benchmarks and levelled well casings are commonly positioned in the beds making it possible to establish a single datum plane for the whole area. Thin (4-6 cm), black rendzina soils cap the beds in the north, whereas thick organic muds (at least 2 metres) blanket the shorelines of Lake Bonney preventing examination of shellbeds. The outlet of Benara Creek however contains marine and lagoon molluscs of similar composition to its northern counterpart. The localities of these fossil exposures are shown in Figure 2.5.

The molluscan assemblages contained in the shellbed reflect the habitats expected to exist near the shores of a lagoon in terms of composition and size. The shells are frequently hinged, and are positioned with internal cavities facing downward but are not aligned in any particular direction. This suggests that they are indigenous assemblages (Craig and Hallam, 1963) which have been deposited under gentle water action. Life assemblages, or shells found in growth position, do occur in upper horizons in the deposit, suggesting that instant death and burial did occur. Conover has collected a column of shells from a deep exposure midway between the mouths of the lagoon (Table A2.1), and the palaeoecological implications of this are summarized below.

Deep, calm water conditions prevailed throughout the lagoon in its early history. Uncommonly large molluscs dominate the first half of the sequence from mouth to mouth suggesting the existence of optimal growth conditions. A gradual reduction in animal size in conjunction with increased frequency of mortality amongst bedmates is seen as evidence of uniform environmental stress. Late assemblages appear to contain few species and these alternate in bands with dark humic material. Although individuals inhabiting shallow water and peripheral shoreline conditions, i.e. Clanculus and Zeacumantus, are common throughout, they are clearly dominant over the last quarter of the stratigraphy. The survival of animals more tolerant of rapid changes in the physical environment such as these indicates unstable conditions within the lagoon generally. The dominance of oyster/scallop banks in the north contrasts with Katelysia beds in contemporaneous assemblages in the south and may indicate the development of separate habitats late in the sequence. The evidence of size reduction, shifts from deep to shallow water conditions at the sample site, and *in situ* mortality, is consistant with increased sedimentation, tidal constriction, and lagoon closure. The absence of dramatic habitat diversity in the exposures argues for uniform tidal conditions throughout the length of the lagoon until, at least, late in its history. Under these conditions, the Robe Range north of Cape Buffon was an offshore island surrounded by relatively shallow waters and an incredibly prolific molluscan life. For prehistoric man during this period, access to the island involved water travel.

It may be concluded from this information that separate environments evolved in the coastal margin. In the north, a tidal lagoon supported a great number of large molluscan species, crab and, undoubtedly, estuarine fish. These communities gradually deteriorated as the lagoon entrances were blocked by advancing beach ridges and as migrating dunes encroached upon the edges of the lakes. Following closure, evaporation exceeded inputs and a series of isolated lakes were formed under conditions too unstable to support major aquatic biota. In the south, the reverse is true. There, low aeolian cliffs at Cape Banks and the beach ridges in Rivoli Bay necessarily constricted tidal interchange into the interdune corridor. Fed by stream and spring discharge from a large catchment area, Lakes Bonney and Frome formed and are likely to have supported rich aquatic populations with both a marine and swampland character. Whether or not exits to the sea periodically occurred is unknown, but they are likely as a result of overfilling or changes of sediments at the narrow outlets. Therefore, while abundant marine resources developed and gradually declined in one area of the lagoon, freshwater aquatic resources emerged in another under the influence of climatic and hydrologic factors.

FOODS IN THE SWAMPS

a) Birdlife

Over 150 species of birds are known to exist in the Lower South East either as year-round residents, or as seasonal visitors. Some of the more common have been identified (Campbell, Cleland, and Hossfeld 1946) and appear below in Table 2.5 - Latin names and ecological information are taken from the most recent comprehensive description of Australian avifauna (Reader's Digest 1976).

Scrub to Open Woodland Habitats

* denotes very abundant species

Emu*	*Dromaius novaehollandiae*
Stubble Quail	*Coturnix pectoralis*
Common Bronzewing*	*Phaps chalcoptera*
Brush Bronzewing*	*Phaps elegans*
Banded Land-rail	*Rallus philippensis*
Spurwinged Plover*	*Vanellus miles*
Banded Plover	*Vanellus tricolor*
Australian Bustard	*Ardeotis australis*
Australian Goshawk*	*Accipiter fasciatus*
Wedgetail Eagle	*Aquila audax*
Whistling Eagle*	*Haliastur sphencircus*
Brown Hawk*	*Falco berigora*
Nankeen Kestrel	*Falco cenchroides*
Boobook Owl	*Ninox novaeseelandiae*
White Cockatoo	*Cacatua galerita*
Gang Gang Cockatoo	*Callocephalon fimbriatum*
Crimson Rosella	*Platycercus elegans*
Welcome Swallow	*Hirundo neoxena*
Noisy Miner	*Manorina melanocephala*
Little Wattle Bird	*Anthochaera chyrsoptera*
Australian Raven	*Corvus coronoides*
Little Crow	*Corvus bennetti*
Blacked Winged Currawong	*Strepera versicolor*
Grey Butcher Bird	*Cracticus torquatus*

Coastal Swamps and Lakes

Lewin Water Rail	*Rallus pectoralis*
Dusky Moorhen	*Gallinula tenebrosa*
Eastern Swamphen	*Porphyrio porphyrio*
White-headed Stilt	*Himantopus himantopus*
Native Companion*	*Grus rubicundus*
White Ibis*	*Threskiornis molucca*
Strawneck Ibis	*Threskiornis spinicollis*
Royal Spoonbill	*Platalea regia*
Yellow-billed Spoonbill	*Platalea flavipes*
Large Egret	*Egretta alba*
White-faced Heron*	*Ardea novaehollandiae*
Black Swan*	*Cygnus atratus*
Mountain Duck	*Tadorna tadornoides*
Black Duck*	*Anas superciliosa*
Chestnut Teal	*Anas castanea*
Grey Teal*	*Anas gibberifrons*
Blue-winged Shoveller*	*Anas rhynchotis*
Musk Duck*	*Biziura lobata*
Swamp Harrier*	*Circus aeruginosus*

Marine Habitats

Black Cormorant*	*Phalacrocorax carbo*
Little Pied Cormorant*	*Phalacrocorax melanoleucas*
Pied Cormorant	*Phalacrocorax varius*
Australian Pelican	*Pelecanus conspicillatus*
Crested Tern	*Sterna bergii*
Silver Gull*	*Larus novaehollandiae*
Cape Barren Goose	*Cereopsis novaehollandiae*
Shearwater	*Puffinus* spp.

Table 2.5 List of Avifauna known to exist in Lower South East.

By far the most significant avifauna are the vast flocks of migratory birds which visit the district some time after January of each year. During a census exercise in February 1975 covering a short stretch of the Coorong, the writer and a Ranger encountered an estimated 10,000 ducks and teals feeding near the shoreline in shallow water. If these densities apply to the district in general, it is easy to believe that the bird population would number in the hundreds of thousands on any given day in the summer.

In considering the potential importance of these aquatic fowl to prehistoric settlement, it is necessary to realize that conditions surrounding the supply of food strongly regulate population size and influence migration. Common foods for these birds include various aquatic insects, swamp grasses, large seeds of sedge, frogs, molluscs, crustaceans and even small fish. These items obviously change with the water level. Both Grey Teal and the Mountain Duck respond swiftly to food improvements and will breed within two weeks of increases in the water stand. Providing that the food lasts, the offspring can survive long enough to become independent of parental support. During periods of drought however, the birds forego breeding and devote their time to the search for new food sources. In this way, populations promptly adjust to the rise and fall of swampland conditions, and vary migration schedules according to the choices in food immediately available.

The modern migration pattern varies between species in a complex manner. The Chestnut Teal prefers to range near a coastal heartland, whereas the Grey Teal is nomadic and wanders over great distances breeding anytime of the year. The Shovellers are sedentary, and their seasonal movements are localized around more permanent swamps in regular climatic conditions. The Musk Duck migrates regularly between autumn nesting grounds on the Murray River and summer foraging areas near the coasts of South Australia and Victoria. Generally speaking however, breeding usually takes place during the winter or early spring wet seasons. The nests are dispersed during this time to avoid competition for food supplies when the young arrive sometime in spring. When flood waters are unusually high and foods are abundant and last into the warmer months, more of the bird population is able to survive, and in this way the stability of the aquatic environment directly influences the biota which depend upon it. The modern pattern of seasonal migration to the coast brings a summer flush as the more inland waterways contract and food there becomes temporarily scarce.

In predrainage days, the situation may have been substantially different. The swamps were so immense that many waterfowl may have been permanent residents in the district. A tenfold increase in shoreline frontage which occurred every spring would have provided a complex ecosystem of shallow lakes and embayments, as well as deeper stands of interconnected, flowing water. With such diverse habitats, the district could have met the specific requirements of deep water feeders, of dabblers, and those birds requiring more permanent protection in the nesting grounds. Wyrie Swamp and similar swamps may then have been the habitats of the year round residents, such as the Chestnut Teal, the Shovellers, and the Musk Duck. Other waterfowl, such as the Black Swans and the Grey Teal may have been seasonal visitors on the more permanent lakes and swamps throughout the coastal margin. During the summer and autumn months, the flocks would be forced to disperse into the coastal lagoons and swamps, or would search for foods on the more open lakes and rivers.

On a year round basis, the aquatic birds of the Lower South East could have contributed greatly to the food quest and made the menu very interesting. During the breeding season the flocks are more likely to be committed to nesting grounds, and they or their eggs would then be vulnerable. Spring moulting also renders a portion of most populations helpless and the flock can in fact be herded into waiting hands or nets. Duck hunting in the summer may require more skill and equipment because of the dispersal of flocks across the terrain, but flocks tend to increase and may become more localized as surface waters begin to disappear. The aquatic birdlife of the Lower South East must have served as a primary food resource of prehistoric settlers, and their role in economic activities would have been closely correlated with the stability of the aquatic environment of the district.

b) Land animals

A list of the land mammals occurring in the Lower South East has been compiled by Campbell, Cleland and Hossfeld (1946), along with Aboriginal names and average body weights for each animal. An abbreviated list of these appears in Table 2.6 below with species names taken from Ride (1970).

Grey Kangaroo	*Macropus fuliginosus*
Red Wallaby	*Wallabia rufogriseus*
Toolach Wallaby	*Macropus greyi*
Red-bellied Wallaby	*Thylogale billardieri*
Black-tailed Wallaby	*Wallabia bicolor*
Common Wombat	*Vombatus ursinus*
Common Native Cat	*Dasyurus viverrinus*
Tiger Cat	*Dasyurus maculatus*
Short-nosed Bandicoot	*Isoodon obesulus*
Barred Bandicoot	*Perameles bougainville*
Common Possum	*Trichosurus vulpecula*
Ring-tailed Possum	*Pseudocheirus peregrinus*
Koala	*Phascolarctos cinereus*
Lesueur's Rat Kangaroo	*Bettongia Lesueur*
Brush-tailed Bettong	*Bettongia penicillata*
Common Rat Kangaroo	*Potorous tridactylus*
Hare Wallaby	*Lagorchestes leporides*
Spiny Anteater	*Tachyglossus aculeatus*

Table 2.6 List of land mammals known to exist in the Lower South East

The distribution of these animals in the district and their seasonal habits have not been described either before or after drainage in detail. There is strong circumstantial evidence that the larger vertebrates were a vital element in the prehistoric diet. A life-long resident since 1846 reported that kangaroos were not plentiful in 1847 when he was a young man, but that twenty-five years later, the herds were immense (Duncan Stewart, n.d.). This observation is significant in that the Aborigines, the chief predators, had been removed in the intervening years and that herd populations were able to rapidly increase despite land clearing and drainage. Over a period of five years, in the 1870s, more than 50,000 kangaroos were killed in the vicinity of Mt Gambier to relieve crop losses. Locally large herds of M. greyi, which favour open grassland and woodland have been reported between Kingston and Penola, and their numbers are regarded as inferior to those of other species living closer to the coast (Finlayson 1927). The wombat population on the Woakwine Range was extensive in the 1840s (Angas 1847) and their burrows continued to endanger livestock well into the 20th century despite earlier efforts to eradicate the animal. Kangaroo drives are said to have taken place along especially narrow ridges surrounded by water where escape was impossible (Campbell, Cleland, and Hossfeld 1946). Placing these animals into their generally preferred habitat, it is likely that they most frequently inhabited the ranges and open scrubland, and therefore could be expected to be important wintering food throughout the protracted rainy season.

SUMMARY

The Lower South East is a vast plain across which large amounts of water move slowly towards the sea regulated by seasonal climatic changes. Winter rainfalls are reliably heavy, while mild summers assure that water loss is low and accumulation is prolonged. In the process, over 3000 square kilometres may lie beneath shallow waters in early Spring and this condition does not change until late autumn when the shorelines return to their normal sizes. Accordingly, the vast herds of terrestial and aquatic wildlife are continually in motion. During autumn and winter, birdlife is prolific within the heartland of the swamps, but as the water disappears, the flocks disperse and great herds of kangaroos and swamp mammals follow the retreat of the shoreline. This rise and fall rhythm is likely to have had a dominating affect on all residents of the district, including man.

If this is true of the interior, it is more so with the coastal margin which receives water from inland sources under the influence of marine processes. Here, a wide range of animals and plants inhabits a narrow and complex ecosystem including lagoons, brackish swamps, and the ocean itself. At the edge of the swamp system, life in the coastal margin exists under the influence of both environments and features characteristics of both. For man, these choices are equally attractive.

The history of these relationships has been uneven in the past. It was wetter and the swamps probably contained more water. At the coast, changes to foreshore and lagoonal environments greatly affected major faunal communities in those areas, and the principal resource, flint, became more readily available in certain localities. Swamps formed in the margin where there were none before, and some land became accessible only comparatively recently. Each of these local events will have obvious local influence upon the character of economic activity, which will have to be understood before generalisations can be proposed for the settlement as a whole. It will then be necessary to examine the environmental history separately from the archaeological, and the evidence of important biostratigraphic sequences will be a help in this task. It is now possible to consider how the last hunter-gatherers placed themselves on this landscape, and for that evidence, we can look at the Buandik.

CHAPTER THREE

THE BUANDIK

INTRODUCTION

Our first description of the Lower South East Aboriginal population is a glimpse southward from Mt. Benson on the Woakwine Range during the winter of 1843:

> We ascended the ridges, which were thickly clothed with Banksia and she-oak, but had some difficulty in finding Mt. Benson, owing to the density of the foliage. The view from the summit was most extensive, and of a peculiar character. It appeared as though we were looking over a sea of wood, with the blue plains melting way away into the invisible distance. To the westward, we traced the shores of Guichen Bay, with Baudin's rocks and a reef beyond the bay, against which a heavy surf was breaking. The white and rugged limestone of the range was intersected in every direction with wombat holes, that perforated the rock like a honeycomb. It was very cold, and the hills attracted flying showers that frequently enveloped us in mist. We collected together a quantity of dry wood, and made a signal fire that must have been visible for many miles. It was soon responded to by the natives towards the south and east, many columns of smoke rising in that direction; and before we descended the hill, the natives were signalizing all around, giving indications of a larger population amongst these Banksia woods than we had anticipated. (Angas,1847:150.)

The smoke columns described by Angas were produced by the Buandik who inhabited the land between the swamps and the coast. The following discussion will indicate how the land may have been used by these people in pre-European times. The discussion is based on both ethnographic and ethnohistoric literature, and on the local history of the region as transmitted by the descendants of early European settlers.

Reconstruction of the traditional Aboriginal life in the region is hampered by two factors. First, local populations were decimated by European contact. Campbell (1939) estimates that they declined at the rate of 50% every 5 years, beginning in 1855, largely as a result of disease, active hostility of Europeans, and disruption of their habitat through swamp drainage and land clearance.

Equally important is the fact that relatively few observers actually describe traditional life in print. Their accounts are largely anecdotal and are difficult to cross check for accuracy. Although there has been an upsurge in interest in the local Aborigine since the turn of the century, the relevance of any information gained during this time to the problem of establishing the nature of the pre-European situation is clearly limited. Nevertheless, these data cannot be ignored and it is therefore useful to review their sources in order that their potential accuracy and utility may be judged.

The people most familiar with the Buandik were Mrs. Christina Smith and her son Duncan Stewart, who settled at Southend near Cape Buffon in 1846 and lived with the natives for 12 years. Mrs. Smith's diary was published in edited form in 1880 and provides a personal, anecdotal account of her experiences with the Buandik. Stewart, who was befriended by the Buandik at a very early age, was fluent in their language and knew each member of the local groups personally.

George F. Angas travelled from Adelaide to Mt. Gambier in 1843 in the original survey party which included Governor Grey and other well known personalities of the time. As an accomplished artist, Angas was a keen observer of detail and was able to commit his impressions to paper with skill. It is noteworthy in light of other works of the time that Angas attempted to portray the Aboriginal camps and inhabitants as he encountered them, suddenly and without notice. His drawings in watercolour, along with a diary of daily entries recounting his trip are, for this reason, relatively unconstrained by affectation and ethnocentricity.

Reverend George Taplin (1879) was stationed at Point Macleay with the Narrinyeri on Lake Alexandrina in the 1870s and reported widely on their traditional life. While many other Aboriginal communities rapidly disappeared after 1850, those around the Lower Murray River were recorded to have survived into the 1880s and for this reason Taplin's observations offer helpful explanations of a people living a traditional life in an environment similar to that of the Buandik.

The later work of two South Australians deserves consideration in this study. As a young man, Norman Tindale (1925,1926,1930,1935a&b, 1936,1937) travelled extensively among South Australian Aboriginal groups to report on surviving traditional life in the years of its decline. It was during this period that Milerum, whose father was the last of the Tanganekald living on the Coorong, told Tindale the story of his father's people and the tradition they followed near the sea. The foods they ate and the country they owned are described in detail by Tindale (1974) in the general context of his life's work describing Australian tribal boundaries.

As a medical practitioner living in the Lower South East, T.D. Campbell (1934,1939) collected stories of the Buandik from descendants of the first European settlers in the district and attempted to relate these to the natural history of the coast before its alteration. Together with P.S. Hossfeld (1926,1928,1966) who was a trained geologist, Campbell joined another, the botanist, J.B. Cleland to describe the traditional life of the Buandik before all memory of it had disappeared altogether (Campbell, Cleland and Hossfeld,1946).

Together, these sources provide information about the Aboriginal life of the area beginning with European settlement in the 1850s and terminating with the extinction of traditional life at the turn of the century. We can now consider the principal Aboriginal group in the whole of the Lower South East.

THE BUANDIK ETHNOGRAPHY

The Buandik owned "that country extending from the mouth of the Glenelg River to Rivoli Bay North (Beachport) for about 30 miles (50km) inland" (Smith,1880:ix). They were the largest of five "tribes" in the district, each speaking dialects of the same language. Specific local groups identified with particular coastal localities have been recognized by almost every observer, although Tindale (1974) relates the tribal boundaries to the largest geographic area, including inland parts of western Victoria. A resident born in the district in 1859 recalls that these groups numbered from 60 to 100 individuals living in close proximity to permanent water and having, with one exception, direct access to a stretch of coastline (Wallis, as quoted in Campbell, 1939). The connection between these groups and swamps known to be important to Aboriginal subsistence at the time of European settlement is revealed in Table 3.1 below. The list of groups is not exhaustive. Figure 3.1 depicts these groups in relation to physiographic features of the district already mentioned in Chapter 2. This information suggests distinct coastal economies operated within clan territories and that these may have formed only one aspect of Buandik economies as a whole.

NAME	LOCATION
Robe	Northwest Woakwine Range-south to Woakwine Swamp-Coast at Robe
Woakwine	Rendalsham-Lake Frome-Coast at Beachport
Mt. Burr-Mt. Graham	Mt. Burr Peninsula-Dismal Swamp
Mayurra	Wyrie/Pompoon/Mayurra Swamps-coastline including Northern Lake Bonney
Kongorong	German Creek Swamp-Southern Lake Bonney-Coastline
Mt. Gambier	South of Mt. Gambier-east to Glenelg River-Coastline
Tarpeena	North of Mt. Gambier-east of Mt. Burr Peninsula

TABLE 3.1 List of Buandik clans with territory at the coastline. After Campbell,1939.

Two references disclose the sentiments felt towards these clan territories. While Mrs. Smith was travelling towards the Woakwine Range from Cape Buffon with an Aboriginal friend, the latter said of the scene before them:

> There is the swamp; yonder is the Lake [Frome]. Here is the country where I followed my husband when I was a burrich burrich (girl). There are my good swans, lapps lapps (small fish), gnarps (apples-Kangaroo Apples, Solanum aviculare), nroite (honey-Banksia), carlie paron marton (plenty plenty good). I am old, and am the only wife he loved. He was the lord of Lake George (narhter). (Smith,1880:3).

Another friend of Mrs. Smith told her:

> The Schanck [Mt. Schanck] was my father's land, which he seldom left, except to act as chief in quarrels and disputes, to prevent bloodshed. My uncles and my father and mother lie buried there. I buried my wife and child there. (Smith,1880:xi).

Population estimates for the Lower South East are difficult to assess owing to uncertain circumstances surrounding early census efforts and due to disruptions to the subsistence behaviour of local groups caused by European settlement. Accepting estimates from Wallis for local Buandik populations living near the coast between Kingston and the Glenelg River, the population density is about one person per 8-10 square kilometres. Campbell (1939) discounts this figure because of depopulation and proposes, on the basis of extrapolation, an original population of 2000 to 2500 people, or about one person per 2-4 square kilometres. In view of the vagaries accompanying these estimates, however, these figures are taken more as an indication of the approximate size of local populations, than as true census accounts.

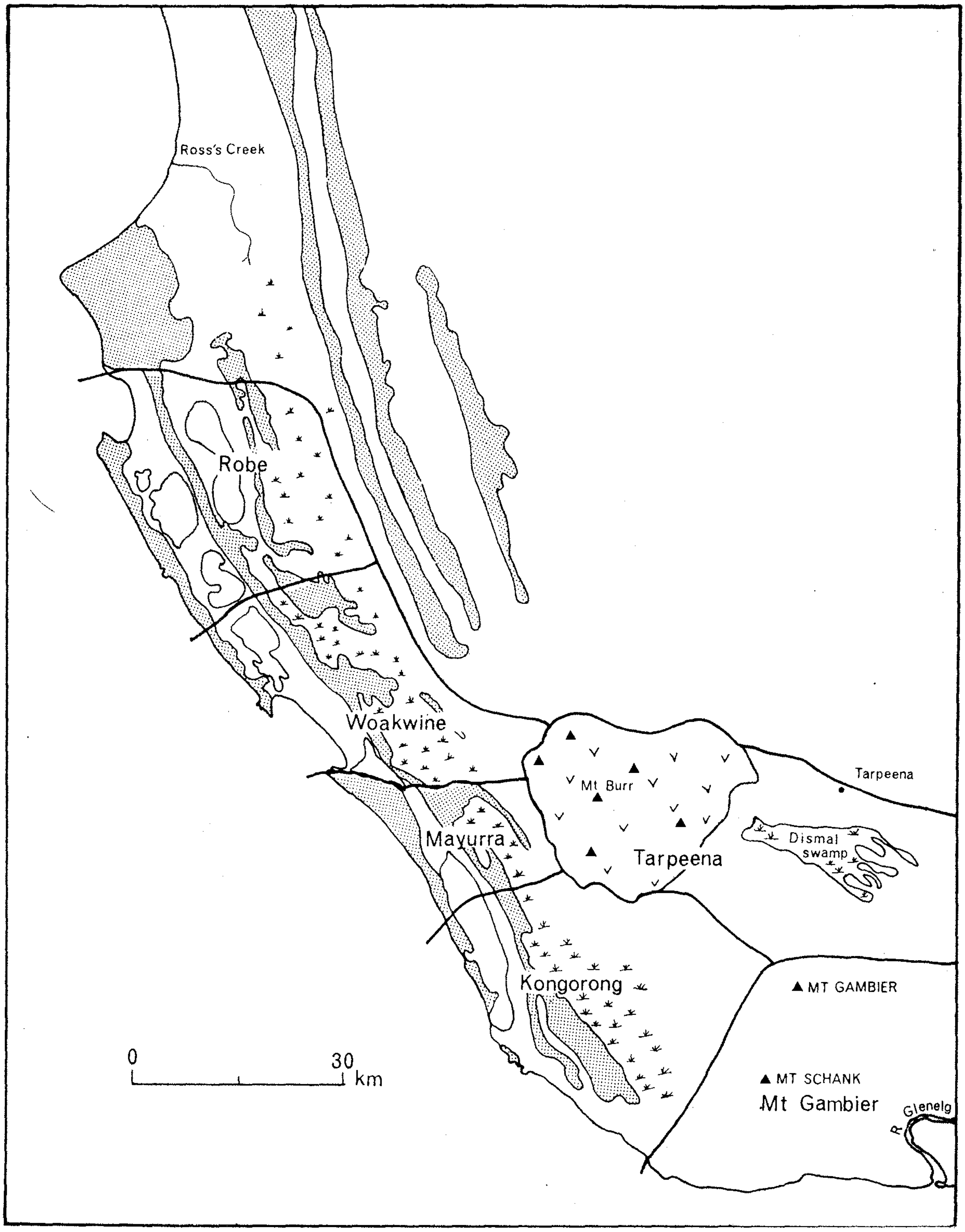


FIGURE 3.1 Map of Buandik clan territories at coast as identified by Wallis (quoted in Campbell, 1934). Buandik names translate as: Woakwine-my arm, Mayurra-fern straw, Kongorong-corner, Tarpeena-red gum. Stiple represents Pleistocene dunes.

A few fleeting glimpses reveal life around the Buandik campfire and the way in which nearby foods were acquired. At Ross's Creek (Figure 3.1), wicker snares and a blind-like arrangement constructed in brush were used to capture birds (Angas,1847:148). In the open stringy bark country (E. baxteri) on the northwestern slopes of the Woakwine Range, native tracks and abandoned wurlies (huts) were a common sight, with melliferous cones of Banksia heaped beside.

> On some of the swamps, the natives had built weirs of mud, like a dam wall, extending across from side to side, for the purpose of taking the very small mucilaginous fishes that abound in the water when these swamps are flooded....we came up so suddenly upon a native encampment that the savages had barely time to take alarm at the noise of our horses....there were two large wombats roasting in the ovens, several choice heaps of roots lay amongst the ashes, and a fine parrot, not yet cooked, was suspended to a stick. In their precipitate flight they had left all their things behind them--spears, baskets, snaring rods, and a variety of curious implements; these we examined and left precisely as we found them.... (Angas,1847:155; observed on May 2,1843).

A common method for catching ducks described by Wallis involved swimming quietly beneath the bird and pulling it into the water to a silent death.

As Angas and his party approach the shores of Lake Frome, they again suddenly interrupt another campside meal which they describe:

> The water of this lake was very slightly salt....and native camps were numerous. On the brow of a steep, wooded hill, we surprised a party of natives, cooking their food around their fires. We examined the encampment from which its occupants had fled so precipitately, and found various baskets resembling those of the Tattayarra (east of Lake Alexandrina) tribes; with a narrow triangular shield, very similar to that used near King George's Sound. One of their baskets contained a piece of lava from Mount Gambier, a large biscuit tufa, a long white stone, a sheep bell, a boomerang, and a lump of ochre and fat. Before one fire were frying a quantity of very small mucilaginous fishes, which the natives catch in weirs upon the swamps and in the shallow waters of Lake Frome; and at another fire they had been roasting aquatic beetles, which here form an article of food amongst these miserable creatures. (Angas,1847:173; observed on May 8, 1843).

A striking feature of the Buandik habitation mentioned by almost every traveller through the district is the construction of substantial wurlies or huts (Tolmer,1847; Angas,1847; Smith,1880). Although details of their design and construction were not precisely described, they were said to consist of a framework of branches and brush, covered occasionally with soil or skin rugs (Campbell, Cleland

and Hossfeld,1946). Factors which may influence their size or number at any one locality are not indicated by observers, but it is clear that huts in groups of more than 10 were common on the Woakwine Range. Some structures were capable of holding at least six adults, but again ranges in size are unavailable. The frequency with which these huts were occupied is also not indicated.

The use of well built huts is typical of the more exposed, wetter portions of South East Australia generally and seems to reflect attempts to combat the effects of cold, wet weather. Around Lake Alexandrina for example, Aborigines built huts,

> resembling beehives, to protect them in these exposed situations from the cold south and west winds, that prevail during that season. These huts are composed of turf and mud over a framework of sticks, and have a small entrance on the leeward side. Along the shores of the Coorong they cover these huts with sand and shells, so as to form hollow mounds, impervious to the wind, beneath which they creep in stormy weather. (Angas,1847:64).

A hut built from brush, reeds and timber on the shores of Lake Alexandrina appears on the frontispiece of a book by Taplin (1879) along with heavy rafting poles and other equipment leaning against the shelter. Several similar structures in the Coorong have been drawn by Angas (Plate 3.1), and in the construction of these, the climate seems to be an important influence in the design of the shelter and number of people around the campsite. Huts of sod and timber construction have also been described for the western district of Victoria by an unidentified settler (Smyth, 1878:125-6;footnote).

Few detailed descriptions of the tools used by the Buandik exist other than to indicate that a variety of boomerangs, spears, digging sticks, clubs, shields and spear throwers were employed. The most common spear appears to be constructed from a shaft of reed joined with a hardwood tip about 30cm long, which was hardened in the fire. Wallis states that almost all wooden implements were made from sheoak (Casuarina), although spear shafts were made from the ti-tree (Melaleuca). Barbed spears are described as common and may have been made of either bone or stone flakes set in resin. Of a group of Aborigines inhabiting the western district at Goolwa Beach near the northern end of the Coorong, Angas says:

> Their weapons are the throwing stick (midlah), which is made of the she-oak (Casuarina) wood...the spear, usually with a single barb; the wadna, for striking fish; and the wirri. They carry in their wallets surplus barbs, which they attach to spears by means of

PLATE 3.1

ABORIGINAL SHELTERS

I. A hut of the Milmendura tribe, on the shores of the Coorong. On these bleak shores, the huts are built facing the northeast so as to shelter the inhabitants against cold southerly gales.

II. Sketch of a usual summer encampment on the shores of Lake Albert near Lake Alexandrina.

III. These winter huts on Lake Albert are more snugly built than amongst the northern tribes and are constructed with greater labour. When occupied, a fire is kindled at the entrance and the inhabitants huddle together inside until the hut is completely filled.

IV. A bark hut east of Adelaide.

Plate taken from facsimile of *South Australia Illustrated* (Angas, 1846).

PLATE 3.1

I.

II.

III.

IV.

> kangaroo sinews bound round them. These barbs are formed of very hard wood, scraped to a sharp point with pieces of quartz. With these spears they strike fish with extraordinary dexterity. (1847:111).

Angas illustrates numerous implements from the South East showing a variety of tools developed in the subsistence technologies; some of these are shown in Plate 6.2.

Other than the foods mentioned in the literature (Campbell, Cleland and Hossfeld,1946) and discussed in Chapter 2, little direct evidence from observation is available on the menus perused by the Buandik. The prolific herds of marsupials and flocks of water fowl which inhabited the ranges between Mt. Burr and Mt. Gambier however, astonished even the local European residents of the day. One such person, travelling near Mt. Burr, relates that he scarcely ever passed the area,

> ...without seeing a flock of emus, or a mob of kangaroos, or both, on some part of it, and the ferns, which are dense and luxuriant everywhere on the lower and sandier slopes of the range extending from Mt. Graham and Mt. Burr, fairly swarm with marsupials. On the flats wild turkeys (Plains Bustard, Ardeotis australis) are plentiful, and on the lagoons on the timbered flats stretching northward from the foot of Mt. Graham wild duck, teal, geese, and swan abound at certain times of the year. (Ward,1869).

The use of marine resources at the foreshore is also less than well documented in the ethnography. Residents of Robe remember stories that Aborigines often gathered south of the town in large numbers during the summer to collect lobster and crab and to feast on these in nearby dunes. Small parties of shellfish gatherers were frequently encountered combing the beaches looking for stranded whales or seals while they collected foods from the seafront. Foraging trips to the cliffs to gather eggs and sea birds occurred frequently in summer. The only direct observation regarding the timing of these activities comes from an unpublished source stating that "the natives disappeared and did not molest us--I've learnt since that they were on a peaceful errand to gather shellfish, the low tides at that time of the year being favorable." (Smith, Jan.7,1846). Tides from November to February are indeed lower and the waters are generally calmer than during the remainder of the year. Descendants of Mrs. Smith were told that parties of shellfish gatherers congregated near the shorelines on a regular basis, but the duration of their stay and the size of the groups is not indicated.

It is significant to note that only a single reference suggests that the Buandik made or used watercraft of any description. This is the word "wola" (canoe), which appears in a vocabulary list from the Mt. Gambier district (Curr,1886), but probably refers to small boats or rafts occasionally used on the Glenelg River (Martin, in Smyth, 1878:414). Otherwise, residents and visitors to the area make no mention of canoes or rafts. In view of the shallow watercourses and fluctuating water levels in the swamps, boat travel was perhaps unfeasible. Also missing from the tool inventory is the fish hook, which was introduced to the Lower Murray River Aborigines (Taplin,1873) during the 19th century and gradually replaced nets and spears as the traditional implements for catching fish.

Perhaps the most important plants consumed by Aborigines in the well watered areas of South Australia were the numerous aquatic flags, rushes, and flags, which grew in prolific quantities in shallow permanent water. The importance of these as staples as well as the principal material for making clothing, matting, twine and netting, is seen in the following description of bulrush (Typha) being used by the Narrinyeri, near Lake Alexandrina.

> The Narrinyeri make fishing lines and twine from two kinds of fibre. One is a blue rush which grows in the scrub; the other is the root of a flag or bulrush which grows in fresh water, and is called menungkeri. The rushes or roots are first of all either boiled or steamed in the native oven, and then chewed by the women. A party of them will sit around the fire and masticate the fibre by the hour. While they do so, the masses of fibre which have been chewed are handed to the men who sit by, and they work it up, by twisting in it on the thigh into hanks of twine, either stout or fine, according to the purpose to which it is to be applied. Others receive the twine as fast as it is made, and make it into nets. They make lengths of this net about four feet wide, and tie straight sticks of mallee across it to keep it open, then a number of lengths are tied together end to end, and it is used for catching fish or moulting ducks in the usual way. (Taplin,1873:41).

Most reports from travellers in the Coorong indicate that a great variety of tightly woven, durable mats and baskets were made (from bulrush) by the coastal inhabitants. Some of these are shown by Taplin (1879:65).

Aborigines in the Lower South East are known to have consumed a great variety of fruits and berries, which ripen in the sandhills between February and April. The most common are the Muntries (Kunzea pomifera) and the Native Elder (Billardiera spp.), both small fruits being collected in the autumn by women who bring basket loads back to their camps at the end of the day (Angas,1847). Sought for its bitter-sweet juices, the succulent Pig Face (Carpobrotus cf, rossi) is abundant throughout the dunes and can be found close to the foreshore. Although specific reference to the use of these and similar plants in the dunes are not provided with quantitative detail, it is clear that the seasonal flush of these resources attracted Aborigines to the coastal strip.

Other plants were important resources to inhabitants of the swamps, but, except for their names appearing in Mrs. Smith's vocabulary list, little is known about their roles in either the diet or the domestic activities of the Buandik. Included in this list are various gums, or resins, Bracken fern (Pteridium esculentum), sheoak (Casuarina stricta), Blackwood (Acacia melanoxylon), swamp tea-tree (Leptospermum pubescens), and many others (Campbell, Cleland and Hossfeld,1946). These resources were widely available throughout the ranges and were commonly used by Aborigines in southern Australia generally (Cribb and Cribb, 1975; Cleland,1966).

From the information discussed above, a sketch of the Buandik subsistence strategies begins to emerge. Clan territories were maintained around primary resource areas in the swamps and coastal margin in order to guarantee access and a regular flow of energy despite seasonal changes in productivity in the ecosystem. Except for clans inhabiting the volcanic highlands which might have also had access to the coast, the coastal economy appears to have been confined to the clans inhabiting the Woakwine Range, which is the most prominent landform in the territories. That the Range exerted an important influence on the subsistence strategies in the past is suggested by the numerous clusters of earth covered huts and the extensive network of main trails connecting camps throughout the full length of the ridgetop. This picture is consistent with the Range as a major ecotonal boundary between the inland swamps and the marine environment, from which resources changes in each zone could be surveyed and effectively monitored. For these groups then, seasonal shifts in resources stimulated by regional climatic and hydrologic conditions, became the basis of divisions in economic focus between coastal resources in the summer, and winter exploitation on the Ranges and swamps.

The ethnography of the Buandik indicates that seasonal strategies may have operated differently according to the size and organization of clan groups. Shellfish collecting groups for example, visited the coast at a certain time of the year, and individual families appear to have claimed ownership of particular lakes, swamps, or embayments, suggesting that a flexibility in group organization permitted population density to adjust to the seasonal changes in resource supply. The data are insufficient to describe this mechanism for the Buandik however, and in an attempt to provide resolution of this situation, the discussion will now briefly consider another Aboriginal group at the periphery of the swamps.

THE TANGANEKALD SUBSISTENCE MODEL

The Tanganekald lived in the Coorong (Tindale,1974) in a setting closely resembling that of the Lower South East. A wide, shallow lagoon separated the narrow coastal strip of sand dunes from a zone of mallee scrubland which stretched inland across ephemeral swamps. The dunes are covered with sparse, low vegetation of sword grass, saltbrush, pigface, and a number of fruit and berry-bearing plants, while more dense cover surrounds the lagoon itself, including various tea trees, reeds and stunted malleeforms. The beach is entirely sand covered and the only food regularly available is the cockle Plebidonax. Fresh water is present in only a few springs in the dunes, but is more widely available near the swamps further inland. The distribution of these resources in clan territories has been mapped by Tindale according to his informant Milerum (1974:25,67).

The only significant environmental differences between the Lower South East and the Coorong are rainfall patterns and vegetation forms. Precipitation in the Upper South East is uneven, with an annual average of about 300mm. This increases and becomes more reliable to the southeast. Fed by flood waters from the southeast, a wide expanse of shallow, intermittent swamps form between low dune ridges inland from the lagoon during the winter. These rapidly diminish at the onset of warmer weather. The vegetation is comprised of either open heath or mallee woodland with patches of grass cover and little understorey vegetation on the stretches away from the coast, while the coastal scrub is exceedingly sparse. Under these circumstances, human population densities would be lower than those in the well watered Lower South East, but given similar ecologies, economic organization in both places should be similar.

Numbering between 20 and 22, each of the Tanganekald clans inhabited a territory measuring about 15-25km along the coastline and 25km inland. Clan size ranged from 20 to 30 individuals and each clan maintained territorial boundaries around principal resource areas, including swamps, lagoon and a strip of the foreshore. In this, a transect of the landscape oriented at right angles to the coast belonged to each clan, resembling the configuration of clan territories of the Buandik. Tindale indicates that, generally speaking, clan ownership of the resources within its country was paramount and that except under negotiated terms of settlement, neighbours did not trespass without fear of rebuke or punishment.

The principal food of the Tanganekald was fish, but other important foods included shellfish, waterbirds, and various marsupials adapted to the dry conditions of the hinterland desert. The two most common fish are the Mulloway (Sciaena antarctica) and the Yellow Eye Mullet (Mugil foresteri), which were taken from the lagoon. The largest of these, the Mulloway, is found shoaling in brackish and fresh waters during the summer and is easily caught by net and spear in sizes up to 30kg. The Mullet, on the other hand, inhabits the brackish lagoon in large numbers and, as a small fish, is generally caught in nets. Besides the fish, the lagoon supported an enormous quantity of migratory birds, including duck, swan and teal, in addition to more permanent residents such as heron, pelican and emu. The marsupials exploited by the Tanganekald are not specified, but are likely to have been the Red-Bellied Wallaby (Thylogale billardierii), the Western Grey Kangaroo (Macropus fuliginosus), Toolache (Macropus greyi), and wombat, each of which were common in the area in the past (Jones,1923-25; Finlayson,1927).

Plant resources used by the Tanganekald are rarely identified in print, although frequent mention is made to the use of muntries, rushes and the Pig Face succulent. Presumably the large woven bags and baskets carried on the back of women and children were filled with these foods after a day of foraging.

According to Tindale, Tanganekald subsistence strategies were influenced by climatic conditions, changes in relative food supply, and the hostility of inland neighbours. Two broadly defined seasons emerge from this information, each with its own pattern of clan behaviour and menus. These are the summer and winter habitations, and these can be considered separately.

Lagoon resources figured heavily in the annual food quest but appear to have been exploited mostly during the summer. Traps and nets in each clan territory were set up and monitored by the male members of each family on the coastal edge of the lagoon, where access to coastal resources was unhampered. Mullet and other small fish were caught in stone traps with the aid of other household members, and the campsites nearby consisted of a flimsily built brush and stick shelter to afford protection against winds and the severe noonday sun. One of these camps with several inhabitants is shown in Plate 3.1ii, with the sea in the background; this reflects the open atmosphere of the camps and the informal organization of the campers around them. Tindale (1974:62) indicates that women went from the camps daily in search of foods in the sandhills, and to collect Plebidonax from the beaches. Wood was carried from the lagoon halfway to the beach and the catch was cooked there on the return trip so as to reduce the carrying burden. As a consequence, few shellmiddens appear on the foredunes. Although the role of the waterfowl is not specified in the literature, the arrival in the Coorong of large flocks is correlated with diminished foods in their nesting grounds on the Murray River. They arrive in late January or early February and depart sometime in late autumn, and thus would have been a huge boost to the summer economy on the coast. Other resources occurring in great quantities in the dunes are various berries, fruits and succulents, all of which ripen sometime after February. During the summer then, most of the Aboriginal population was concentrated in a narrow stretch of dune country with its main economic focus directed to lagoon and marine resources.

During the winter months, people moved to the inland side of the lagoon, which was relatively sheltered from the ocean storms and had adequate supplies of firewood and house timber. Huts, consisting of a timber frame shaped like a beehive and covered by pipeclay or mud, were constructed within a few metres of the lagoon shores, close to the stone fish traps. The occupants of the hut appear to be family members who owned that particular part of the clan territory and who claimed ownership of the resources within a designated area. The reasons for establishing households at the edge of the lagoon are not clear. This may have been influenced by fear of hostile neighbours further inland, who may raid the fish traps, or simply because the traps required constant attention.

The focus of activity during the winter was influenced by the dispersal of resources into the swamps, by departure of seasonal resources such as migratory birds and some fish, and by the misery of the winter wet. Families appear to have taken up residence within their territory and to have operated between the lagoon and the nearest inland swamps. Rising water levels in the swamps would have provided adequate nesting grounds for some bird populations, but would have forced herds of kangaroos and wallabies onto high ground where they could be more easily pursued and caught. With the downturn in plant life and dispersal of wildlife, community life of the Tanganekald appears to have been disbanded and, according to Angas, staples were sometimes scarce. Fires were hard to keep lit and wet wood was difficult to burn as the rains became heavier in June and July. Compared with the summer habitation then, winter subsistence strategies involved dispersion of primary groups across a wide area and may have been characterized by low levels of group interaction, considerable discomfort and hunger. The primary foods consisted of fish, kangaroo, waterfowl and few plant resources procured between May and November.

The main distinction to be made then between winter and summer habitation strategies of the Tanganekald is the change in organization of groups around primary resources as they become scarce seasonally. The pattern of winter habitation is characterized by exploitation of lagoon and swamp resources by small groups dispersed over a relatively wide area. In summer, the population appears to increase in the coastal margin and is organized around locally abundant resources which are available for a relatively short period of the year. The strategy then seems to emphasize maximum exploitation by as many people as possible, even including cooperative efforts by neighbouring clans. The essential characteristic of the summer subsistence strategy is seen then in the relaxing of claims of resource ownership in order to pool manpower and share profits. Accepting the general ecological balance in the plant and animal communities identified in the ethnography, we can suggest that optimum summer conditions for habitation took place between January and April, and that winter lows in the food supply occurred between June and October when the swamps were the highest and temperatures were lowest.

That this is a feasible reconstruction of the Tanganekald organization is seen in the archaeology of the Coorong near Salt Creek.

There, flints, hearths, some small stone ovens, and small scatters of Plebidonax shells litter the edge of the lagoon, whereas Plebidonax middens are more frequent midway between the lagoon and foreshore. This picture is consistent with Tindale's account and confirms that valuable commodities are moved toward the principal economic focal point at the lagoon.

With the Tanganekald habitation strategies at hand, the discussion can now consider Buandik subsistence strategies. The similarities in the resources available to each of these groups can be seen in the description above and indeed, the ecosystems inhabited by each undergo identical seasonal shifts. As well, the distribution of clans across the principal ecotones is identical in both settings, which suggests similar organization strategies. The one major distinction to be made between the two areas however, pertains to the seasonal behaviour of the swamps in the Lower South East. It remains then to consider the influence on winter habitation of the Buandik by permanent water in the swamps.

The hydrology of the swamps must have been an important factor in the wintering subsistence behaviour of the Buandik. The waters at Narrow Neck (Cootel Swamp) which backed up towards Kingston in 1864 are the same flood waters Angas crossed at Ross's Creek in the winter of 1844, which flowed into the sea nearby. For this flow to have occurred, a sheet of water would have had to have formed between the Reedy Creek and Woakwine Ranges for a distance of about 120km to the southeast of Kingston at depths up to 5m during the peak winter stand. The floodwaters created at this period would effectively prevent access to more inland locations anywhere on the Range except by water travel. The Wyrie, Pompoon, Mayurra and German Creek Swamps would similarly be flooded, leaving the Buandik with a swelling shoreline and a shrinking landscape from which to make a living.

THE BUANDIK SUBSISTENCE STRATEGY

Some aspects of the Tanganekald food quest have been considered in conjunction with seasonal changes in climate and swamp hydrology, in an attempt to reconstruct Buandik subsistence strategies. The data invoked to accomplish this are sketchy and therefore limit the discussion to broad generalities involving simplistic relationships between man and his environment. Nevertheless, certain conclusions may be inferred from this examination which will be useful in identifying the archaeological record of the Buandik.

A cross-section representing the land occupied by the Buandik clans (Figure 3.2) shows the principal resource areas available to coastal groups together with the foods known to have been consumed during the 19th century. The Woakwine Range is the most prominent landmark in the clan territory and represents the seaward extent of Eucalyptus woodland in the area. With its deepest stand at the base of the Woakwine Range, a shallow swamp stretches across the interdune flats towards the Reedy Creek Range for a distance of about 15km. Seaward, are a number of lakes or lagoons in the interdune corridor and beyond these are the sandhills of the Robe Range, and the ocean front. Unlike the sparse cover of the Upper South East, the coastal vegetation in Buandik territory consists of relatively dense Melaleuca/ Eucalyptus/Leucopogon woods across most of the Robe Range, which serves as an ideal habitat for various small animals and provides fuel, construction timber and shelter for human habitation. Several coastline morphologies are featured, but the most favourable are reeflined beaches where a wide range of fish, molluscs, crustaceans and flint nodules are readily available. This close association of complex ecotones supported abundant resources enabling the Buandik to find year round food supplies within a comparatively small area. Provided with an exceedingly productive plant and animal community in the coastal strip, the Buandik probably could include a greater range of resources in their summer diets than could their neighbours in the Coorong.

The primary economic activities of Buandik summer habitation in this environment are most likely to have focused on the resources of the coastal margin and the seaward slopes of the Woakwine Range. Shown in Figure 3.2, these were available in the sea, sandhills, swamps or lagoons within easy access from almost anywhere on the Range. Using the Tanganekald model, summer camps were established near the boundaries of each of the principal ecotones. For the Buandik, this probably meant camps were located in the interdune corridor where a constant vigilance could be kept on Lake Bonney, Lake Frome and the other lakes to the north of Beachport. The coastal scrub provided shelter and additional animal and plant foods. From the high ridges, both the lagoon and the ocean could be viewed with advantage. Indeed, we are told by a friend of Mrs. Smith that individual families identified with

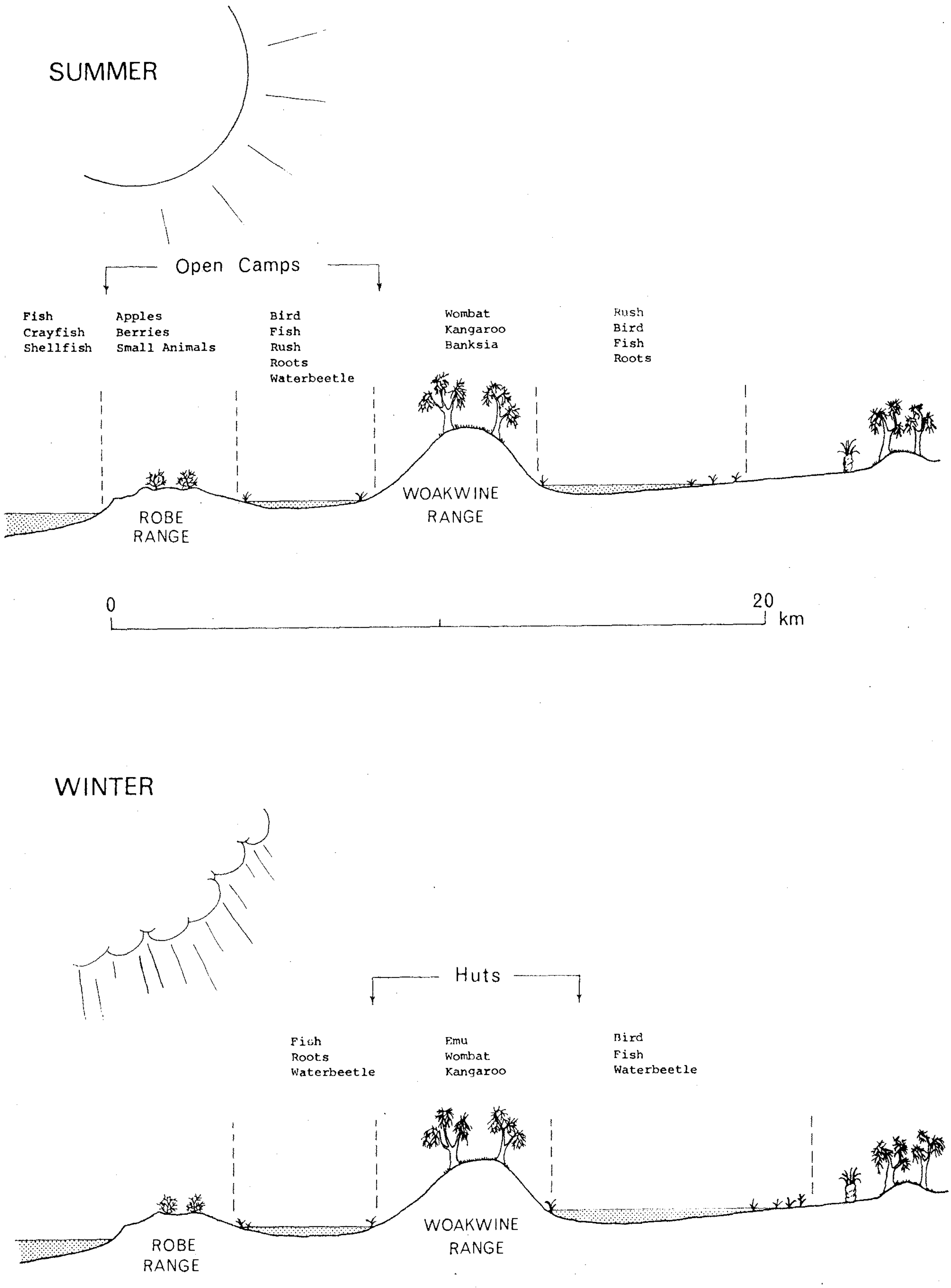


Figure 3.2 Diagram of seasonal land usuage pattern of the Buandik based on ethnographic, hydrologic, and environmental data. Foods mentioned are those identified from 19th century observation.

specific lakes or swamps in the interdune corridor and spent a considerable part of the year within the territory. Those groups which visited the foreshores to collect shellfish, birds' eggs and to dive for lobster were probably camped in the sandhills, where they would return for the night. If this was so, the strategy of the summer habitation was to maximize contact with all resources from a central location. Movements parallel to the coastline as well as across the sandhills probably forced a string of habitation sites to emerge as the groups shifted with the change in local supply. There is, however, insufficient evidence to indicate whether or not seasonal base camps were involved in the summer habitation.

In addition to habitation camps, special focus activities would be expected at the foreshore, at the lagoon, and scattered throughout the scrub wherever particular resources were being exploited. These might be associated with shellfish collecting, reed gathering, duck hunting huts, or net fishing to name only a few such activities.

The timing of the summer habitation at the coast would coincide with the advent of warmer weather and improvement in living conditions in the coastal margin. In spring, bird eggs, nesting and moulting waterfowl, shellfish and many small animals driven into seclusion during the winter are available in increasing numbers as the temperatures rise. The peak period of exploitation therefore took place between January and about April.

The winter habitation is more difficult to describe in detail, but the dispersal of swamp resources by the rising water levels and the cold wet of the winter climate are believed to be important determinants of places to live and movements away from the camps. In the most severe part of winter, huts were located on high ground, probably in sheltered spots near the high water mark of the swamps. There, nesting birds, small fish and beetles could be caught and an abundant supply of firewood was available. It is uncertain whether these camps occurred near the more permanent swamps or were located near shallow water at the perimeter of the swamp system. Whatever the case, it is clear from published accounts that the Woakwine Range itself was a central focus of wintering camps and that groups congregated on this and more inland dune ridges. Since the swamps were largest at this time, direct communication between groups was limited and the size of these groups would have been small.

In light of this reconstruction of the Buandik subsistence strategies, we can consider the archaeological implications of habitation patterns in the coastal economy. As a result of resource exploitation, at least three types of archaeological residues will occur, recognized on the basis of contents, location and morphology.

The first and simplest type of deposit pertains to single focus activities at the site of procurement, and examples mentioned in the ethnography include fish weirs and traps, duck blinds, snares and fencing and various other paraphernalia used for the ambush of game. Obviously, archaeological traces of these activities will be scant unless associated stone tools or less perishable residues can be used as a basis for identification. The second and more complex type of deposit will be located away from the site of procurement and relates to the processing of one or more resources for consumption. The party of women shellfish gatherers who brought wood into the sandhills of the Coorong and returned to cook their catch would have left kitchen middens of scattered shell and a hearth. Likewise, scatters of crustacean parts around a hearth would have been left by lobster and cray divers near Robe. The groups of women who retrieved reeds from Lake Alexandrina constructed ovens nearby from stone or clay to steam their meal. The group membership at these camps may be determined by any number of factors, including family affiliation, age classes, sexual roles, or skill, but the size of the groups are probably generally small and reoccupation of the same campsite is likely to be limited. The residues left behind will then be discrete deposits and the general character of the occupation will reflect a limited economic focus by groups in transit.

The third type of deposit will be derived from habitation in the major ecotone and will reflect exploitation of the range of major resources available within that zone. For the Buandik, these ecotones are located at the edges of the lagoon, the coastal scrub and the Woakwine Range. Huts and informal shelters will be erected in the camps, and cooking and other domestic activities, as well as construction and maintenance tasks will be performed during occupation. Although many huts may occur at these locations, no evidence suggests that large groups occupied the camps or that occupation continued for long periods of the season. Therefore these camps are more likely to have shifted within the ecotone or may have relocated in an adjacent ecotone. The archaeological residues in these camps then reflect technological and economic diversity, heavy use of the campsite location, and recurrent occupation.

The seasonal distribution of these three types of sites throughout the annual food quest will correspond to the habitation patterns outlined above. Habitation camps of the Buandik will appear at the edge of the lagoon or in the scrubland of the sandhills during summer, and on the Woakwine Range during winter. The other two types of sites are difficult to place on the landscape with accuracy, but are expected to reflect the daily foraging range from the habitation camps. In the summer, this range may be comparatively short due to the abundance of resources everywhere, whereas in winter groups may have been committed to more frequent foraging trips over greater distances in search of foods. The residues will then accumulate near high water mark of the swamps and along the range tops during winter, and along the clifflines, the scrub zone of the sandhills, and around the water-line of the lakes and lagoons in summer.

The summer diet will be distinctive by its seasonal constituents of shellfish, fruits and berries. Only broad differences in the consumption of other foods however, can be used to distinguish seasonal habitation. Plants and seafoods, including some aquatic birds, will dominate the summer menu, while more vertebrates, small swamp fish, tadpoles and beetles will characterize the winter diet. In this list of resources, the best seasonal indicators will be the shellfish, and if preserved, the plants. Resources exploited exclusively during the winter are not known.

The technological attributes of each of the three types of sites will be determined by the functions to be performed, the social and sexual composition of the group, and other factors which are variable in time and in space. Distinguishing characteristics are therefore too elusive for a discussion of tool kits to be of use in this study. The only solid reporting on this topic (Tindale,1968:625) indicates that Tanganekald women were forbidden by men from handling cutting tools. As a consequence, the women allowed their thumbnails to grow and used these to cut reeds, open fish and to scrape roots. A women's campfire would then contain few, if any sharp stone implements designed for extraction and a women's tool kit would be limited to food preparation and processing tasks as is suggested by grinding or pounding stones, water containers and so forth.

We have considered the Buandik seasonal food quest and have identified the primary archaeological record which will be created by the economic strategies operating in the coastal margin. The discussion can now review previous archaeological investigations and the results of a survey conducted during this investigation.

CHAPTER FOUR

THE ARCHAEOLOGICAL RECORD

INTRODUCTION

The South Australian Museum and its associates have amassed a large corpus of environmental, ethnographic and archaeological data pertaining to Aborigines and their particular relationships to the land. Much of this information has been incorporated into the preceding discussion. The state's first archaeological investigation was conducted in stratified cave deposits on the banks of the lower Murray River near Adelaide (Hale and Tindale, 1930; Tindale and Cleland, 1936) and produced the earliest definitive evidence of cultural succession in Australia. Later investigations (Mulvaney, 1960; Mulvaney, Lawton and Twidale, 1964) expanded the local record while areas further to the south, including Kangaroo Island, were being explored (Cooper, 1943, 1959, 1960; Tindale and Maegraith, 1931). Using single type specimens from only a few dated and stratified deposits in South Australia, Tindale (1957a) has erected a cultural succession for southeastern Australia spanning the Holocene. Mulvaney (1961) has drawn attention to the dangers of using poorly defined and dated markers to relate technological traditions across distant areas, and has recommended that attention be given to historic continuity.

The development of the archaeology of the South East has been based almost entirely on surface investigations conducted by personnel closely familiar with the area's natural history. Tindale spent some of his childhood days with relatives near Kingston, and later attempted to interpret the coastal geology (1947, 1952, 1959). A trained geologist, Hossfeld (1950) joined with botanist and field naturalist Sir John Cleland and T.D. Campbell, who was a medical practitioner from the district, to study all remaining traces of the Buandik. Their efforts produced a greater understanding of the ecological implications of the field evidence than was commonly the case at the time. The following discussion summarizes some of their findings and sets the stage for the direction taken in this study.

SURFACE DEPOSITS

Surface deposits have been the subject of two principal surveys. The first (Campbell and Noone, 1943) located and described ten campsites on the Woakwine Range and the coastal dunes in the general vicinity of Millicent. The description concentrated upon morphological traits of a portion of the tool kits and upon the techniques of manufacture of certain microliths. The technologies on more inland ranges consisted mainly of large scrapers and planes generally associated with woodworking, whereas those of the coastal margin were principally microlithic. Although these industries are not mutually exclusive in their spatial distribution, the morphological distinction was seen as a reflection of heavier timber stands on the ranges than on the coastal dunes.

The survey was subsequently extended (Campbell,Cleland and Hossfeld,1946) to include over 30 additional site complexes. The tools collected from both surveys were formally classified according to morphological traits identified in statewide surveys and specimens from each class have been illustrated. No attempt was made however, to define the morphological traits used to sort tools into groups, nor were the tool assemblages associated with particular campsites fully described.

Although the technological character of individual campsites is not described in detail, the second survey clearly reveals a morphological and technological complexity consistent with the ecology of the area. Coastal resources, such as shellfish and flint occur more frequently in the coastal margin, in association with microlithic industries, whereas larger tool types, suggesting wood working, are more common at the edge of the lagoon and on the range slopes where wood is more readily available. Some campsite aggregates, described as extending for a kilometre or more on the range, consist of numerous hearths, knapping debris with large tools, and occasional shellfish (Subninella) scatters. The intensity of occupation and the range of site types seem to increase in the vicinity of Lake Bonney and further to the south along the coast. Whether or not microlithic components are mixed with other tool types is not clear from the survey data, but microlithic workshops at which 150 or more implements were recovered is a common occurance throughout the area. The profusion of these deposits therefore clearly underscores the very considerable exploitation of lagoon and coastal resources in the past and suggests that the interdune flats were a major staging area for a variety of economic activities.

A collection of bifacial axelike implements has been described from the vicinity of Cape Northumberland south of Lake Bonney, and identified as "Buandik bifaces" (Stapleton,1945). Although stratigraphic provenience is not described for these finds, they are believed to be quite ancient (McCarthy,1967).

THE DATED EVIDENCE

The oldest dated evidence of human occupation in the district comes from the A horizon of an eroded terra soil at Cape Martin near Beachport (Tindale,1957b). The remains, which were excavated from the surface, include a scatter of deeply patinated flint tools and flakes in addition to the molluscs Chione (referred to as Katelysia in this study), and Mytilus, both lagoon species. Charcoal from a concentration in the horizon described as a hearth has yielded an age of 8700±120BP.

Two difficulties accompany these finds. The first concerns the possibility that cultural materials found within the terra rossa are not necessarily related either to the soil formation or to each other. This difficulty arises in many coastal settings involving high energy deposition and is considered further below. Equally important is the fact that on projected sea level curves for this part of southern Australia (Thom and Chappell,1975), the coastline 8000-9000 years ago would have been about 30m lower and 15km further to sea than at present. If the molluscan assemblage present in the soils represents food refuse from an 8700 year old occupation, the source could not have been close to Cape Martin.

In 1963, a test excavation (Campbell,Edwards and Hossfeld) in a shelter near the summit of Mt. Burr uncovered a similar antiquity for human occupation. Cultural remains occur throughout 4m of an otherwise unstratified aeolian sand matrix and include flint tools, knapping debris, and bone tools, as well as a variety of vertebrates, emu egg shells, and molluscs. The shellfish, identified as Brachidontes and Velesunio, are present only as small fragments. Charcoal from 6 excavated levels in the shelter has produced ages in correct stratigraphic sequence from basal layers upwards, and these appear in Table 4.1 below with corresponding depths for each layer as measured from the surface. Small tools and microliths form a significant element in the site technology during the last 1000 years, but are absent earlier. No diagnostic tools occur in the lower levels, and the total number of implements is low relative to the volume of sediments excavated.

Depth to base of level (m)	Antiquity
.30	320±90
.61	380±90
1.2	1020±40
2.1	7030±40
2.6	7450±270
3.3	8600±300

TABLE 4.1 Radiocarbon dates for Mt. Burr Shelter from charcoal

From this dated stratigraphic sequence, it is clear that two distinct periods of occupation are suggested; an early period dated to between 7000-8600BP, and a later period, dated to between 320-1020BP. Despite nearly equal sedimentation rates (1.2mm/annum) during each of the two occupations however, less than 90cm of sedimentation occurred during the intervening 6000 years. No stratigraphic explanation was offered for this disparity, and because the porosity of the local soils could have allowed downward movement of occupation refuse, the question was pursued further.

The original trench opened in 1963 was left open and the walls were still well preserved in 1973. An inspection of these revealed that no stratigraphic indicators are present in the 4m of deposit and that the calcareous sand matrix was a uniform brown-red in colour. In one area however, a distinctive sedimentary feature consisting of a dark, loose soil appeared to have intruded into the deposit. Measuring about 35cm wide, the feature penetrated 3.2m of the sediments with sharp vertical boundaries beginning immediately below the surface. Compared with the surrounding matrix, this soil contrasted in colour, texture and compaction and was certainly encountered in the 1963 excavation, although no mention is made of it in the excavation report. Considering that this feature may be an erosion channel which was filled with recent sediments, including occupation debris, the discovery raises doubts about the associations within these dated levels which are too serious to ignore. Therefore, the Mt. Burr finds have been put aside in this discussion pending further study of this matter.

About five kilometres south of Cape Buffon at Bevilaqua Cliffs, another dated midden sequence has been described (Campbell,Edwards and Hossfeld,1963). Like the Cape Martin evidence, two different occupations occur in stratified position on the cliffs overlooking the sea. A small number of nondescript tools in association with Plebidonax on terra rossa underlies an upper horizon of reef gastropods, including Subninella and Cellana. Unlike the older stone material, the flint associated with the upper layer retains both its original colour and lustre. The stone tools recovered are not diagnostic of any particular technological tradition. Charcoal from hearths associated with each horizon yielded dates of 8250±60BP and 760±50BP respectively (see Hossfeld,1966:83 for photographs of the section). An unidentified "marine shell" was recovered from loosely cemented aeolianite above the oldest cultural deposit and has yielded a date of 6350±100BP (Gak-423; Kigoshi and Kobayashi,1966). Professor Kigoshi of Gakushuin University has tentatively identified this as Plebidonax on the basis of comparison with type specimens (pers. corres.,1976). This is the oldest evidence of shellfish gathering for the district in which direct radiometric determinations are involved.

Several shell middens in other localities document a wide range of shellfish gathering activities. At Cape Northumberland, shown in Figure 2.4, a large midden composed of the reef gastropods Cellana, Subninella and Haliotis has been described (Tindale,1957b). The technology consists solely of two types of scrapers or planes, which occur in low numbers compared with the large quantity of knapping debris. Charcoal from the basal layer produced a date of 1470±120BP, and claystone pipe fragments and coins are associated with surface scatter suggesting occupation during the 19th century.

In unpublished work on three rock shelter deposits in the lagoon between Cape Martin and Robe, Edwards (pers. comm.) has uncovered evidence of exploitation of ocean and lagoon resources. Two shelters, labelled Shelter 1 and Shelter 2 in Figure 4.3, contain shallow accumulations of Subninella and limpet in a thick matrix of blockfall from the calcarenite outcrop on the leeward face of Lake George. Bird and mammal bone is preserved in these deposits, but is uncommon. A third excavated shelter, situated on the southwest shores of Lake Robe (Figure 4.4), contained one metre of stratified habitation material. Again, bird and other bone remains were well preserved, but were not common. Each of the three deposits rests on fossil shellbeds near mean sea level, and thus may have been washed by tidal waters when the lagoon was open to the sea. On the basis of preservation, these three deposits are all recent.

Before summarizing the dated archaeological record, it is necessary to comment on the apparent antiquity of artefacts in older soils in light of the complex sedimentary process involved in their burial. The typical soil profile encountered near the coast has been described by many workers (Tindale,1957b; Firman,1973) and is presented here (Figure 4.1). The sequence consists of a basal calcarenite or kunkar overlain by a fine grained terra rossa soil, which in turn underlies a series of medium to coarse grained calcareous sands. The upper horizons of the sands are invariably loosely compacted and contain artefact bearing soils distinguished as black organic layers of varying thickness. The lower sands are often lightly cemented and rarely contain implements. An unconformity always exists with the terra rossa indicating that sediments of both the soil and the sand units may be missing. Occupation refuse, such as shell, charcoal and implements commonly occur on the surface of the terra rossa or in its upper horizon to a depth of about 10cm.

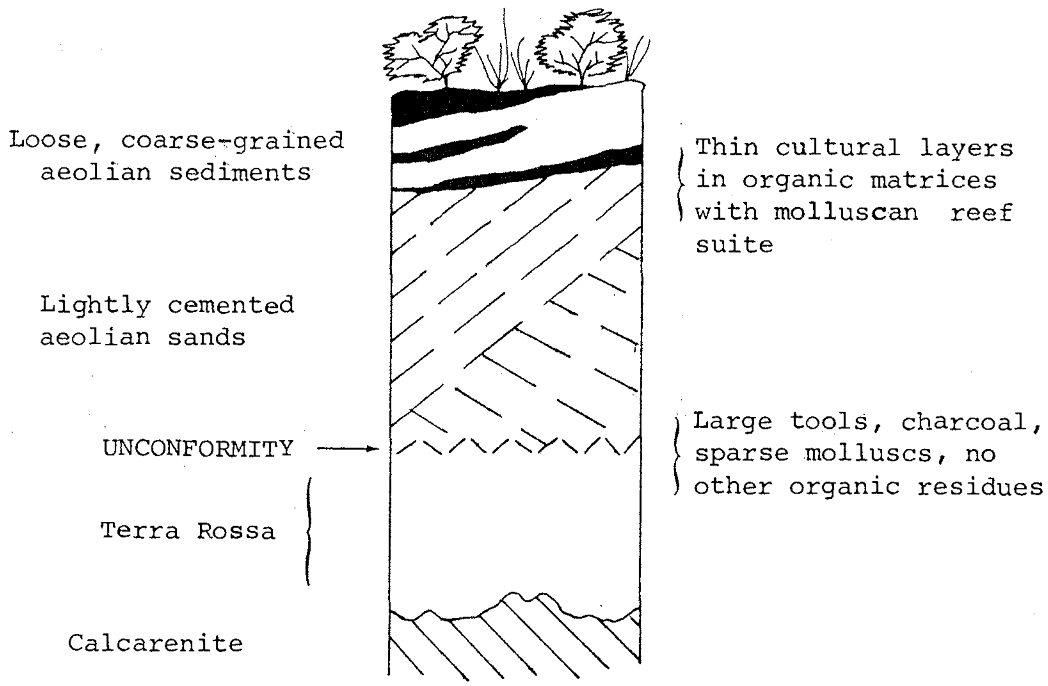


FIGURE 4.1 Typical soil matrix containing archaeological material at the coastline.

The existence of the unconformity between sand and terra rossa soils means that the latter can become a repository of more recent occupation refuse. It is therefore reasonable to question the specific associations of artefacts within the ancient soil when they are argued only on the basis of proximity, which is the case at Cape Martin and Bevilaqua Cliffs. Since the terra rossa is the product of long term weathering, (Blackburn,Bond and Clarke,1965), which is destructive to fragile organic remains, the preservation of shellfish or charcoal in the soil would not be expected. Until fauna, implements and hearths can be shown to be related by acceptable excavation methods, the archaeological picture of early horizons at Cape Martin and Bevilaqua Cliffs is clouded in stratigraphic and geomorphic uncertainty, especially in terms of the exploited fauna. In light of the complex processes of burial described above, the excavation data provides unconvincing evidence of association between occupation residues and the soil. Therefore, the charcoal based ages for the cultural horizons at the two sites 1) indicate a maximum antiquity for the occupation, and 2) may not relate to the fauna.

A summary of the dated deposits in the Lower South East, Table 4.2, shows two distinctive periods of occupation. The first will be labelled Early Horizon, and the second is the Late Horizon. Stratigraphically, the Early Horizon material is related to a terra rossa soil in an uncertain association, whereas the late material almost invariably is associated with dune sands. Both horizons occur at the coast and inland, although components of each are not necessarily equally distributed in space.

Antiquity		Site	Associated Fauna
EARLY HORIZON			
8700±120BP	(NZ-69)	Cape Martin	?Katelysia, Mytilus
8600±300BP	(Gak-429)	Mt. Burr	?Brachidontes
8250±60BP	(Gak-397)	Bevilaqua Cliffs	?Plebidonax
7030±40BP	(Gak-428)	Mt. Burr	?Brachidontes
6350±100BP	(Gak-423)	Bevilaqua Cliffs	Plebidonax
LATE HORIZON			
1470±120BP	(Gak-336)	Cape Northumberland	Subninella, Cellana
?		Cape Martin	"
1020±40BP	(Gak-426)	Mt. Burr	?Haliotis, Brachidontes
(?) 1000BP		L. George Shelter 1	Subninella
(?) 1000BP		L. George Shelter 2	"
(?) 1000BP		L. Robe Shelter	"
760±50BP	(Gak-398)	Bevilaqua Cliffs	"
380±90BP	(Gak-425)	Mt. Burr	?Velesunio ambiguus
320±90BP	(Gak-424)	Mt. Burr	? " "

TABLE 4.2 Radiocarbon dates for the Lower South East Archaeological record, from excavated deposits.

Technological distinctions also accompany these two horizons. The Early technologies, found at Bevilaqua Cliffs and Cape Martin, contain large, deeply patinated flake tools which have been related to a Tartangan Culture (Tindale,1957a,1968) and could also be assigned to the Australian Core Tool and Scraper Tradition (Bowler, Jones,Allen and Thorne,1970). The Late Horizon material on the other hand, consists of a wide variety of smaller flake tools, including a microlithic component. These rarely exhibit deep surface weathering and are typically associated with molluscan remains. The Late Horizon technology can therefore be assigned to the Australian Small Tool Tradition (Mulvaney,1975; Gould,1969,1973).

The earliest firmly dated fauna is Plebidonax, which occurs at Bevilaqua Cliffs at approximately 6300BP, and this represents the earliest evidence of shellfish gathering in the area. The Late Horizon fauna represent a marked change in diet and habitat which seems to suggest that changes in coastline morphologies may have taken place during the occupation. The composition of the midden fauna may therefore be used to estimate the relative antiquity of the respective occupations.

The published description of the archaeology of the Lower South East reveals a rich and diverse range of campsite debris in both the swamps and the coastal margin. The characteristics of the settlement resemble the picture uncovered in many other areas of southern Australia in morphological, sedimentological and chronological terms, and these similarities will be examined in a later chapter. The results of the field survey in this research can now be considered in light of this framework.

A SURVEY OF THE FIELD EVIDENCE

A ground survey was conducted to examine and describe the archaeological deposits within the coastal margin between Robe and Cape Banks, near the southern exit of Lake Bonney. With the inland boundary formed by the Woakwine Range, the research area included about 600 square kilometres. The survey was conducted along transects located both across and parallel to primary ecotones, including the range, lagoon, sandhills and ocean front. Four transects spanning the margin from sea to range over a width of 2 kilometres were searched. These originated at Cape Lannes (Robe), Cape Martin, Cape Buffon and

Canunda Rock (northern end of Lake Bonney) and were roughly parallel strips approximately 10km in length each. Sites in these were located, assigned numbers and described. Less extensive but equally comprehensive searches were made of the lagoon edges north of Cape Martin and south of Cape Buffon in the vicinity of Lake Frome. Because of the great variety of coastline morphologies encountered, the entire shoreline was searched between Cape Lannes in the north and Canunda Rock. The beach further south was spot checked on foot at several localities. In this manner, attempts were made to sample all significant sources of environmental variation.

The coastal margin in adjoining districts was also investigated, although in a less systematic way. This involved visits to Kingston, S.E. Salt Creek, and Goolwa Beach on the Coorong, and to various localities to the southeast as far as the Victorian border. In so covering 400km of coastline, it has been possible to more clearly recognize general patterns of site density and composition as they might correlate with the regional marine ecology.

Sites were located on South Australian Department of Lands Topographic Maps 1:50,000 Series (1971) and assigned a number according to a grid system appearing on each map sheet. Once positioned within a grid, a deposit received the number of that grid as determined by the intersection of latitudinal and longitudinal lines in the Southwest corner of the square. A site number appears after each grid number in chronological order of discovery, and in this text these will follow the description of each site, as for example Nora Creina Shelter (${}^{3}97^{58}68$-2). The area enclosed within each grid is one square kilometre.

To assist in the discovery of buried archaeological deposits, a pointed steel probe 1.2m long was employed throughout the investigation. Designed with a deep channel running its length to collect soil, the small diameter probe is able to retrieve continuous miniature cores. By merely pushing it into the ground and twisting in one direction, a series of samples can be taken in a short span of time. Calibration between readings on the probe and their actual profile in the ground was gained simply by comparing measurements with excavated sections. In this manner, shell-middens were distinguished from shellbeds, soil profiles were traced, and the horizontal extent of deposits plotted.

Property owners have been a significant source of information on the location of archaeological sites and have offered helpful comment upon the past and present conditions of the field evidence. Some of this information describes the conditions surrounding original settlement of stockmen and farmers.

The most remarkable character of the archaeological record is the fact that much of it survives intact on the surface, retaining much of its original organization. Small, discrete heaps of shellfish are a dominant depositional component in the coastal margin even when they combine to form dense accumulations, and these can easily be distinguished upon inspection. Associated knapping material exposed on the dune surfaces is readily reassembled on the spot or can be described and related to adjacent manifestations. Similarly, some debitage occurring on the Woakwine Range can be shown to associate with other knapping debris on the surface. Hence it has been possible in many areas to describe a large cross-section of sites in terms of contents and associations without resorting to excavation. Although similar conditions are seen to exist in similar settings in Australia, the obvious advantage in this South Australian record is the repetition or patterning of the smallest depositional units, the shell heaps, in an exposed state. An analysis of these units would more reasonably approach the cultural and environmental realities ultimately sought in studies of this sort (Ambrose,1967:183).

Site preservation is not uniform throughout the research area. Constant sea winds, winter storms and sea spray attack foreshore deposits. The degree of disturbance is influenced by local factors such as vegetation cover, aspect and elevation above the tide. Wind erosion is a persistent factor even away from the sea wherever vehicular traffic, fire or animals have broken the plant cover. Spectacular dune migration north of Cape Martin on the Robe Range has resulted in massive dunes encroaching upon the three lakes in that area. This problem is especially acute between Five Mile and Ten Mile Rocks north of Beachport where dunes exceed 20m in height on the shore of Lake George. South of Robe, property owners report finding stone artefacts in plough furrows near Lakes Eliza and St. Clair (Domaschenz, Danialson, pers. comm.). The Woakwine Range southeast of the Narrow Neck has been almost entirely cleared of timber and turned to pasturage, making it difficult to find occupation debris owing to increased grass cover or erosion.

Enough well preserved archaeological material exists in all major areas of the district however, to provide a comprehensive description. These areas include 1) the Robe Range, 2) the lagoon, 3) the inland ranges and adjacent swamps and 4) the Mt. Burr Peninsula; and each is described below.

THE ROBE RANGE

Shellmiddens are concentrated in three principal areas of the Robe Range (Figures 4.2,4.3,4.4), and are most numerous at foreshore clifftops wherever extensive platform reefs occur. At these localities, the middens are shallow, stratified heaps of food refuse which consist of the same suite of gastropods found living on the reef today: Subninella undulata, Cellana tramoserica, limpets of the genera Patelloida and Patellanax, and species of the abalone Haliotis. The presence of discrete shell lenses in these suggests repeated occupation over short periods of time. The deposits follow the clifflines for up to 200 metres and extend inland rarely more than 70 metres, making impressive landmarks on the dune surface. With thinner deposits connecting each large site, the middens appear to merge into one long accumulation stretching for miles. Between Cape Buffon and Canunda Rocks, for example, twenty-seven major middens were counted over a straight line distance of 8km (Figure 4.2).

Differences in site density along the Robe Range foreshore appear to correlate with local changes in marine ecology and in availability of flint. Inshore reefs and their gastropod fauna disappear north of Robe and south of Canunda Rocks. Middens outside this reef zone reflect this in their changed molluscan content; the middens of the Coorong, for example, contain only the remains of the surf beach clam Plebidonax. Without exception, shingle beaches of rounded flint cobbles are found within a stone's throw of the clifftop middens, and the middens correspondingly contain an abundance of flint debris. Where this natural source of flint diminishes, and where the reefs disappear, campsites at the foreshore are infrequent. Wherever sandy beaches predominate, as on the Coorong and in Guichen or Rivoli Bay, middens are located inland of the foredune and contain appreciably less flint than their clifftop counterparts. They also contain fewer reef molluscs and more sandy beach molluscan remains.

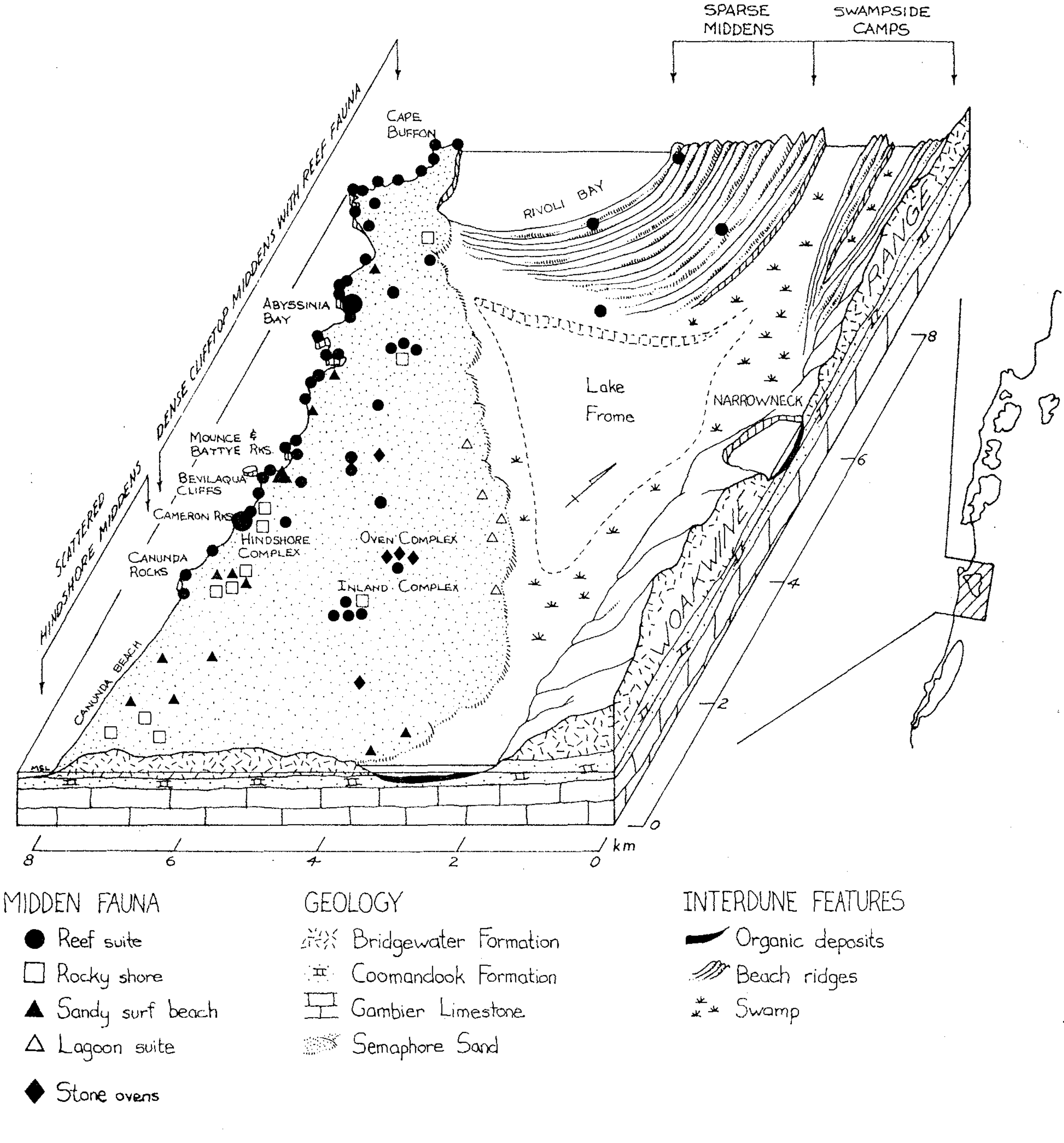


Figure 4.2 Diagram of coastal campsites in the vicinity of Cape Buffon in relation to the physiographic features of the area. Geology after Firman, 1973 and Sprigg, 1952.

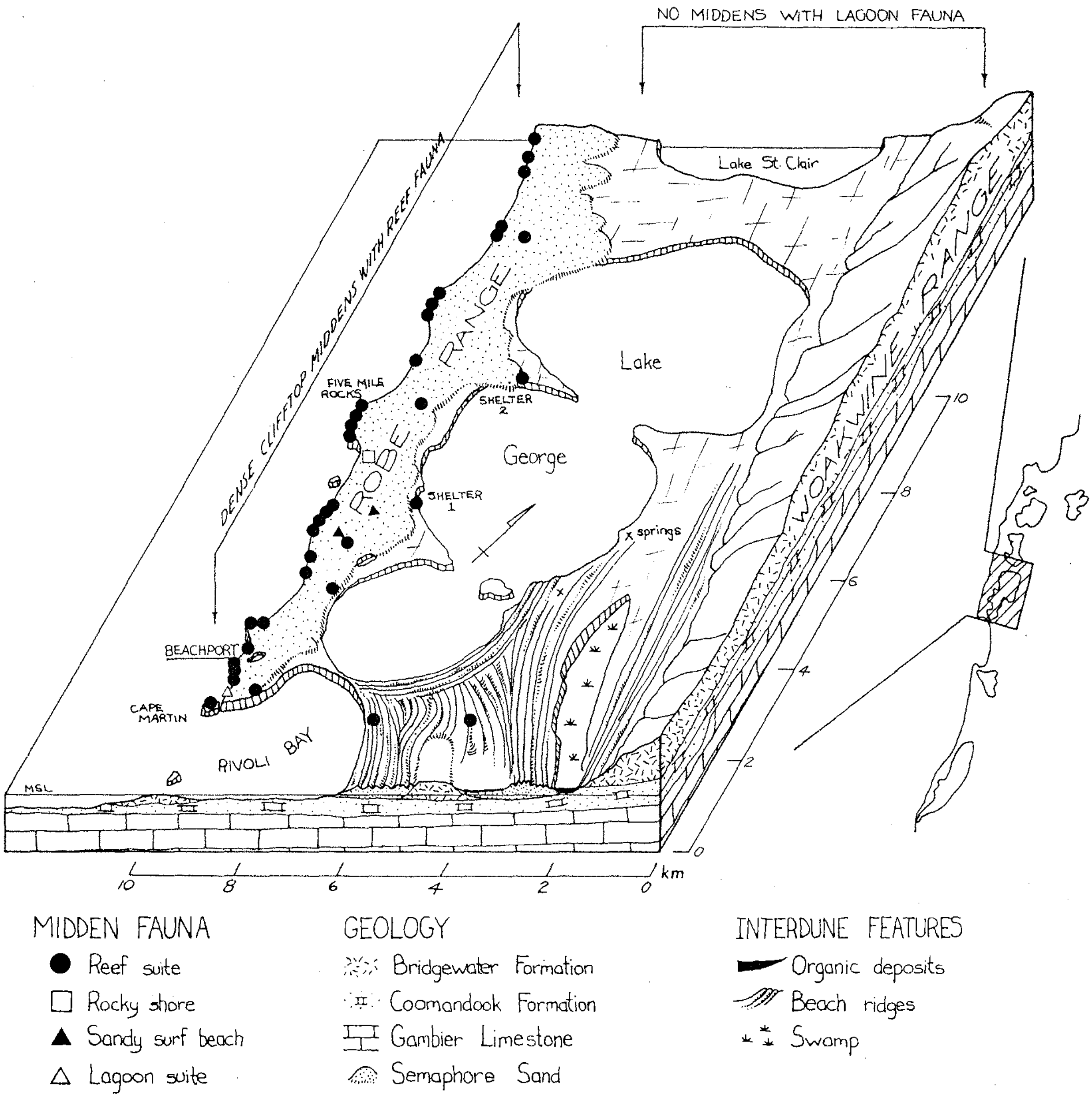


FIGURE 4.3 Diagram of coastal campsites in the vicinity of Cape Martin in relation to the physiographic features of the area.

Geology after Firman, 1973, and Sprigg, 1952.

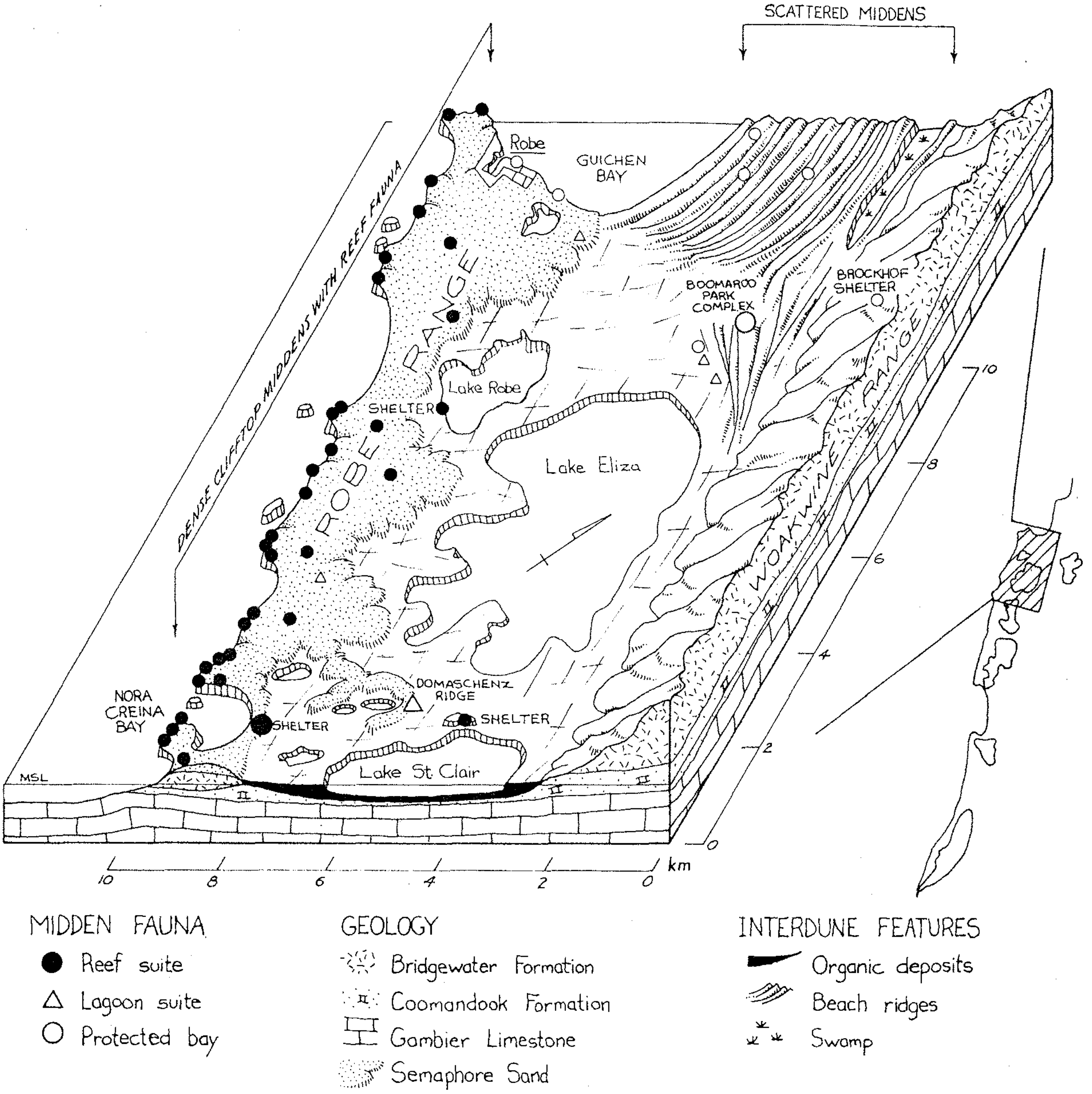


Figure 4.4 Diagram of coastal campsites in the vicinity of Cape Lannes in relation to the physiographic features of the area. Geology after Firman, 1973, and Sprigg, 1952.

Two middens representative of the clifftop sites are examined in detail in a following chapter. These are the deeply stratified site at Abyssinia Bay ($^{4}22^{58}39$-1), and the deflated midden at Cameron Rocks ($^{4}25^{58}39$-1) (Figure 4.2).

The second largest aggregate of shellmiddens lies midway between the foreshore and the lagoon. As at the clifftop sites, these middens consist mainly of reef gastropods - *Subninella* and *Cellana* in particular. However, these inland deposits suffer more from the effects of deflation, and identification of discrete depositional units is more difficult. Hearths and knapping stations are commonplace among the shell heaps, and the three types of deposits occur in great clusters throughout this inland zone. One typical cluster (Figure 4.2) to be discussed later is the Inland Camps Complex ($^{4}27^{58}38$-2), covering about 3 hectares of open scrub. An even larger exposure 100 metres to the south includes over 70 discernible heaps of shellfish.

Easily the most distinctive aspect of these campsites is the presence of a wide array of stone tools and knapping stations in association with many of the larger shell deposits. At a single midden, for example, it is common to find a variety of scrapers, both large and small, heading a list of microliths, flake "knives", cores, ground-edge axes, pounding stones, and numerous aeolian slabs available only from the foreshore. On-site knapping is evident from matching nodule flakes, cores and tools. No other area of the coast contains campsites with equal variety and quantity of tools per individual deposit.

Massive dune buildup between Canunda Rocks and Carpenter Rocks to the south has made it impossible to account for comparable campsites in that area, but similar complexes, labelled KR.1,KR.2,KR.3, KR.4,KR.5 and bearing a mixed microlithic and woodworking industry have been described for the Kongorong district (Campbell,Cleland and Hossfeld,1946:467-8). Despite dune activity north of Cape Martin (Figure 4.3), a search of unaffected areas has failed to locate a single complex fitting this description and it is concluded that none existed.

A different, and perhaps earlier, inland manifestation is represented by the occasional heaps of *Brachidontes*, a mussel from protected habitats than those producing the reef fauna. These deposits are found in paleosols which appear to be stratigraphically below the reef mollusc deposits; and the mussels are consistently associated with a strictly microlithic assemblage. At the other extreme, very recent use of this inland zone is evidenced by bottle glass implements on at least three of the Subninella middens. This occurrence of past-contact materials parallels the finding of clay pipes and sovereigns on the surface of a shellmidden at Cape Northumberland (Tindale,1957b).

Fire blackened heaps of calcarenite nodules are found also within the inland zone of the Robe Range, but are physically unrelated to the shellmiddens. Identical deposits are reported for both foreshore and inland middens further to the southeast beyond Lake Bonney (Campbell et al,1946); these are associated with reef gastropods. These structures closely resemble those described by Angas and Taplin as "ovens" and are here so labelled. By far the largest group is located on the slopes and ridgetop of a high peak taking in a commanding view of the lagoon 3km further inland and of the sea 2km in the opposite direction. Labelled Inland Oven Complex (Figure 4.2), the complex spans about 6 hectares and consists of 121 discernible ovens and an unknown number buried in the sand or obscured in the scrub. Small groups of two to ten ovens is a more common occurrence in the area as a whole. The few shellmiddens within the complex consist entirely of the reef-dwelling molluscs, but these are not associated with the ovens.

The third type of midden complex found on the Robe Range occurs in a narrow zone between the foreshore and the valley floor of the hinddune, usually about 1km from the shoreline. Containing either the cockle Plebidonax or the mussel Brachidontes, these deposits are characteristically small, discrete heaps about 1-2m in diameter with a central hearth of charcoal and charred shell. Almost all of these heaps of shellfish are exposed on the surface of the dune, or on the surface of the underlying terra rossa soil. Middens of Plebidonax cluster in groups of two to eight, whereas those of Brachidontes show less definite patterns in distribution. Microliths and a number of small wood working tools are common either on the shellheap or at its periphery, and slabs of aeolian rock or travertine are usually found nearby. The C^{14} age of Plebidonax from Bevilaqua Cliffs discussed above suggests that these deposits are probably the oldest middens on the coast.

Plebidonax and Brachidontes middens of this type are most numerous behind the expanse of sandy shoreline that stretches from Canunda Beach southeast to Cape Banks, where reefs once again are prominent. Two of these sites, one at Canunda Rocks and one at Mounce and Battye Rocks, will be examined in Chapter 5. These middens are also common near the small bay beaches that break the cliffline from Canunda Rocks north to Cape Buffon (Figure 4.2). North of Cape Martin however, where a rocky shore predominates, such campsites are rare. Only two *Plebidonax* heaps were located behind the foreshore in this region, one at Three Mile Rocks and one at Five Mile Rocks (Figure 4.3). Still further north, two severely disturbed concentrations of the cockle were found near Robe. The scarcity of these ancient, mono-specific middens on the Robe Range north of Cape Martin is consistent with the early isolation of that dune ridge by the lagoon waters as discussed in Chapter 2.

LAGOON SETTING

Sites containing lagoon resources include both rock-shelters and open-air camps. Each of the two site types has its own characteristic faunal assemblage suggesting different exploitation patterns. Rock-shelters are typically situated at high water mark on the lagoon shore line. A major portion of the shellfish consumed in the shelters was collected from ocean reefs directly across the Robe Range, and included *Subninella*, *Cellana* and *Patelloida*. A small but persistent percentage of these shelters' faunal assemblages consists of bird and mammal bone. The collection and subsequent transport of marine foods for several kilometres to a destination where lagoon resources and particularly molluscs, might have been more common is a curious aspect of the occupation. It suggests either that the lagoon foods were not readily available at the time, or that some preference was being expressed by the consumption of marine molluscs in the rockshelters. The good preservation of fauna, particularly the bone, suggests a relatively recent date for shelter occupations. The fact that lagoon closure and decline may have a similar date indicates that availability is the principal influence in the faunal content of the rockshelters. The quantity of stone tools associated with these sites is meagre and morphological traits are simple.

In addition to the shelters excavated by Edwards and dated less than 1500 years old (pers. comm.), shelters at Lake Robe ($^{3}93^{58}80$-2), "Fayrefield" ($^{3}94^{58}83$-1), Little Dip ($^{3}97^{58}74$-1 and 2), "Eurobodalla" ($^{4}01^{58}71$-1 and $^{3}97^{58}71$-1), and Nora Creina ($^{3}97^{58}68$-2) were found to contain this mixture of reef and lagoon fauna (Figure 4.4). Although, strictly speaking, the Nora Creina shelter is located on a former marine bay and not on the lagoon shore, it nonetheless shares the lagoon shelter characteristics of excellent stratification, mixed reef-lagoon molluscan content, and good bone preservation.

In contrast to the heavy marine influence in the rock-shelter faunal assemblages, open-air campsites invariably contain a high number of lagoon and protected bay molluscs. Dominant species are the mussel Hormomya and mud-clam Katelysia, both of which are also major species in the fossil shellbeds. The principal tool component of these middens is microlithic. Open camps within the boundaries of the lagoon are situated on ridgetops overlooking the water. Typical of these sites is Domaschenz Ridge Midden ($^{4}00^{58}71$-2), the largest known such deposit of lagoon shellfish (Figure 4.4). Exposed only recently by wind erosion, it is a small, dense accumulation of shell and rock located on top of one of the many sandy extensions of the Robe Range into the lagoon. Molluscs within the site are species which, for the most part, could have been collected from the waters immediately below.

At the northern mouth of the lagoon is a second type of open campsite containing lagoon fauna. Situated on beach ridges between the Woakwine Range and the modern shoreline of Guichen Bay (Figure 4.4), these deflated middens show more reliance upon fauna from the bay and lagoon mouth than upon species common to the lagoon proper. The sites are extensive (covering up to 4 hectares) and composed of numerous shell heaps lying upon the surface of an immature soil. Occasional deposits are found in situ in soil remnants stabilized by vegetation. The beach ridges closest to the modern Bay shoreline are the most recent and, likewise, sites closest to the present water's edge contain species which inhabit Guichen Bay today. The large complex at Sandy Lane ($^{3}94^{58}86$-1), to be discussed below, typifies this situation. Two and one-half kilometres further inland is the Boomeroo Park midden ($^{3}96^{58}83$-1), with an archaic bay fauna. Both sites contain cuttlefish remains and driftwood flotsom of the sort common to the present beach, thus suggesting that occupation may have occurred near the foreshore. If this is the case, the buried cultural deposits associated with ridge formation would correlate with stages in the lagoon closure and could be used to date those events.

It has been suggested above that tidal backwaters may have effectively limited occupation of the Robe Range north of Beachport and deterred habitation of the rockshelters at the water's edge until the lagoon closed. If this was the case, shell middens containing lagoon molluscs would be expected to occur in large numbers on the inland edge of the lagoon at the base of the Woakwine Range. Despite a thorough search of drains, barrow pits, roadcuts and hillsides, however, no shell middens were found. When it is considered that the dominent lagoon molluscs alone could have provided immense quantities of food within easy grasp of shellfish gatherers, one can only infer that their absence is a significant indicator of their economic unimportance.

THE RANGES AND INTERDUNE SWAMPS

The nature and distribution of archaeological remains on the Woakwine Range and other ranges in the swamps are known only from spot checks in the vicinity of drain cuts, roads and fence lines. Ground visibility on the ranges is generally hampered by either dense grass cover or by woodland litter.

As mentioned by other field workers, shellmiddens are rare on inland ranges, suggesting a marked decline in marine resources in the economy as a function of distance. Small amounts of shellfish are found around Lake Frome, on the slopes of the Woakwine Range facing the sea, and at the Belt Site ($^{4}32^{58}52$-1), which is located 16km from the sea (Figure 4.5) and is illustrated by Campbell, Cleland and Hossfeld (1946:456). In each instance, these deposits consist of small numbers of Subninella and other reef gastropods and are usually scattered. The bay clam, Amphidesma which is still plentiful in Guichen Bay, occurs on the floor of Brockhof Shelter ($^{4}00^{58}82$-1), a small, shallow cave near the summit of the Woakwine Range (Figure 4.4).

Two types of deposits occur in the swamps. The first consists of numerous small tool scatters close to the shorelines of the swamps. The shapes and forms of these tools are highly variable and include scrapers with steep edge retouch, concave scrapers, and occasionally heavy choppers and planes. Heavy edge damage is apparent on many larger tools. Discrete lithic concentrations are suggested on the surface, although deposits are obviously deflated and mixture has

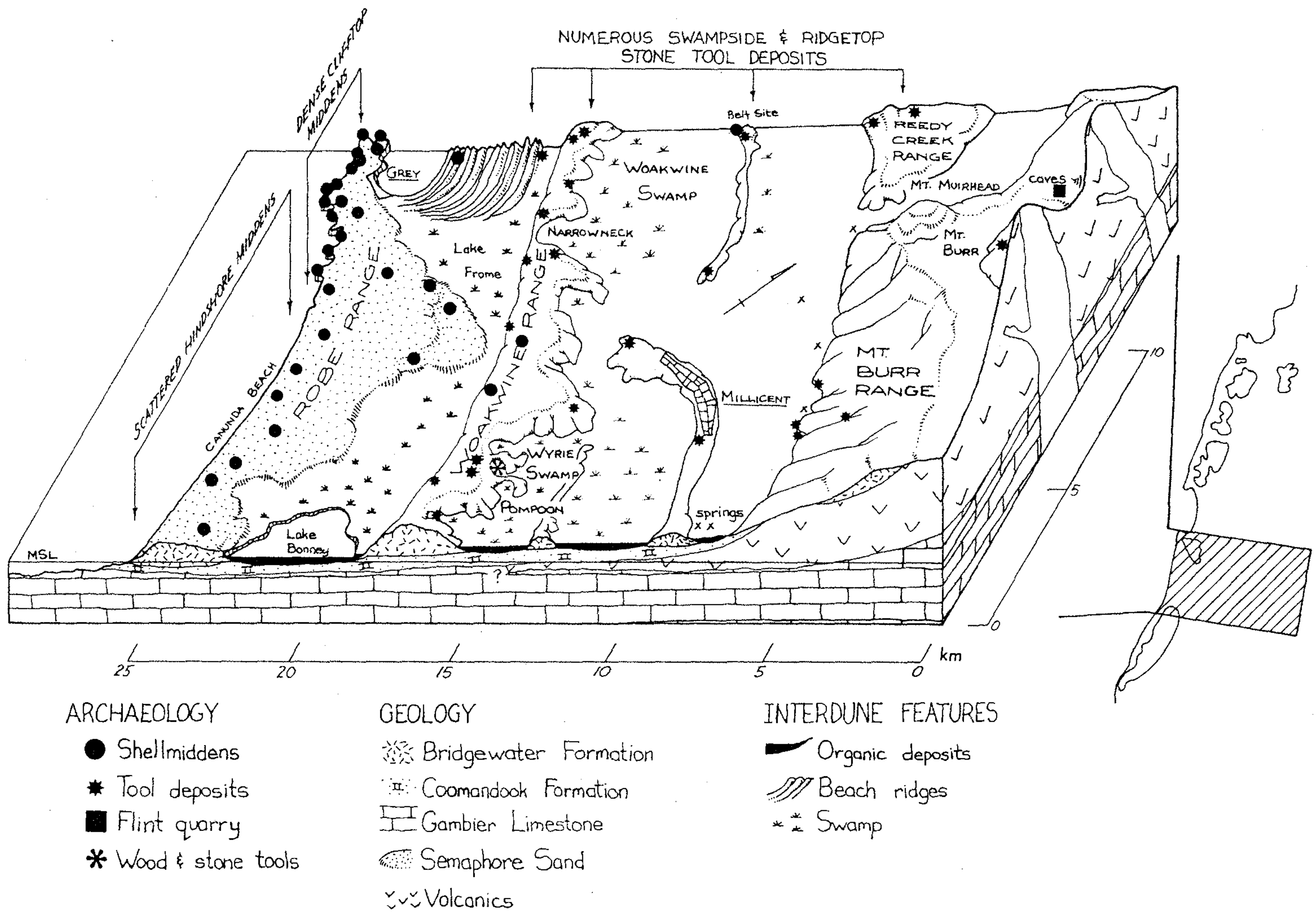


Figure 4.5 Diagram of major coastal and inland archaeological deposits from observation and published description (Campbell, Cleland, and Hossfeld, 1946). Geology after Firman, 1973, and Sprigg, 1952.

occurred. Hence the possibility that these concentrations reflect specific workshop activities or are household scatter could not be investigated. Likewise, the second type is equally difficult to fully describe. The deposits consist of numerous small hearths, knapping debris and implement scatters, all seriously deflated on the surface. The tools range from large wood working forms to smaller, concave scrapers and simple flake scrapers, but taken as a group, the assemblage is dominated by small scrapers. These occur usually on the higher slopes of the Woakwine Range facing the sea and form extensive linear scatters paralleling the shoreline of the swamps below. As many as fifty such deposits were examined in this study, and a similar site measuring almost one kilometre in length has been reported in a previous survey (Campbell et al,1946).

A third type of site consists of small deposits of large flake tools with deep, red patination. These are found on all ranges including the Robe Range, usually near the crest of a ridge, and are associated with some knapping debris. Finely trimmed edges characterize the tools in these assemblages, and stratigraphically these belong to an early cultural horizon in the district which at Cape Martin has an antiquity of 8600BP (Tindale,1957b). These deposits are only partially exposed and have been scattered by the wind.

MT. BURR PENINSULA

The volcanic peninsula, labelled Mt. Burr Range in Figure 4.5, was historically an exceedingly popular location with the Buandik, and the debris of occupation is everywhere present on the slopes. In the present study however, no comprehensive attention has been given to this record; several of the cave sites common to the area are briefly described.

Bat Cave ($^{4}56^{58}38$-1) is a solution chamber situated in a depression near an unnamed swamp. It contains flint flakes in a matrix of guano at the entrance. Other caves have similar remains which are usually buried beneath a thick humic infill.

The most interesting evidence of human occupation occurs in the vicinity of Mt. Burr township and represents quarrying of flint nodules and veins from limestone caves. At Gran Gran Caves ($^{4}53^{58}45$-1) and again in a solution cave 100 metres away ($^{4}53^{58}44$-2), the evidence is of deliberate removal by percussion from all exposures within arm's reach. At Gran Gran itself, the veins have been completely exhausted, while in another dark underground cave, both nodules and veins have systematically been removed from the walls. In one chamber, flakes were found with bulbs of percussion which could have been created only after the material was removed from the limestone. These extraordinary efforts to quarry the locally scarce sources suggest that great significance was placed upon flint at some time in the past.

SUMMARY OF THE FIELD EVIDENCE

The archaeological evidence suggests that two types of cultural horizons may be distinguished according to site content, morphology and stratigraphy. The first is characterized by a technology of large flake implements which can be assigned to the Australian Core Tool and Scraper Tradition. Where this assemblage occurs, its precise stratigraphic position and association with other cultural debris are usually unclear. It is however, deposited early in the stratigraphic sequence of the coast, and hence, is referred to here as the Early Horizon. While datable material in positive association is suspect on stratigraphic and geomorphologic grounds, several dates do exist for the horizon and these support its Early Holocene antiquity. The horizon is widespread across eastern South Australia, occurring on the coast, in the swamps, and in dated deposits at Cape Martin, Bevilaqua Cliffs and on the Lower Murray River at Tartanga.

The second, or Late Horizon is characterized by a much wider range of habitation debris in a more recent stratigraphic context. Typically, these campsites contain shell, bone and a stone tool kit belonging to the Australian Small Tool Tradition. This horizon also appears in a datable context at the coast, in the swamps, and on the dune ranges.

The Late Horizon is evidenced at two distinctive types of sites of different antiquity. An Early and a Late Phase of this recent horizon can be recognized. Early Phase sites are distinguished by a locally extinct open marine molluscan fauna consisting of either the surf beach cockle Plebidonax, or the mussel Brachidontes. The remains occur in association with a variety of small tools and a prominent microlithic component. Sites in this phase are typically located on the coast and include deposits at Bevilaqua Cliffs dated to about 6000BP. Similar sites located during this survey include deposits on the hind-shore at Canunda Rocks, at Mounce and Battye Rock, and at similar localities on Canunda Beach.

Late Phase sites share a similar tool kit with the Early sites except that microliths are either rare or are absent altogether. On the basis of faunal content, the sites suggest two co-eval aspects of this phase, reflecting local resource conditions. Those sites which are distributed widely along the foreshore contain an extant reef fauna dominated by Subninella. This reef assemblage is also present at sites between the foreshore and tidal lagoon, and in rockshelters on the lagoon itself. Occasional sites on the Woakwine Range slopes and swamp camps such as the Belt Site contain small quantities of these reef species, with the quantity diminishing the further the site is from the shore. Dated deposits reflecting this aspect occur in upper layers at Bevilaqua Cliffs and at Cape Northumberland, with the latter producing the oldest date for the Late Phase (1470BP). Surveyed sites of this type include those at Abyssinia Bay, Cameron Rocks, the Inland Camps Complex and the rockshelters at Nora Creina, and the edges of Lakes George and Robe.

The other aspect of the Late Horizon sites for which a phase distinction is unclear is illustrated by shellmiddens at Domaschenz Ridge, Boomaroo Park and Sandy Lane. In addition to modern reef species, these sites contain lagoon or bayside molluscs which are, for the most part, locally extinct today. Domaschenz Ridge midden reveals this faunal assemblage in association with microliths, whereas the other two sites contain almost no lithic material and no microliths.

It is notable that Late Phase sites predominate at the fore-shore north of Cape Martin almost to the exclusion of Early Phase sites. In view of the isolation of that portion of the Robe Range by tidal waters in the lagoon at some time in the past, it would seem that Early Phase occupation was hampered because this northern coastline was inaccessible.

These differences in site distribution and composition through time suggest a shift in the exploitation of coastal resources, and in particular marine molluscs, which coincides with an increase in the frequency of transport of resources away from the collection site. The earliest shellmiddens are thin, monospecific concentrations on the coast wherever beaches and bays occurred with suitable habitats to support the respective shellfish populations. Such sites rarely occur further inland than the hinddune, and the shellfish were apparently not transported off the Robe Range. Sites containing these species are confined to the portion of the Range south of Rivoli Bay and are almost absent from the Range north of Cape Martin. These camps thus reflect a very localized economic focus in which shellfish and flint nodules were the only primary resources exploited. Since these would have been available in the littoral nearby, the occupation appears to reflect small scale activities directed exclusively at marine resources.

By contrast, later middens are often deeply stratified, contain a number of species of marine fauna, and occur in a variety of settings. The camps also represent a wider range of economic activities, from collection and consumption of resources at the foreshore, to tool workshops in the centre of the Range, and including routine domestic activities such as the preparation of foods and processing of plants in stone ovens. Contemporary sites on the lagoon shores further suggest that the economic focus was diversifying in this period and that there was a greater use of a wide range of resources within the coastal margin, and finally that new settlement strategies were being employed to accomplish this.

This evolution in the economic character of the coastal settlement was occurring in part under the influence of changes in the local environment. The intertidal ecology was undergoing constant change caused by transformations in the coastal morphology and sand barriers began to form across the lagoon entrances at Rivoli Bay and Guichen Bay. As sedimentation clogged the exits, the lagoon system north of Cape Martin collapsed and hypersaline lakes developed in its place, thus significantly altering the availability of marine resources in that portion of the coastal margin. The situation south of Rivoli Bay was less dramatic, and Lakes Frome and Bonney both developed as substantial brackish and freshwater habitats in which animal and plant communities thrived. Intricately tied to this coastal development is the climatically sensitive swamp system upon which late prehistoric subsistence economies depended. Given this changing tableau, it is appropriate to have a close look at just how the prehistoric settlement responded to changes in the choices available to it and to consider the process of adaptation to it.

The archaeological presence of the Buandik in this picture is clearly visible in the Late Phase occupation. All of the three basic types of deposits believed to correlate with seasonal habitation strategies of the Buandik are present. The Inland Camps Complex contains a diverse technological character and the camps reflect recurrent habitation. Similar camps have been identified at the edge of the lagoon, both from this and from previous survey investigations. Special focus occupation is suggested on the seacliffs and elsewhere in the sandhills, each site containing shellfish which inhabit the reefs today. This evidence then permits us to associate the late prehistoric occupation with the Buandik and use their ethnography as a basis of comparison with previous occupations. All that is required now is demonstration that the distinctions uncovered in the archaeological evidence are correct. To this end, the following chapter examines a number of excavated sites representing each of the site types discussed above in an attempt to erect a settlement chronology.

CHAPTER FIVE

THE EXCAVATED DATA

A thorough search of the coastal margin has identified several major types of archaeological deposits, distinguishable in terms of morphology, contents, and location. Using existing dated evidence from the area, a preliminary time frame has been imposed on this data and a sequence of environmental relationships has been proposed in an attempt to unify the field data. Ten deposits, each representing a different type of habitation have been chosen for excavation to further document the settlement chronology and to more closely examine the character of subsistence economies. The following discussion describes the excavation techniques employed at each site and presents the primary data obtained by excavation as they bear upon the general character of site economy. Because the objective of this study seeks to elucidate the development of subsistence strategies in a coastal setting incorporating such a large number of sites, this discussion necessarily must emphasize only the highlights of this character rather than specific details.

The only preliminary statement required at this point is a description of the grid numbering system used in excavation and sampling. The number applied to material removed from the archaeological record places that material in the overall organization of the excavation. The following is an example; the FS designation represents Field Specimen or Field Sample:

FS2.1.3

The first number (2) designates a specific excavation square or a deposit; The number 1 in this example represents a specified layer or level within the square or deposit; and the last number (3) is assigned to a specific artefact or sample within that level or layer. Hence, specimen FS2.1.3 may be the third artefact in the first layer of Square 2. Combined with the site number, which is a grid coordinate reference appearing on 1:50,000 series topographic maps, this system accurately relates objects to a spatial organization. The key to understanding this organization is the site map, which locates a specific excavation unit within the landscape.

Discussion of the excavated date can now proceed, beginning with the archaeology of the swamps. This will be followed by the coastal deposits located seaward of the swamps.

WYRIE SWAMP

(A) Introduction

The archaeological material in Wyrie Swamp came to light as a result of a fire in 1955, which swept through the peatfields between the Woakwine Range and the town of Millicent. Drainage canals were hurriedly dug to divert water to drown the smouldering peat, and in the process unusually thick peat deposits were encountered in the vicinity of Wyrie Swamp. The deposits consist of pure, fibrous peat of the type sought by gardeners and landscape specialists. Commercial quarrying began in the 1960's when water was pumped from the swamp and a deep trench was cut into the centre of the deposit. Almost immediately, the equipment operators reported finding pointed sticks and boomerangs from the bottom of the deposit, which was composed of a characteristic dark peaty mud with a distinctive sulphurous aroma. Stone tools were equally numerous, although they did not appear to be associated with the wooden implements. The uncontrolled conditions under which the artefacts were recovered naturally raised doubts as to their stratigraphic position, and the rapid deterioration of the delicate untreated wood further complicated the task of determining the authenticity of the reported finds.

In 1973, with less than 10% of the peat left intact, Mr. Hans Van Schaik, presented me with two tool fragments immersed in water, thus dispelling any lingering doubts about the artefactual contents of the swamp. The tools, a boomerang wing tip and a sharpened stick with its bark intact, showed indisputable markings of manufacture and were perfectly preserved with portions of the peat still adhering to their surfaces. Two investigations swung into action to document the archaeological significance of the discovery.

The first sought to locate the cultural horizon and establish its antiquity. To do this, Test Trench 1 was excavated from the shoreline towards the centre of the swamp. Rising water forced a halt, however, before the deeper portion of the peat could be examined. Details of this operation will be discussed below. The second project, directed by Dr. John Dodson, sought to reconstruct the vegetation history of the swamp and to relate it to possible human occupation. A peat sample collected from a column near the deep end of Trench 1 contained a large flint flake. A radiocarbon date of 9010BP on this sample provided the first definitive evidence of both the antiquity and the relative stratigraphic placement of the artefact-bearing sediments.

The subsequent data recovered from Wyrie Swamp are still under examination and, in fact, constitute a separate project to be fully described in a later publication. For this reason, the present discussion on the nature of occupation is necessarily limited and should be considered preliminary. Nevertheless, documentation of the Wyrie swampside exploitation is of considerable value here, even if in generalized terms. The following therefore describes the details of the excavation and attempts to relate the findings to the overall picture of coastal settlement.

(B) Setting

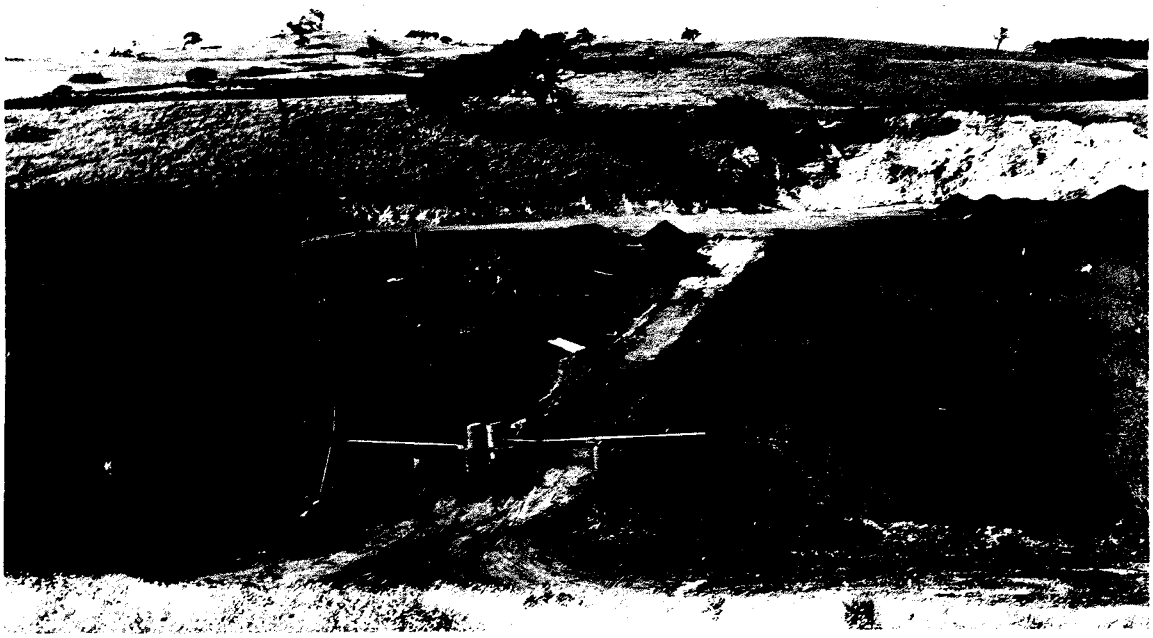
Wyrie Swamp is situated on the lowest point in the interdune corridor between the Woakwine Range and the Mr. Burr Peninsula and is a part of the vast peatfields which span this depression for a considerable length of the Range. The swamp covers about 2.5 hectares within a deep embayment created by a narrow arm of the Pleistocene dune (Plate 5.1a). The organic sediments stretch across the swamp floor as a slightly depressed basin, and the surrounding banks rise abruptly to about 12 metres above the peat. The Woakwine Range at this point is about 1.5 km wide and overlooks the whole area at elevations up to 50m in height. Today, a narrow zone of bracken fern marks the boundary between the lowlands and the dune slopes, whereas before land clearance, stands of Drooping Sheoak (*Casuarina stricta*) and Tea Tree (*Melaleuca lanceolata*) covered most of the range down to the waterline. A modern drain cuts through the Range one half kilometre to the north at Milnes Gap, and another dissects a large open peatfield 3 km to the south at Englishs Gap, just south of Pompoon Swamp. Before drainage changed the Swamp's original character, water is said to have stood across the flood plain to a depth of possibly 3 metres (Towers, pers. comm.). In prehistoric times, its primary features would have included the seclusion afforded by dense foliage, steep, high approaches, and a single narrow exit to the greater swamp area nearby.

A search of the adjacent peatfields near the Woakwine Range was made for cultural material. At Englishs Gap, which is located in a protected setting like that at Wyrie Swamp, a small pit had been excavated into shoreline sediments in search of a white basal clay. Three large

A.

PLATE 5.1

B.



A. Aerial view of Wyrie Swamp looking northwest across Lake Bonney's catchment to coastal dunes on horizon. A line of brachen fern marks the swamp shoreline in the foreground. Thick tree cover (Casuarina) once dominated the Woakwine Range down to the water's edge. Commercial peat quarrying has exposed the local water table.

B. View of 1974 excavation trenches at Wyrie Swamp looking south with trench 3 to the left. A coffer dam holds back water to the right.

flint flakes were found in this cutting in a shallow, black sandy clay, which was overlain by a thin peat layer. Pompoon Swamp, by contrast, is a large, open peatfield, exceeding 500 hectares in area. There, a deep trench cut from the shoreline towards the centre of the swamp for about 200m was thoroughly examined for signs of human habitation. Not a single artefact was recovered however, even though the fibrous peat is as thick as that at Wyrie Swamp and contains identical aquatic plant residues. It might be concluded therefore, that human habitation of these swamps is primarily influnced by environmental factors such as seclusion and protective cover along the banks.

(C) Excavation

The purpose of excavation was to document the full record of human use of the swamp within the general sedimentological history of the deposit. In the face of continuing destruction of the site by quarrying, a section of the swamp exhibiting the most undisturbed sediments was set aside by the quarry owner for scientific examination. Two areas of interest were immediately identified, each containing sediments requiring special techniques for their excavation. These will be discussed individually.

Three trenches were excavated in the peat, each composed of several two metre squares. Trench 1, dug as a test in 1973, contains Squares 1 and 3-10, numbered in chronological order of excavation beginning at the shoreline, is seen in Figure 5.1a. With two baulks one metre wide each, it is 20m long and penetrated 1.5m of peat at the deepest end. Trench 2, which consists of Squares 10 through 23, is 31m long, while Trench 3 is 27m long and is composed of Squares 24 through 36. Square 10 of Trench 1 is designated "1973" to distinguish it from Square 10 of Trench 2, which was excavated in 1974.

Other collections were routinely made. Three selected pollen sample sites are discussed at length by Dodson (1975a) and appear in Figure 5.1a. Site W7 represents samples collected by hand auger in which a flint flake was associated with fibrous peat dating to 9010BP. Site W3 is the locality from which a continuous peat core was collected by John Dodson using a GEMCO 610B drill. A major portion of the vegetation history of the swamp is described from this core. Site W7 represents a single surface find consisting of a cube of fibrous peat containing a

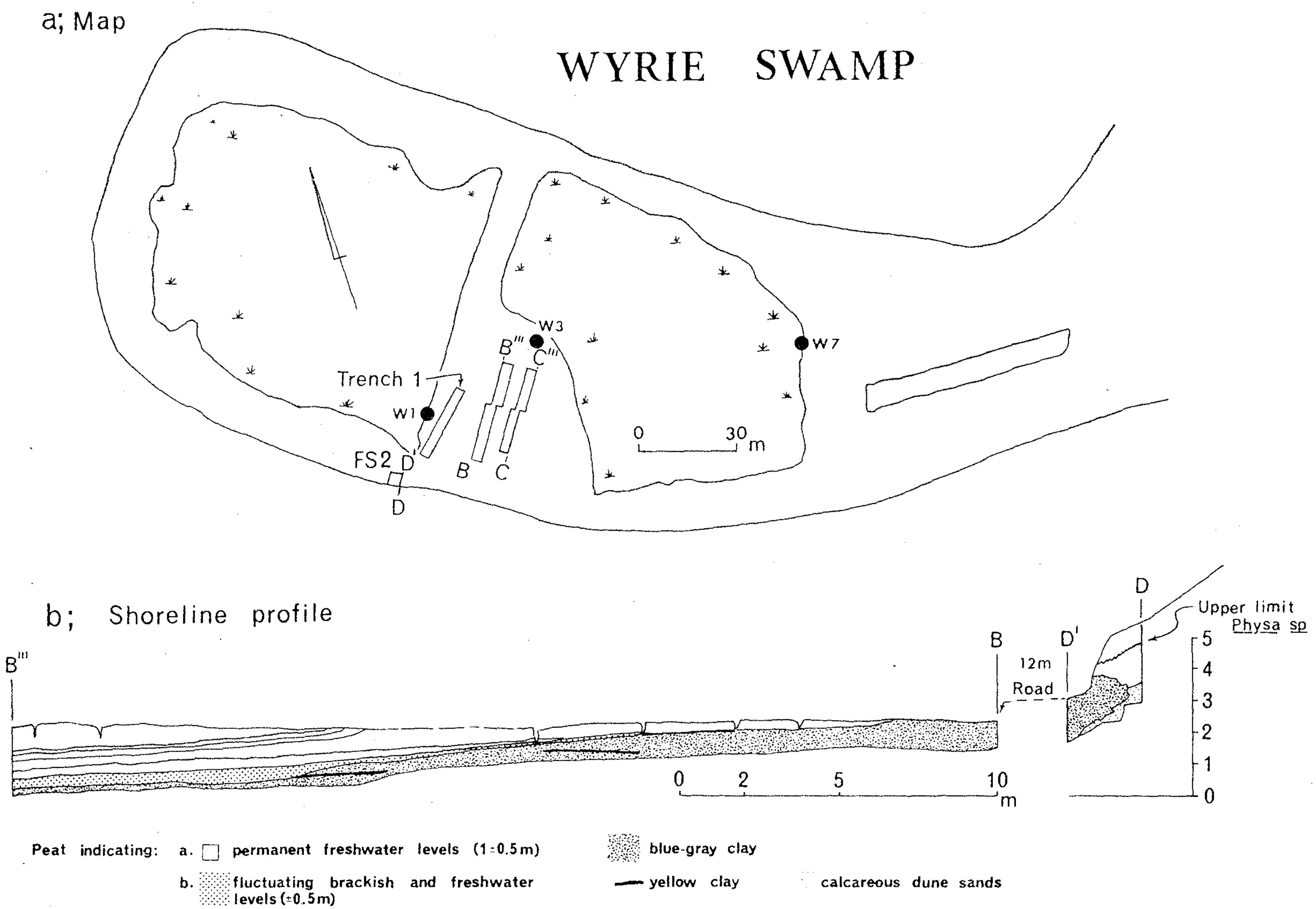


FIGURE 5.1 Map and shoreline profile of Wyrie Swamp

fragment of a wooden spear.

Excavations began on the dry deposits of the dune slope to locate the interface between the dune and the organic deposits of the swamp. A column 2.5m high and measuring 2.2 x 2m in area was excavated into the bank of the dune at the road cutting, labelled FS2 in Figure 5.1. Shown in Figure 5.2, this exposure reveals the precise juncture between the aquatic sediments of the swamp and the aeolian sands of the Woakwine Range. Excavation commenced with the removal of horizontal levels ranging from 10-20 cm in thickness. The material from each layer was sieved through nested 1/2 and 1/4 inch square mesh screens and has been set aside for further study. Cultural residue found in situ was measured in place in relation to the east wall, and a datum plane was established with an optical level. The stratigraphy of this section will be discussed below.

The excavation of fragile degraded wood from a dense peat matrix below the water table presented several technical problems. Loss of buoyance by removal of water caused the trench walls to distort and collapse, while deep fissures allowed the pits to flood and further added to the weakened state of the walls. A large coffer dam (Plate 5.1b) was constructed to reduce this problem by lowering the water level around the excavation area. One metre wide baulks spaced at irregular intervals were maintained in the trenches to reinforce the walls and reduce the amount of water to be pumped at any one time. A simple sludge pump then was used to evacuate individual sections of the trenches as the need arose.

The wood buried in the peat is so enmeshed in the fibres that removal from the surrounding dense mat is impossible without serious damage. The standard procedure adopted for excavation was to cut one centimetre thin slices of peat using a sharp, wide blade shovel. Once a piece of wood was uncovered by this technique, it was removed in a block of peat, fitted into a small wooden box, and submerged in a tank of water for the journey to the laboratory. For this reason, the identifications could not be completed until each tool in the collection was properly dried and reassembled. The location of each find was measured on the floor of the trench with coordinate references established at the northeast corners of the respective trenches, and elevations were determined from a single datum plane illustrated in the stratigraphic drawings.

The archaeological remains deposited in the shoreline sands

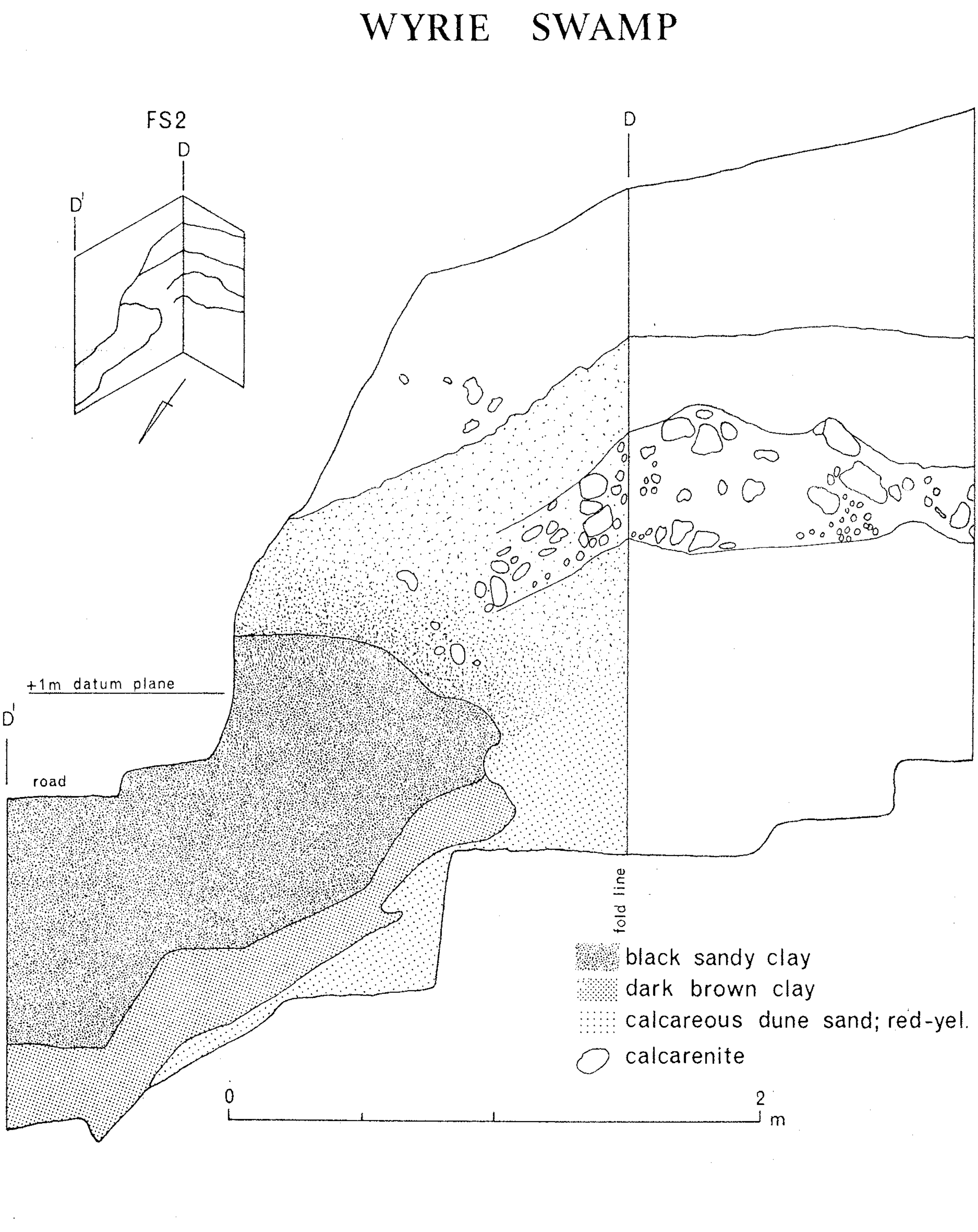


FIGURE 5.2 Shoreline stratigraphy in Square 2, Wyrie Swamp.

and muds below the peat were excavated in much the same way, although these sediments were considerably harder and more compact. As the steel shovel struck flint, a distinctive ringing sound alerted the excavator of the presence of even the most minute quantity of stone with a minimum of damage. The locations of these finds were then recorded and each piece individually labelled. Neither natural strata nor arbitrary levels were followed in the excavation of these matrices.

Artefacts on the swamp surface were routinely collected. Stone tools found in either the peat or in shoreline deposits exposed by the quarrying equipment were collected and labelled according their context and location. In some instances, these were still encapsulated in the original peat matrix, although they were disturbed stratigraphically. In such cases, the matrix was collected with the tool for pollen analysis in an attempt to place them stratigraphically. The pollen spectra associated with two finds matched dated zones in the master pollen sequence (Dodson, pers. comm.)

Likewise, it was standard procedure to collect two peat samples associated with artefacts uncovered by excavation. One labelled "Peat for Dating" is self explanatory. The other, labelled "Peat for Pollen" and collected by pushing a plastic vial into the soft sediments, provided a pollen sample for comparison with the master pollen list (see Dodson, 1973 for explanation of analytical procedures).

(D) Stratigraphy and Chronology

The stratigraphy of Wyrie Swamp is known from extensive exposure, by excavation, and from deep core samples. Of the several organic layers preserved, the uppermost is the thickest and is the only one known to contain cultural material. Older layers therefore will only receive brief attention in this discussion.

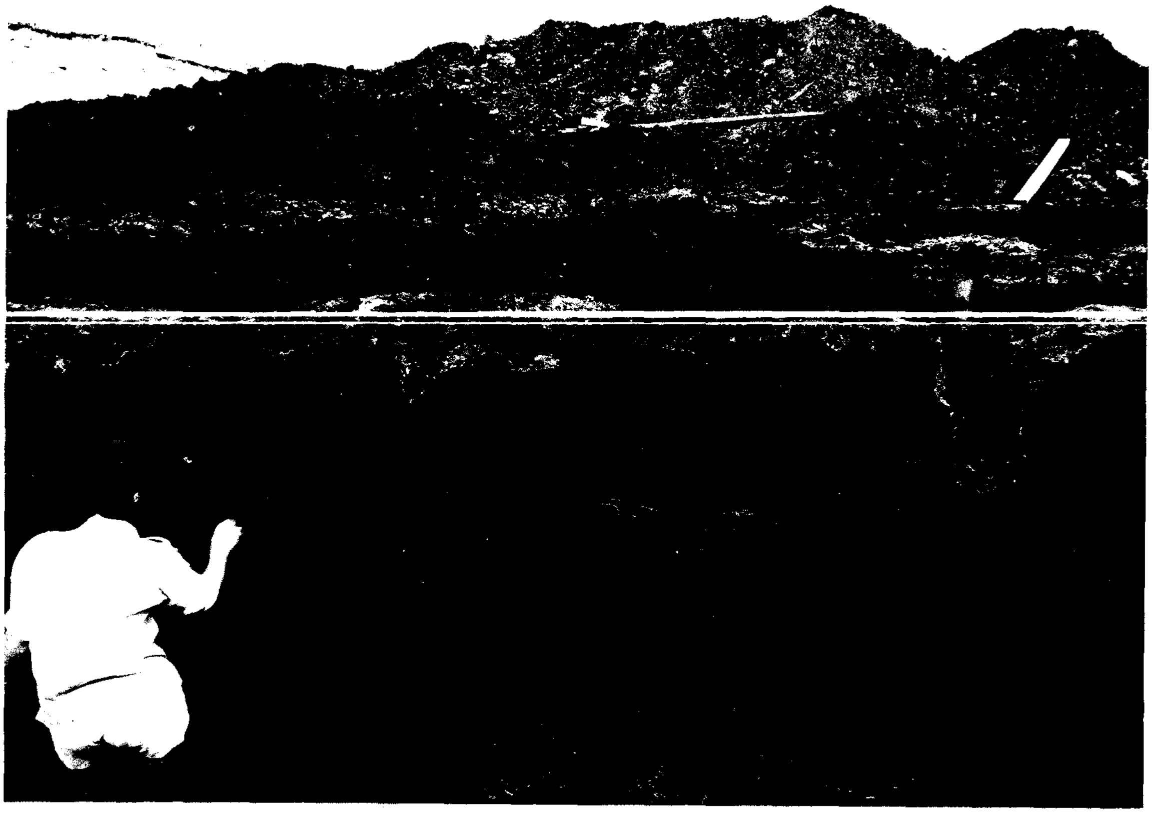
A summary of the swamp deposits (Figure 5.1b) shows a shallow profile of a dense peat layer overlying a dark blue-gray clay. The peat is about 2m thick in the centre of the swamp and thins considerably towards the shore where machines have removed a portion of the deposit. The blue-gray clay, which is defined from core samples, is at least 50 cm thick at the centre of the swamp and consists of both fine mineral sediments and some coarse plant residues. A pronounced rise occurs in its surface contour, and shoreward of this feature, the proportion of calcareous sands in it increases greatly. More than one distinctive yellow clay layer occurs in the blue-gray clay, and these are discontinuously distributed on approximately horizontal surfaces. One thin layer of yellow clay is present discontinuously at the base of the peat for more than one third of the section. The contact between peat and clay becomes diffuse with depth and except for the rise mentioned above, the slope of the clay is low. Deep shrinkage cracks occur throughout the swamp, sometimes extending into the basal clay near the shoreline.

Two distinctive layers of peat have been recognized. The basal layer consists of a dark, decomposed peat with a low fibre content and a characteristic odor of sulphur dioxide. An abundance of the seed of Triglochin cf.procera, a common aquatic plant eaten by Aborigines, is the basis for calling the layer "Seedy Peat". The upper peat layer consists of a coarse yellow-brown fibrous peat with few seeds in it. Dark, thin layers in the fibrous peat can be traced continuously throughout the exposures (Plate 5.2a), dipping towards the centre of the swamp. The boundary between the two peat layers is sharpest at the swamp's centre and becomes less distinct towards the shoreline. The Seedy Peat is confined to the deepest part of the swamp depression and could not be identified in shallow sediments at the eastern exit of the swamp. By contrast, the Fibrous Peat is widely distributed and has been traced through the narrow exit to the adjoining peatfield. The surface of the swamp is capped by a layer of charred peat and ash up to a thickness of 40 cm. On the basis of pollen analysis, Dodson (1975a) has proposed that the Seedy Peat accumulated under fluctuating brackish and freshwater conditions not exceeding 50 cm in depth. Dry periods may have occurred intermittently. The Fibrous Peat represents increased permanency in waterstand ranging between 1-1.5m in depth under conditions of freshwater only.

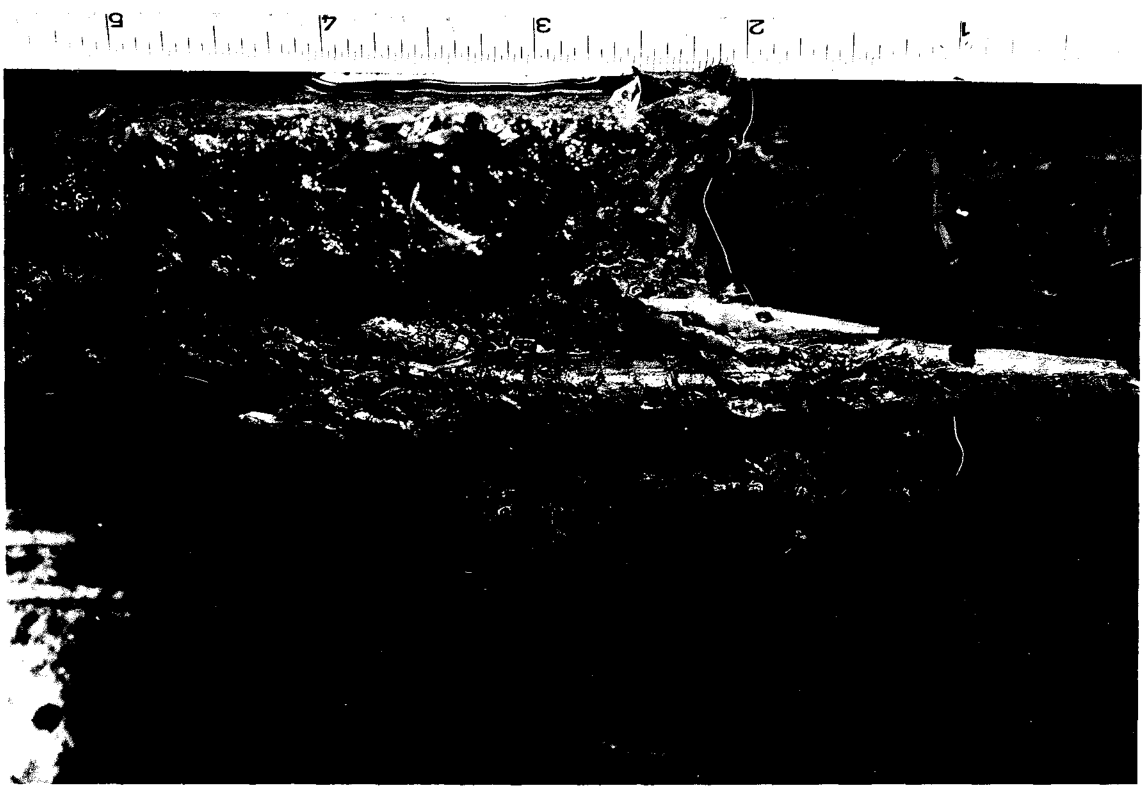
The stratigraphy of the shoreline consists of a basal unit of calcareous sands of the Pleistocene dune and, rich organic sediments of the swamp which form a sharp boundary with the sand. The dune sands are cream and yellow in colour, whereas the swamp deposits are dark brown or black and contain a high proportion of fine sediments. A zone of whole and

A.

PLATE 5.2



B.



A. View of typical peat exposure at Wyrie Swamp (west face of square 34, Trench 3) with centre of swamp to the right. The dark, basal Seedy Peat, which is visible at the water line, has yielded a date of 10,200 BP. The top surface is a truncated horizon about 7000 years old.

B. View of barbed, wooden spear tip (FS 0.0.94) from Wyrie Swamp encased in peat as it was found. The surrounding peat has yielded a date of 7930 BP and the scale is in inches.

fragmented snail shell, Physa spp., can be traced around the swamp in the dune and appears to mark a former shoreline. The snail inhabits freshwater ponds and cannot survive out of water except in very moist conditions. Its shell, even in life, is exceedingly fragile and commonly breaks and disintegrates shortly after death. The appearance of whole shell in the sediments would therefore suggest the position of a former water stand in the swamp. If this is true, Wyrie Swamp was at least 2.5m deep at sometime in the past. A disturbed layer of sand containing rabbit and sheep bones overlies this zone of snail. Figure 5.2 shows the shoreline sediments in detail.

Detailed drawings of the stratigraphic sequence in each trench were compiled at the completion of excavation. A single datum plane, at an elevation of 12.82m above MSL (corrected to AHD), was established and all measurements of elevation are related to it in the drawings. The location of artefacts is projected onto the trench walls to illustrate their stratigraphic position. Because Trench 1 did not penetrate the full stratigraphic sequence, it will not be described, although the picture seen in it is identical to that revealed in the remaining excavation trenches in so far as it is possible to detect. Our attention can then be directed to Trenches 2 and 3.

The major sediments in Wyrie Swamp are presented in Figure 5.3 (Trench 2) and 5.4 (Trench 3) with associated cultural debris. Square numbers appear along the swamp surface and the centre of the swamp is to the left in the drawings (north). It can be immediately seen that the occupational residues are confined to the basal peat layers and to the shoreline blue-gray clay directly underlying them. A scatter of flint tools, chips and flakes clearly demarcate a relatively narrow zone, which terminates about the point the peat dips into the deeper portion of the swamp. Although wooden tools were recovered on this blue-gray clay, none were found buried in it. The Seedy Peat contains approximately one half the total number of wooden tools while the lowest layer of Fibrous Peat accounts for the remaining half. No artefacts are known from younger peat layers. The original surface of the swamp was extensively burned in these sections and was removed prior to excavation.

The relationship of Pleistocene sediments to the occupation is shown in Figure 5.4 as known from core W3. These sediments include two thin fibrous peat layers of which only the topmost is shown with its

WYRIE SWAMP; Trench 2

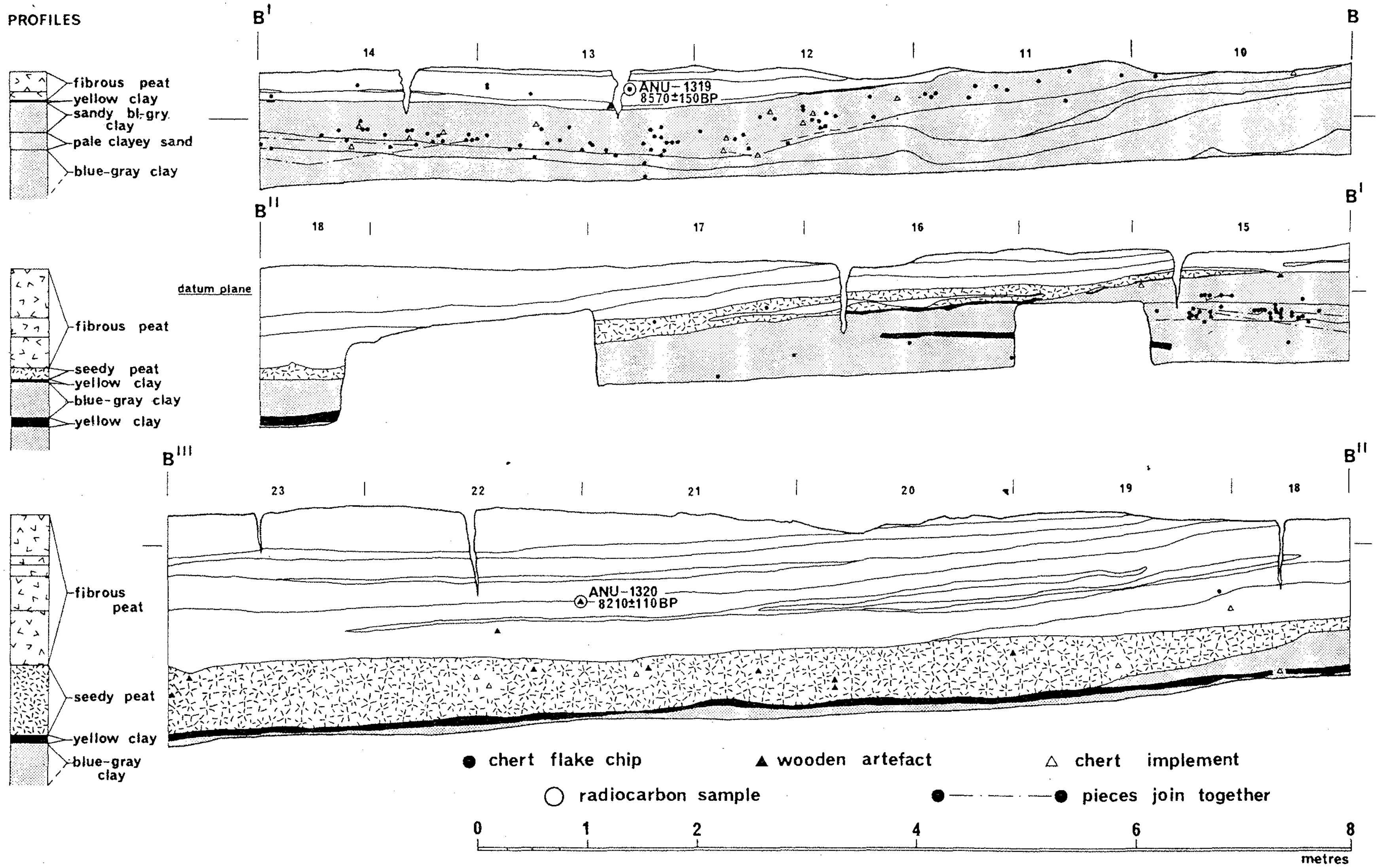


FIGURE 5.3 Stratigraphy of Trench 2 at Wyrie Swamp showing cultural remains, radiocarbon samples, and profile of sediments.

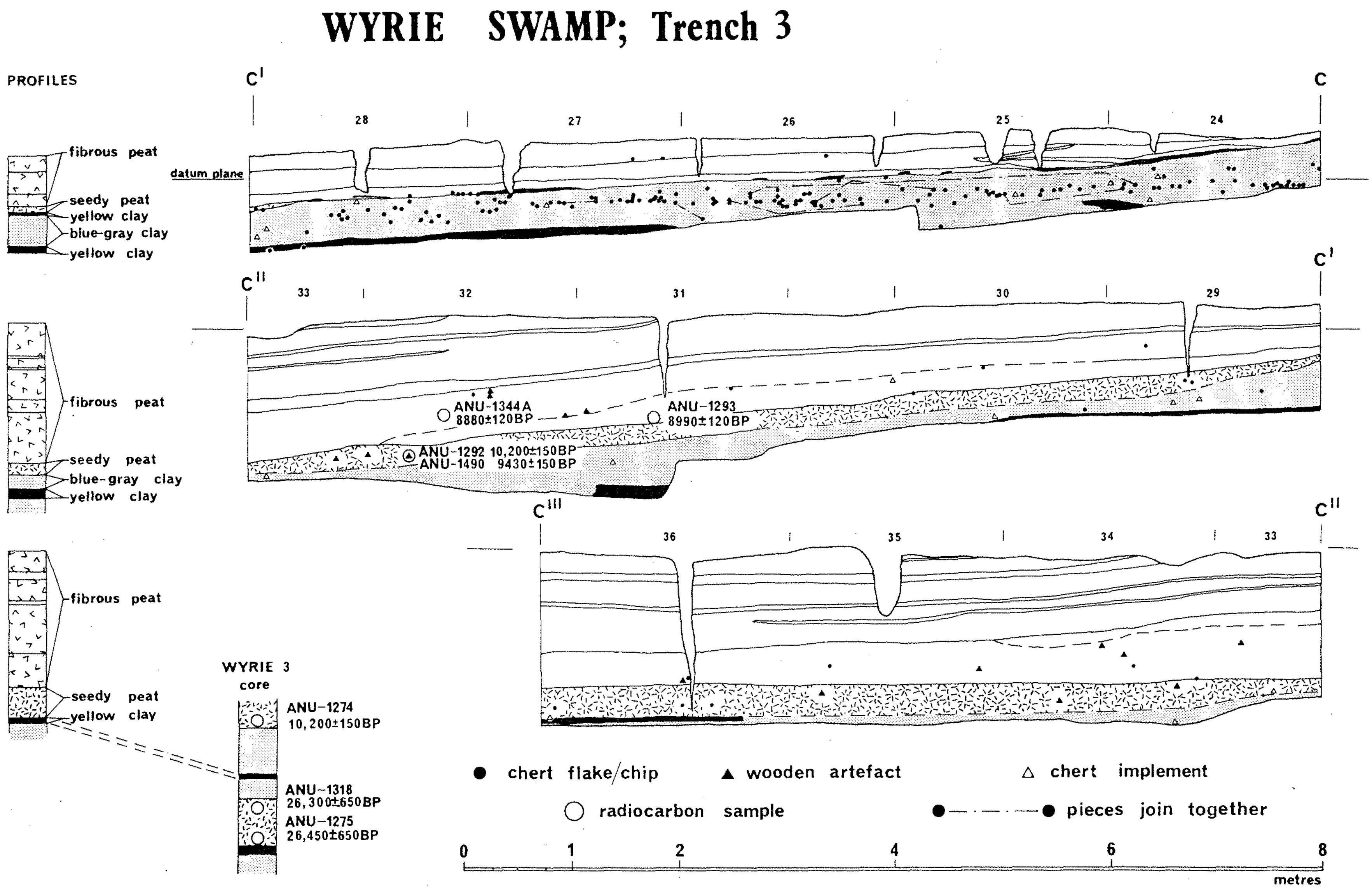


FIGURE 5.4 Stratigraphy of Trench 3, Wyrie Swamp showing cultural remains and profile of sediments. Core sample dates courtesy of J. Dodson.

corresponding dates. A thin yellow clay layer within the blue-gray basal clay in the core sample is believed to correlate with the yellow clay in contact with the Seedy Peat as exposed by excavation.

The Holocene chronology of Wyrie Swamp (Table 5.1) is established from ten radiocarbon determinations based on mostly peat samples. Two samples collected from the base of the Seedy Peat, ANU-1292 and ANU-1274 produced identical ages of 10,200 ±150BP, and these dates are believed to correlate with the initial wet phase of the swamp's Holocene history. The base of the Fibrous Peat has yielded a date of 8990±120BP (ANU 1293), while another date of 8880±120BP (ANU-1344A) was obtained from a sample located almost in the middle of the layer as shown in Figure 5.4. Peat surrounding the highest artefact in the stratigraphy, which is a boomerang wing fragment, has yielded an age of 8210±110BP (ANU-1320). The shoreward extent of the Fibrous Peat is dated in Square 13 (Figure 5.3) with an age of 8570±150BP (ANU-1390) as determined on peat surrounding a flint flake. These five radiocarbon age determinations indicate that the swampside occupation took place between 10,200BP and about 8000BP. It is significant to note that the dates are consistent with the stratigraphic sequence.

A barbed spear fragment (FS0.0.94), shown in Plate 5.2B was recovered from a cube of peat (W7) lying on the surface in the eastern outlet of the swamp (Figure 5.1). The age of the peat surrounding this specimen is 7930±160BP (ANU-1377), which represents the youngest dated implement from the swamp. This implement will be discussed in Chapter 6.

There is a possibility that wooden implements may have moved downward in the stratigraphy, in which case the peat will be older than the objects introduced into it. To determine whether or not this had occurred to the wooden implements, the age of a wooden implement and the peat surrounding it were compared. Prior to this, experiments conducted by Henry Polach of the Radiocarbon Laboratory (ANU) were made to validate a decontamination process for wood impregnated with the preservative Polyeythelene Glycol (PEG). Peat samples ANU-1344A, B1, B2, B3 were used in the experiments. Following successful completion of this treatment (Ambrose,1975), a boomerang wing tip, FS32.1.6, was impregnated with PEG and dried. The implement was then reassembled, thoroughly measured, photographed for three-dimensional replication, and a cross-section of the wood removed for wood identification. The remaining wood was decontaminated

SAMPLE NO.	RESULT (BP)	LOCATION	MATERIAL	COMMENT
ANU-1377	7930±160	Eastern perimeter out of context (W7)	Peat	Surrounds spear fragment
ANU-1320	8210±110	FS22, Trench 2	Peat	Surrounds boomerang frag.
ANU-1319	8570±150	FS13, Trench 2	Peat (Cellulose)	Highest sample; dates shoreline deposits
ANU-1192A*	8470±150	120-122 cm below surface (W1)	Wood	Peat surrounds wood and is associated with chert flake
ANU-1192B*	9010±120	120-122 cm (W1)	Peat	As above
ANU-1293	8990±120	FS31, Trench 3	Peat	Sample rests on seedy peat
ANU-1490	9430±150	FS32, Trench 3	Boomerang	Dates use of boomerang
ANU-1292	10,200±150	FS32, Trench 3	Seedy Peat	Surrounds boomerang above
ANU-1274*	10,200±150	275-285 cm below surface (W3)	Seedy Peat	Dates base of deposit
ANU-1344A	8880±120	FS28, Trench 3	Peat	Whole, untreated sample
ANU-1344B1	8440±120	FS28, Trench 3	Peat	Fines removed
ANU-1344B2	12,300±150	"	Peat	Impregnated with PEG
ANU-1344B3	8410±150	"	Peat	Impregnated with PEG and decontaminated by washing
ANU-1318*	26,300±650	305-312 cm below surface (W3)	Peat	Dates top of youngest Pleistocene peat layer
ANU-1275*	26,450±650	315-323 cm below surface (W3)	Peat	Dates base of youngest Pleistocene peat layer

* Sample collected by J. Dodson

TABLE 5.1 Radiocarbon date list for Wyrie Swamp occupation horizons.

and dated. The age of the wood is 9430±150BP (ANU-1490), which is 770 years younger than the Seedy Peat (ANU-1292) surrounding it. This difference may be explained either by a downward movement of the wood into older sediments, or by contamination of the Seedy Peat by older carbonates.

Other age determinations from Wyrie Swamp may be considered for resolution of this large discrepancy. The original discovery of a peat sample surrounding a flint flake in W1 was also accompanied by a small wooden branch, which has been dated (ANU-1192). The difference between the C^{14} age of wood and associated peat (ANU-1192B) is 440 years. In this instance, the branch could have penetrated into older sediments when it fell into the swamp. Therefore again, the age discrepancy may be caused by carbonate contamination, or by misassociation between the peat and the wood samples. Since older carbonates may be present in the form of fine sediments, it is then significant that the age of an untreated fibrous peat (ANU-1344A) is 440 years older than the same sample with its fines removed (ANU-1344B). This evidence would suggest that the apparent radiocarbon age of organic sediments is influenced by free carbonates in the swamp. If this is true, the age of wooden implements in the swamp may be of the order of 300-400 radiocarbon years younger than the age of the surrounding peat.

The age of the lithic scatter buried in the sandy blue-gray clay beneath the shoreline margin is not easy to determine. The soil sediments are largely derived from the calcareous sediments of unknown origins and could only produce an ambiquous antiquity, while useful stratigraphic indicators do not exist in the blue-gray clay. We may conclude that the assemblage is older than the overlying peat, which is 8570BP and no older than 26,300±650BP.

If it is assumed that occupation occurred during wet phases in the swamp's history, the relationship of the lithic scatter to the aquatic sediments suggests that the stone technology is associated with an Early Holocene habitation. Seen in Square 15 (Figure 5.3) and Square 28 (Figure 5.4), a pronounced rise occurs in the surface of the blue-gray clay which marks the shoreward extent of the Seedy Peat and the closest the narrow zone of flint comes towards the centre of the swamp. This evidence shows that, between the period 10,200BP and 9000BP, when Seedy Peat formed in shallow water, the swamp was much smaller than it is today, and that the rise may have been at its edge. It would have been possible then for camping to have taken place on moderately dry ground around the water's edge during this period, and the lithic scatter would therefore represent discards from knapping operations. It follows that rising water may have forced a shoreward migration of campsites and subsequent abandonment of the site. If this reconstruction is correct, the stone tools and the wooden tools are exact contemporaries and could be considered as a complete tool kit used in swampside exploitation.

Two types of macrofossils associated with the Early Holocene deposits deserve attention. A network of interwoven branches of trees and trunks occur around the perimeter of the swamp in shallow peat layers. These are probably Drooping Sheoak, Casuarina stricta. Many of these are irregularly charred at both ends, or have been scorched along one side, and most are still covered by bark. These seem to be fallen trees and swamp litter which have accumulated at the bottom of the steep banks and burned. No pattern in their arrangement or charring could be identified to show use of the material, but obviously fire may have been deliberately set in the course of occupation without signs of it being left behind. The charred remains of a hut or blind will preserve better in this environment than most organic residues and future investigations in the swamp must attempt to search for them around the shoreline.

The second fossil is the carapace of a large aquatic beetle which still inhabits the swamp in large numbers. Predominately found in the Seedy and lower Fibrous peat layers, these insects are an irridescent green and form a striking contrast to the rich brown and yellow colours of the peat. This beetle is probably the same one Angas saw heaped around two campfires on the shores of Lake Frome in 1843, only 3 km away (1847).

(E) Wyrie Swamp Technology

Despite serious degradation which has destroyed about 80% of the plant tissue, the wooden tools are remarkably well preserved. The conservation methods employed have been developed by Ambrose (1975) and involve saturation of the wood with Polyethylene Glycol 400. After a lengthy period of soaking, the specimens are individually dried at low temperatures under vacuum. Since fragmentation is high at the time of discovery and increases with each stage of treatment, assembly is necessarily a laborious process requiring experimentation and patience

(Luebbers, 1977). At the present time, the entire collection has not been adequately mended for detailed measurement and photographs to be presented here. A general description however, provides a useful impression of the technology.

Three types of wooden tools dominate the Wyrie Swamp inventory (Table 5.2). The most common are short straight sticks with one end sharpened to a point and the other slightly rounded. Of the four complete specimens, all are covered by bark from end to end, are uniform in diameter throughout their length, and deviate only slightly from 39 cm in length. No modification of the bark is obvious, although slight polishing seems to have occurred around the midshaft of one stick. These tools might have been used to throw at water fowl, or to dig plants and tubers from the soft shoreline muds.

Boomerangs are the second most common implements and are represented by three complete and six fragmentary specimens. Each exhibits the classical properties of a well designed aerodynamic missile (Hess, 1975). Wing cross-sections are biconvex, with the top curvature decidedly greater than the lower, while in the more complete specimens (5) a distinct rotation of the wing around its axis gives a twisted configuration. The angle between wings is moderately wide and the arms generaly join in a sharp elbow. Physical dimensions of the weapons are variable. One fragment is especially thick relative to the others, is wider, and judging from the curvature is likely to have had a wing span greater than 50 cm. The smallest complete boomerang has a wing span of only 29 cm, and another fragment is likely to have been a duplicate of it. The widest boomerang span is 41 cm. Another specimen is designed with one end resembling a weighted club. Except for shallow incisions executed in a cross-hatch pattern on two specimens, no evidence of decoration could be found.

The third most common tool is the spear, and it is represented by three remarkable specimens. The most complete (Plate 5.2b) of these is a fragment of the leading tip of the spear including a barb, shoulder and mainshaft section. The delicate barb is carved from the shaft of the spear. A second spear fragment, FS10.1.3 (1973) is an exact duplicate of this find except that the existence of the barb is indicated only by opposed incisions carved into the shaft near the tip. A third spear, FS33.1.3, was uncovered in the peat with its central shaft missing as a result of excavation damage. Both ends are shaped into slender points

FS3.1.1	Bark-covered stake sharpened at both ends
FS7.1.5	Shaft fragment with rounded end; spear?
FS8.1.1	Unidentified
FS9.1.1	Unidentified
FS10.1.3 (1973)	Spear shaft (front) on which single barb is missing
FS20.1.5	Branch with cut marks around circumference severing specimen
FS20.1.2	Complete digging stick
FS21.1.1	Spear shaft?
FS22.1.1	Boomerang wing fragment; associated peat dated
FS23.1.3	Digging stick, complete; 62cm long
FS31.1.1	Barked stake with both ends sharpened
FS31.1.2	Bark-covered stake with end sharpened
FS31.1.5	Bark-covered stake fragment with end sharpened
FS32.1.1	Boomerang fragment
FS32.1.3	Digging stick fragment
FS32.1.5	Bark-covered stake with end sharpened
FS32.1.6	Boomerang wing fragment; wood and surrounding peat radiocarbon dated
FS33.1.1	Boomerang fragment
FS33.1.2	Digging stick fragment
FS33.1.3	Spear, complete; 1.20m long. Not made with barb.
FS34.1.3	Complete boomerang
FS34.1.4	Bark-covered stake fragment with end sharpened
FS34.1.5	Complete boomerang
FS35.1.2	Bark-covered stake fragment with end sharpened
FS35.1.3	Bark-covered stake with both ends sharpened; 32.0 cm long
FS36.1.2	Complete boomerang
FS0.0.94	Spear tip with single barb; associated peat dated
FS0.0.95	Boomerang wing tip
FS0.0.96	Bark-covered stake with both ends sharpened

TABLE 5.2 Inventory of all wooden artefacts from Wyrie Swamp.

with no evidence of a hole to receive the hook of a spearthrower. Measured in in situ, the spear is 1.20 m long.

A thin section of boomerang wing fragment, FSO.O.95, was submitted to the C.S.I.R.O. Forest Products Laboratory for comparison with known species of wood. The wood has been identified as Casuarina stricta root. The anatomy of this wood is quite distinctive in respect to other woods available at the swamp and has been examined in each specimen. It is believed that, with one possible exception, all implements at Wyrie Swamp were made from this sheoak.

The lithic debris occurs primarily in the sandy shoreline muds as small chips and flakes. Out of a total of 326 pieces of flint excavated, 292 (90%) were associated with the mud rather than the peat. Table 5.3 shows the types of knapping debris according to the sediments in which it was recovered. A chip has been arbitrarily recognized as any piece of flint 5 mm or less in size. Twentyfive percent of all flint excavated exhibits surface and colour alteration consistent with intense burning, some to the extent of shattering.

	PEAT		MUD/CLAY	
	No.	%	No.	%
Tools	10	29	25	9
Flakes	21	61	141	48
Chips	3	9	126	43
Total	34		292	

TABLE 5.3 Excavated lithic debris from Wyrie Swamp listed according to surrounding matrix.

Over 150 flint tools have been recovered from surface localities across the swamp and these have been labelled and catalogued according to the sediments in which they were deposited.

The morphological attributes of the Wyrie Swamp stone tools have not been measured nor has the collection been systematically analyzed, but a few distinguishing characteristics are apparent. A generally high proportion of the implements are made from large, symmetrical flakes of a uniform thickness. The bulb of percussion is intact in these and lateral edges exhibit a high degree of extensive unifacial retouch in many cases. Some tools with multiple working edges occur, and these may be described as asymmetrical concave scrapers. Only one utilized flake in the collection of more than 150 tools has been identified and few, if any, of the other flakes are suitable for use because most are too chunky in character. There is little evidence of tools being refashioned into other forms by knapping, nor do they appear to have been used to the point the tool was no longer functional. It appears then that large, regular flakes were emphasized in tool manufacture and that these were extensively modified and used before they were discarded or lost in the swamp. The wooden tool component found in the swamp could easily have been fashioned entirely by the stone tools found in the swamp, and the morphology of the lithic assemblage reflects such maintenance activities. Food procurement tasks may also be represented, but detailed study is required to verify this possibility.

On morphological grounds, the Wyrie Swamp lithic assemblage is not unique in the Lower South East. The small concentrations of red stained tools located on the ridge tops on the Woakwine and Ranges further inland compare favorably with the collection excavated at Wyrie, despite the fresh appearance of the latter. Broadly speaking, these knapping sites are believed to belong to the same industry and are contemporaneous with the Early Holocene occupation of Wyrie Swamp.

The density of artefacts in Wyrie Swamp is an indicator of local economic activity, and this can be calculated from excavation data. The distribution of artefacts in the swamp sediments, as reported by the quarry operator, is generally uniform around the margin. This conclusion is further supported by observations made during routine surface collecting and applies equally to stone and wooden equipment. Assuming a uniform distribution does exist in densities equal to those determined by excavation, calculations suggest that one wooden tool is preserved in every 4 square metres of peat, and that one flint tool is buried in every 3 metres of deposit. Considering that these tools may be concentrated only around the shoreline and not in the centre of the 2.5 hectare swamp, we might assume that 1.5 hectares, or 15,000 square metres of the deposit contain artefacts. This would mean that 3750 wooden tools and 5000 flint tools were originally discarded by prehistoric inhabitants. In the course of a 2000 year occupation, the annual rate of equipment loss would approximate 4.3 tools. Accepting that this estimate is subject to errors of measurement, nevertheless the magnitude of tool densities agrees reasonably well with reported finds and observation. This leads to the conclusion then that Wyrie Swamp was an important focal point in swampside exploitation between 10,000 and 8000 years ago.

(E) Discussion

Wyrie Swamp was occupied between the period 10,200-8000BP by hunter-gatherers who camped on the shoreline and exploited the aquatic resources of the swamp. The tool kit was designed to exploit a variety of these foods, possibly including reeds, tubers, sheoak and waterfowl. Indeed, two plants, Typha and Triglochin, in addition to a water beetle, known as important foods for the Buandik, were present at the time of occupation. Wyrie Swamp, and by analogy, numerous other deposits on the dune ranges, illustrate the importance of the swamps in the Lower South East to prehistoric subsistence economies as early as 10,200BP. This situation is likely to have continued throughout the Holocene.

THE COASTAL OCCUPATION

An examination of the archeological evidence has shown that Aboriginal dependence upon swamp resources has had a complex and ancient history. The discussion will now focus upon the coastal strip where an equally complex array of deposits relates to an ecologically diverse setting. Attention in the following discussion will be directed to documenting 9 sites or site complexes in terms of their temporal and spatial significance as this information bears upon an overall picture of resource management. For the sake of historic perspective, older sites will be examined first.

CANUNDA ROCK SHELLMIDDENS

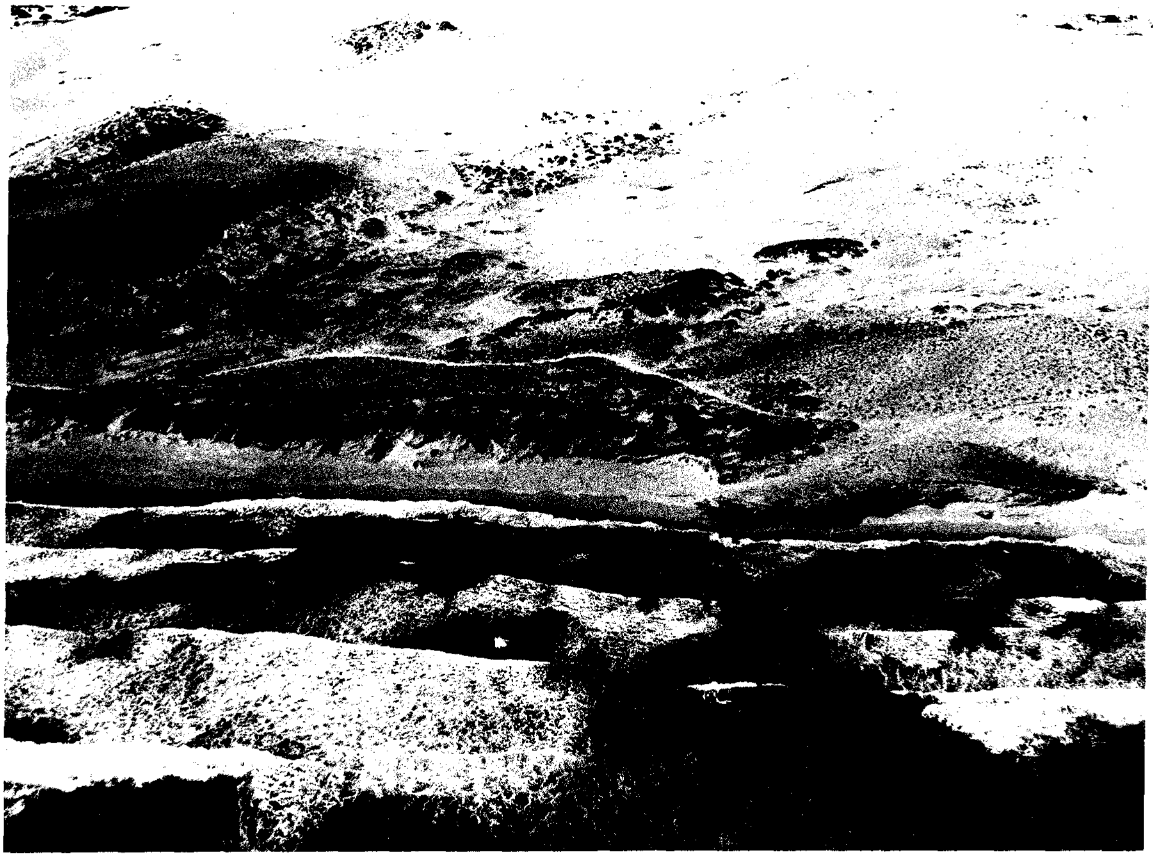
(A) Introduction

Canunda Rock is set in a typical foreshore environment for the Lower South East (Plate 5.3a). A low aeolian cliff protrudes into the sea at the Rock itself and is lined by sandy beaches on either side. Except for small, isolated dunes near the foreshore, all loose sediments have been blown away from the clifftop for a distance of about 250m inland. Thus a thin calcarenite and terra rossa soil has been exposed extensively at the foreshore, and these appear as dark coloured areas to the left in Plate 5.3a. A deep depression behind the foreshore (Plate 5.3b) has been denuded by deflation, and in the process a large number of small shellmiddens and knapping stations have been exposed on the ground surface. Most of these are relatively undisturbed. Because of good visibility and state of preservation of these sites, the Canunda Rock area was selected for detailed examination.

Two types of shellmiddens occur in the area (Figure 5.5). A deflated midden composed of several species of reeftop gastropods is situated on the edge of the cliff overlooking Canunda Rock. This type of large, dense kitchen midden will be examined at other localities. The second type of midden occurs behind the foreshore and is composed of discrete heaps of a single species of locally extinct mollusc. Since the distribution, composition, and morphology of these deposits distinguish them from all others, the field investigation endeavored to establish their significance in the history of economic development on the coast. Thus our attention is first focused upon the size, composition, antiquity, and spatial arrangements of these small middens. More specific implications of these characteristics will be considered in subsequent

A.

PLATE 5.3



B.

A. Aerial view of Canunda Rock looking north towards interdune lagoon. Main group of middens is between road and mobile dune seen in background. Canunda Beach is off the photograph to the right.

B. View of discrete Plebidonax deposits on valley floor behind Canunda Rock. Distant black zigzag lines are exposed soil layers upon which camps are deposited.

chapters.

(B) Midden Size and Composition

As a prelude to a detailed description of individual middens, a survey of site distribution was made. A survey area one kilometre long and one half kilometre wide was located on the ground in accordance with a map sheet, beginning at the foreshore. All archaeological material within this area was inspected, described in terms of composition and condition, and plotted (Figure 5.5). Each concentration was given a number, size was recorded, and other observations made. A thin scatter of individual shellfish has accumulated in certain depressions as a result of deflation and these were ignored in the formal survey. Figure 5.5 shows the distribution of all midden concentrations from which measurements could be taken.

The preservation of the majority of shell heaps is excellent. Many possess a remnant hearth which is surrounded by an undisturbed, circular zone of densely packed shell, and this in turn is encircled by another zone of shell scatter. The perimeter of the deposit is most often distinct, as are the boundaries between in situ and disturbed refuse. Small clusters and scatters of knapping debris are associated with a majority of deposits either adjoining them at the side, or overlapping with the shell scatter. In consideration of the fact that these heaps may represent the refuse of individual meals, and that campsite arrangements are reasonably intact, it was proposed to relate the size of the middens to the people dining on them. To achieve this objective, each midden was described in terms of the minimum number of shellfish present.

The procedure adopted for minimum shell estimates employs a subsampling routine based on direct counts. Since the intact centre and disturbed peripheral zones contain different densities of shell, each was sampled separately. To begin, a one quarter metre square was marked on the surface of each zone and all shells within the area were excavated by hand and counted. Middens larger than about one square metre were sampled twice and in such cases, the mean shell density between the two counts was computed. The shape of the majority of middens approximates either an ellipse or a circle. Employing the appropriate formulae, the area of each zone has been calculated from field measurements and the shell contents for each zone have been determined by multiplying unit density values by the area of the zone. A counting error derived from repeated counts

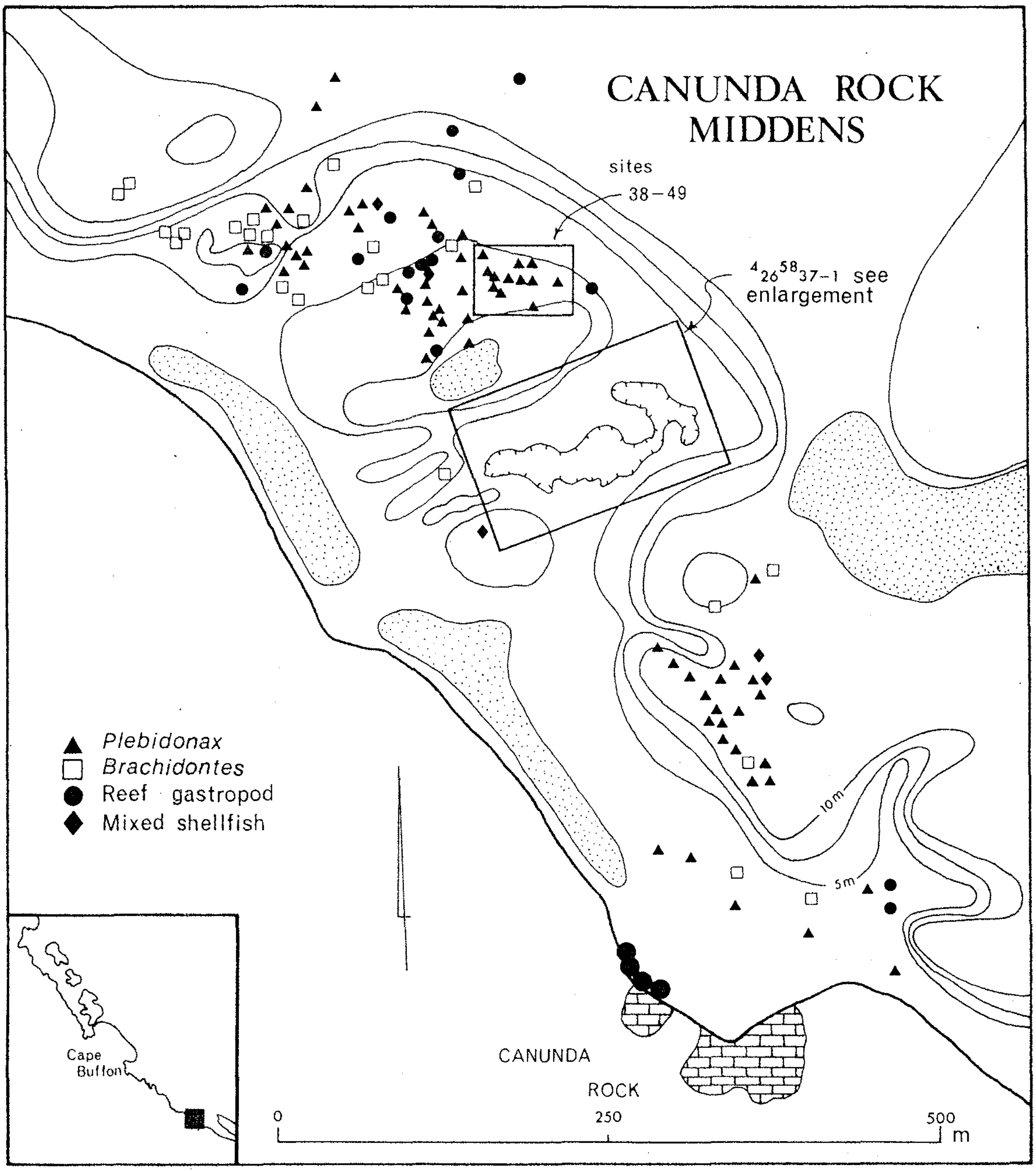


FIGURE 5.5 Sketch map showing location of shellmiddens of Canunda Rock. Inset areas are discussed in the text.

has been attached to minimum estimates. Expressed as a percentage of the mean, this error is calculated as one half the range. The total estimated number of shellfish in each heap is obviously the sum of shells in each zone.

Molluscan identification, shell density, midden size, area sampled, and estimated minimum number of shellfish in each deposit is itemized in Appendix A5.1. Other relevant observations are also presented. These pertain to the condition of the midden, the existence of charred shell, and the associated lithic material. A deposit was considered undisturbed or in situ if a hearth was present. If individual shell valves were positioned either flat on the surface or aligned in a pattern, or were dispersed, the midden was recorded as disturbed. In these cases wind transport had dislodged the deposit and caused a lateral spread to occur. It is noteworthy that non-molluscan remains are absent from these deposits.

A summary of the survey data (Table 5.4) is based on a total of 180 middens, each of which has been measured and described in the same way. It is clear that a majority (90%) are monospecific and that of these Plebidonax accounts for 56% of the total sample. By contrast, concentrations of shell representing several habitats, such as clams mixed with gastropods, represent only 10% of the total sample. Plebidonax middens are the largest in size, contain the greatest number of animals, and are the most variable in size. The second most common middens are comprised of Brachidontes rostrata, which inhabits rocks in the intertidal zone.

Shell Type	No. of Middens	% of Total	No. *in situ*	Mean No. of shell	Sd	Range of Shells
Plebidonax	101	56	33	1571	1569	80-8230
Brachidontes	44	24	19	1576	1409	50-6980
Mixed reef gastropod	14	8	-	----	----	------
Subninella	12	7	9	300	191	200-750
Sandy/reef species	4	2	3	273	352	70-750
Dicathais	2	1	2	140	134	50-240
Cellana	2	1	--	---	---	-------
lagoon species	1	1	--	---	---	-------

TABLE 5.4 Summary of midden contents from Canunda Rock by minimum number of shells.

A summary of the mean, range, and standard deviation of midden shells is also presented in Table 5.4 above. The significance of these calculations is difficult to determine in view of the effects of differential preservation across the sampling zone. Middens nearest the foreshore are generally disturbed and often partially destroyed.

Those recently exposed on the valley floor on the other hand are well preserved. The effect of this is to extend the range in the size of middens and to reduce the number of shells in the middens closest to the foreshore. It is reasonable then to assume that, taken as a whole, the collection on middens at Canunda Rock may have been larger in the past, but that the range in midden size was smaller. On the basis of observation, the average *Plebidonax* midden may have had 500-1000 animals in it, and the minimum may have been about 200 animals.

In order to study the distribution of these middens, an assortment of well preserved deposits (labelled $^{4}26^{58}37$-1 in Figure 5.5) was chosen for examination. The middens occur exposed on the surface of an almost flat valley floor, which is bordered on its inland side by a large sand dune. Using an optical level and a tape measure, over 70 shell concentrations were plotted on a topographic map and the size and contents of each deposit were recorded. Figure 5.6 presents the results of this survey, with the numbers beside each deposit referring to individual deposits itemized in Appendix A5.1.

The most significant conclusion derived from this study is the fact that middens consisting of the same species tend to cluster together on the surface. For example, *Plebidonax* deposits in the northern sector of Figure 5.6 are concentrated into two groups with about 5-7 heaps in each group. Likewise, heaps of mussel in the southwestern sector of the valley (Nos. 13-15,17,18) seem to be arranged in a pattern. In other areas, mixture and superpositioning of middens has confused specific relationships between deposits, but without sufficiently blurring a basic affinity in the distribution of middens according to species. This pattern of affiliation between middens suggests that the groups dining at the camps were exploiting the same setting and were probably related to one another.

In the course of sampling middens in this valley, two *Brachidontes* middens, numbered 59 and 65 in the east central sector of Figure 5.6, were excavated by hand. In each case, a lens of *Plebidonax* shells in sand was recovered about 4 cm below the mussel layer. Alerted to this relationship, an inspection was made of exposed *Plebidonax* deposits in a search for

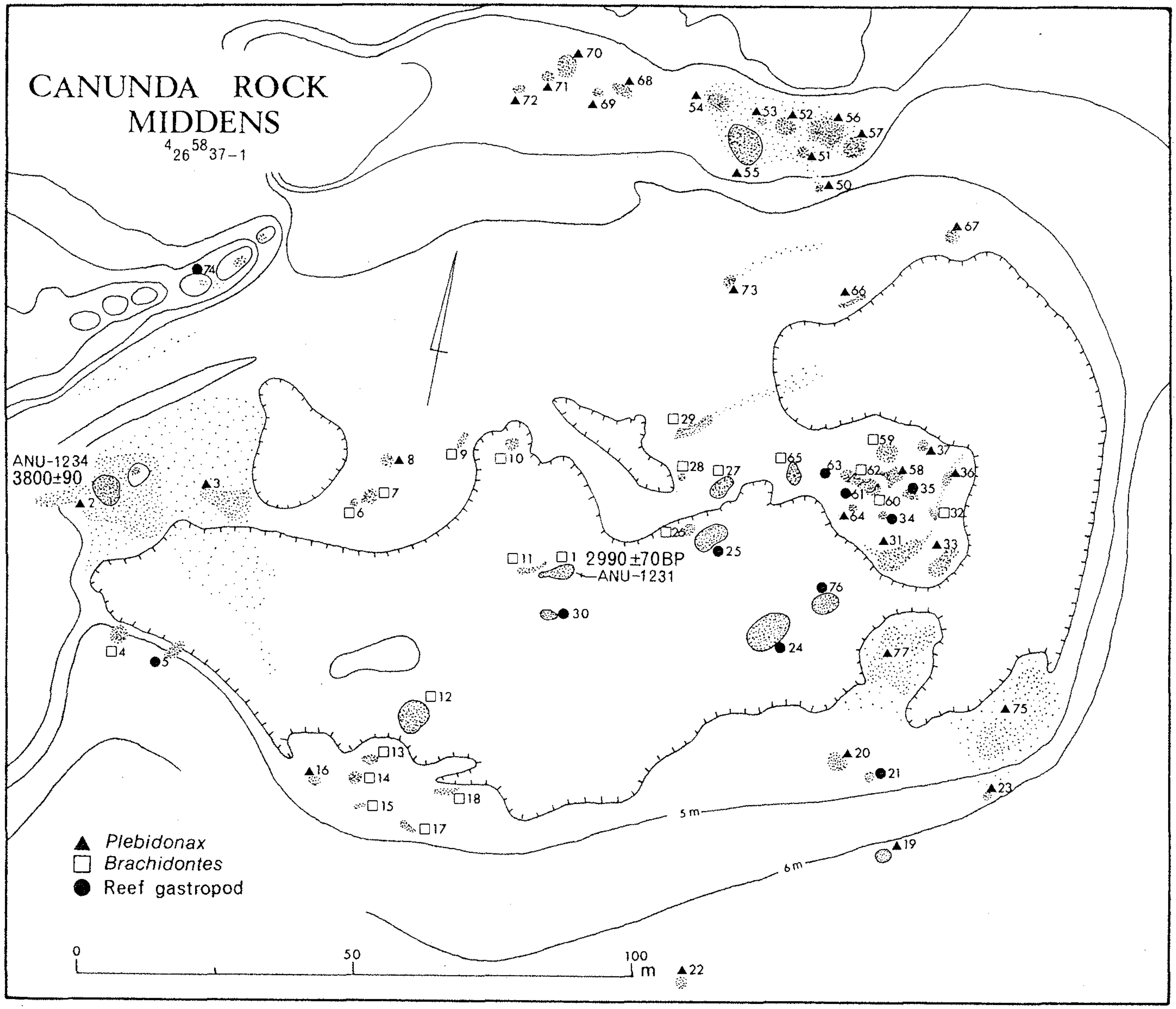


FIGURE 5.6 Map of Canunda Rock middens with radiocarbon dates.

similar lenses beneath them. In three cases, there were underlying lenses of Plebidonax and in no case were other species found. This suggests a succession of habitats in the marine biosphere and a time difference between the appearance of these two mollusc resources. The stratigraphic evidence would indicate that the cockle communities colonized the beaches first.

(C) Antiquity

Two middens, each containing one of the two species, were chosen to test this hypothesis. The first, labelled FS2 and shown in Plate 5.4a is the largest Plebidonax midden sampled by a factor of approximately three. It consists of a 14 cm thick layer of charcoal and densely compacted charred shell surrounded by an apron of shell scatter approximately 12 metres wide. Internal stratification in the hearth consisted of slight textural changes between thin horizontal lenses near the bottom. This feature may be evidence of rekindling of the fire. Charcoal extracted from below the surface of the hearth yielded an age of 3800±90BP (ANU-1234).

A small heap of Brachidontes, labelled FS 1 and shown in the centre of Figure 5.6, was chosen for dating. The midden consists of a densely packed central area of mussel, burned shell and charcoal, and a comparatively wide band of dispersed shell encircling the hearth. At the centre, the hearth is about 3 cm thick and contains several small pieces of charcoal in a martix of powdered charcoal, ash, and shell. The entire hearth was excavated for the collection of the charcoal, which provided a date of 2990±70BP (ANU-1231).

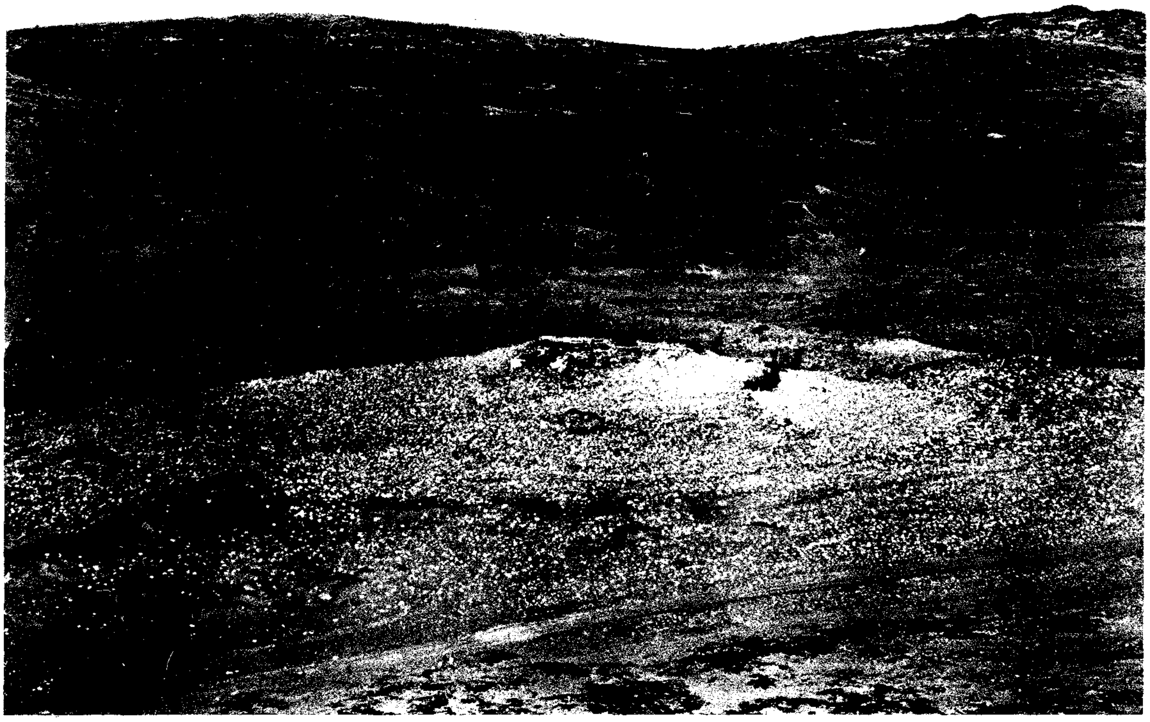
We can conclude on the basis of two radiocarbon age determinations, that Plebidonax middens in this valley are likely to be older than Brachidontes middens. This has been confirmed on stratigraphic grounds in two instances as well.

(D) Technology

The character of lithic debris associated with each midden was routinely observed and recorded throughout the survey, and the presence or absence of stone at each deposit is mentioned in Appendix A5.1. Perhaps the most striking attribute of the tool kit in these middens as a whole is the predominance of microlithic implements such as Bondi and Woakwine

A.

PLATE 5.4



B.

A. View of a Plebidonax deposit, Site 2, at Canunda Rock looking west towards the sea. Charcoal from the hearth seen in the centre of the scatter has yielded a date of 3800 BP.

B. View of hearth and associated Plebidonax deposit at Mounce and Battye Rock discussed in text. Charcoal from this hearth has yielded a date of 3870 BP. The preservation of the hearth and shellfish is typical of deposits of this type.

Points and geometric microliths of various forms. These appear often in small clusters and almost always are associated with knapping debris belonging to brief episodes of manufacture. This is evident upon inspection of the larger flakes which can be joined together and occasionally fitted to a core. In these cases, decortication has usually occurred on site, and in this respect the entire sequence of tool manufacture from preparation of the nodule through tool shaping, to tool use can be said to have transpired around the campsite.

Larger tools are less common and are occasionally absent altogether irrespective of the presence of microliths. These tools range from simple retouched flakes to unifacial flakes with multiple working edges. Crude, chopper-like implements are also infrequently present, as too are small, water-rounded slabs of calcarenite which are common on storm beaches.

Although patination cannot be accepted as a reliable indicator of age, the relative antiquity may be reflected in the degree of surface alteration seen in flint. Almost all original colouration has disappeared from the flint associated with Plebidonax middens, rendering a white, slightly dull luster to the surface. Whenever lithic assemblages from mussel deposits are compared with those from Plebidonax middens, slight differences in patination can usually be detected.

A striking difference exists on comparison with demonstrably younger assemblages. The technological character of these middens will be considered more fully in Chapter 6.

(E) Discussion

A survey of 180 middens located behind the foreshore has shown that small groups of shell gatherers camped on the dunes between 3800 and 2900 BP and dined on a limited menu of seafoods. The primary elements in the tool kit consisted of backed blades, geometric microliths, and other small tools commonly associated with coastal middens throughout the region. Together with a small showing of wood working tools, and possibly pounding stones, technological activities may have included tool manufacture and maintenance and household chores.

A dietary change from emphasis on Plebidonax to Brachidontes appears to have occurred, with the menu remaining almost exclusively monospecific throughout the occupation. Chronological data supported by independent stratigraphic information indicates that the cockle was exploited initially and that mussels replaced it as the primary seafood. In view of the mutually exclusive habitat requirements of these two mollusc, the best explanation for this change would appear to be the natural evolution of the intertidal zone which influenced the relative availability of the foods exploited. To test this hypothesis, the antiquity of similar middens in nearby localities will be considered.

The absence of non-molluscan foods in these middens may reflect loss of the more perishable food refuse, such as bone and plant tissue, or it may realistically reflect a menu comprised entirely of seafoods. Shell itself is remarkably well preserved in this calcareous environment and, if bone were deposited in the shell scatter, it would likely be preserved too. The compactness of the hearth and burned shell litter would suggest that the cook built the fire to roast or steam only shellfish rather than a mixture of foods. Indeed, in several of the mussel and cockle deposits, some bivalves were still hinged together as if portions of the meal remained in the fire after it had been used. This observation would suggest that the cooking process was not disturbed or interrupted and that the shells around the camp are the discards of a single meal which the diners simply left behind untouched as they departed. If this is true, these shell deposits represent a single economic focus.

MOUNCE AND BATTYE ROCK SHELLMIDDEN

(A) Introduction

The archaeology of the Mounce and Battye Rock midden is similar to that of neighboring clifftop sites, and to that of the Canunda Rock area 3 km to the southeast. A large midden containing several reef dwelling gastropod species hugs the cliff for a hundred metres, and a profuse scatter of fragmented flint nodules caps its deflated surface. The ground rises gradually away from the cliffs for a distance of about 300m before sand drifts rise abruptly and cover the ridgetop of the Robe Range. In this exposed area about 250m from the sea are a number of groups of mussel and cockle heaps of the type described at Canunda Rock and elsewhere on the hindshore. Most of these deposits are badly deflated and are unsuitable for detailed description and dating. Two remarkably well preserved *Plebidonax* middens situated about 4m apart in this zone are however especially attractive. One was chosen for investigation and is described below.

(B) Sampling

The midden (Plate 5.4B) is a compact layer of shellfish occurring in two distinct zones. The most compact is a central hearth of charcoal and charred shell about 70 cm in diameter and 6 cm thick. This zone extends beyond the charcoal concentration for an additional 15-20 cm and the deposit in this area is regarded as *in situ*. The hearth is surrounded by an apron of shell scatter in the shape of a 6 x 3 m ellipse, which thins to a sharply delineated perimeter. As seen in the photograph, the hearth is easily recognized by its contents, and the boundary between the two zones is marked by a sharp decline of shellfish as well as a change in surface contour. *Plebidonax* shells are well preserved in this midden and still retain a slight pinkish hue from their natural pigmentation. A few small, amorphous flakes of flint, but no tools, are associated with the refuse.

Because of local variation in shell concentration, both zones were sampled twice. Two 50 cm squares were marked on the surface of each zone at opposite ends of the deposit and all shell occurring within each square was removed by hand and counted. Only shells with umbones were considered in the count and wherever these were fragmented (rare) those with less than one half the umbo present were ignored. The counts from the four sample areas were recorded in a notebook and the mean density for each zone was computed from the respective counts. The comparative variation has been calculated by dividing the range by the mean, and expressing it as a percentage. Table 5.5 presents this information.

Subsample	Shell Density 1/4 sq. m	Mean Shell Density	Area of Zone	COMPARATIVE VARIATION
in situ 1	161	180.5	3.07 sq.m	±11%
in situ 2	200			
Scatter 1	81	95.5	11.06 sq.m	±15%
Scatter 2	110			

TABLE 5.5 Shell density calculation for a single meal at Mounce and Battye Rocks.

The steps followed in calculating estimates of the minimum number of animals in the Mounce and Battye midden are presented below in Table 5.6. Since Plebidonax is a bivalve, the number of animals is equal to one half the number of shellfish valves.

Area of Zone		Density			Min. No. of Shellfish
3.07 sq. m	times	180.5	shells per 1/4 sq. m.	=	2216±11%
11.06 sq. m	times	95.5	shells per 1/4 sq. m.	=	4224±15%
			Total shells		6440±26%
			TOTAL ANIMALS		3220±26%

TABLE 5.6 Calculation of Minimum number of animals in Mounce and Battye midden.

(C) Antiquity

The exposed surface of the hearth was trowelled to remove free charcoal which may not be associated with the hearth and several small in situ pieces of charcoal were collected for dating. An age of 3870±80BP (ANU-1545) is indicated for this midden.

(D) Discussion

The age of this Plebidonax deposit is consistent with the age of FS 2 at Canunda Rock. Along with the date of 6350BP on Plebidonax shell from Bevilaqua Cliffs, this evidence supports the hypothesis that cockle populations colonized the beaches of the Lower South East soon after the Mid-Holocene and survived until the third millenium before the present.

The stratigraphic relationship of this species with Brachidontes, as seen at Canunda Rock, indicates that changing coastline morphologies may be responsible to this shift in faunal remains and for confirmation of this, another mussel deposit will have to be dated.

INLAND CAMPS COMPLEX

(A) Introduction

Several types of archaeological deposits are situated in a zone of coastal scrub about 1.5 km from the sea. Stretching parallel to the coast for 20 km, this strip is composed of stands of *Melaleuca* and *E. diversifolia* and low grasses which protect the dune against drift. Breaks in the vegetation have opened large, irregular shaped areas and have exposed a wide array of campsites, knapping stations, and ovens of blackened stone. Taken together, these sites seem to reflect an economic complexity unparalleled elsewhere in the coastal margin, and field investigations were designed late in the research to describe and relate these deposits to resource utilization on the coast generally. Two sites, the Inland Camps Complex and the Ovens Complex, are typical examples in this group and will be considered individually.

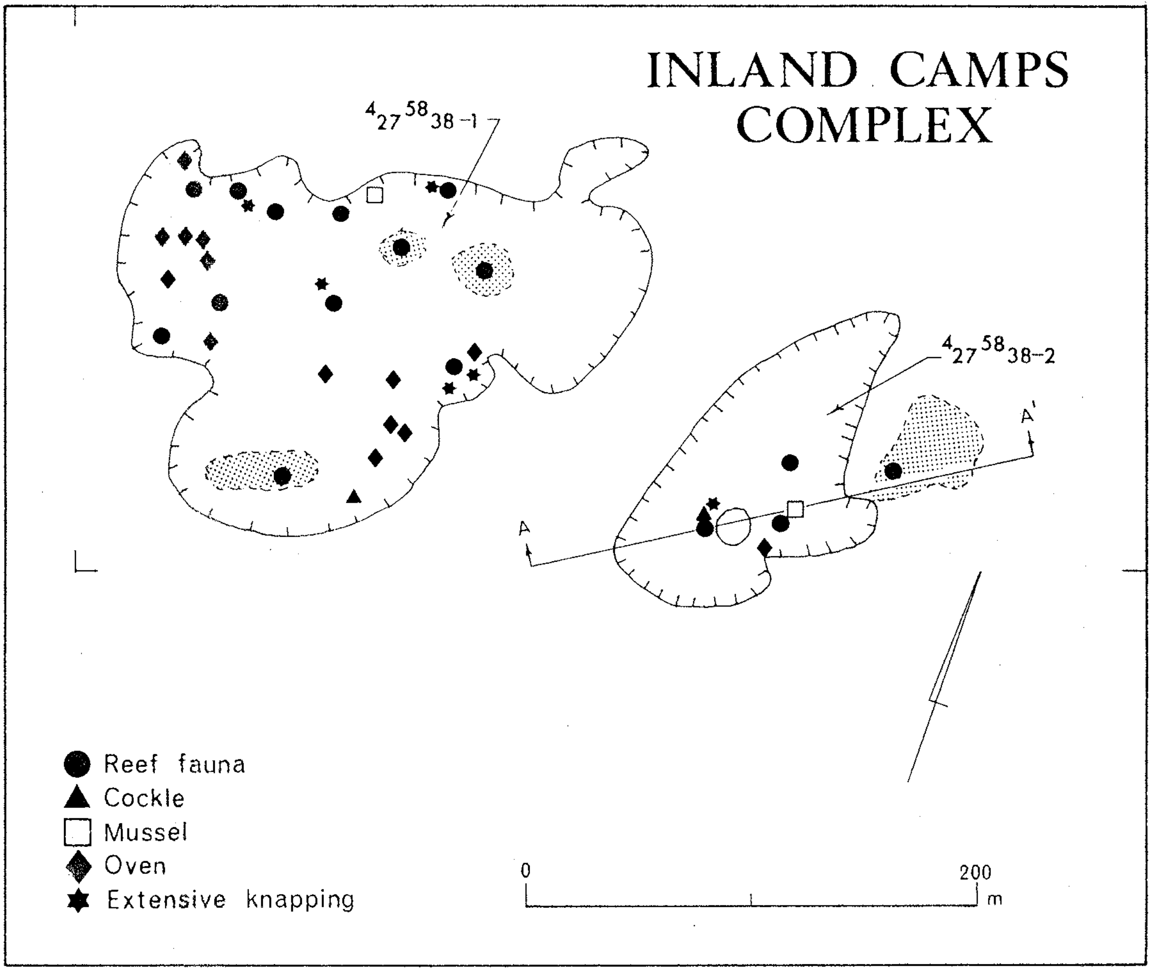
(B) Setting

The Inland Camps are a complex of different types of deposits located in sparse scrubland several hectares in area, surrounded by sand drifts which originate at the modern seashore. The camps are exposed on two deflated surfaces, labelled $^{4}27^{58}38$-1 and $^{4}27^{58}38$-2 in Figure 5.7a in environs otherwise devoid of landmarks. A site map was compiled from a topographic map sheet of the area and the distribution of the deposits is plotted onto it according to content. Field observations were recorded in the course of several surveys across the dune clearing and, except as stated below, measurements and samples were not routinely taken. Visibility across the area is unimpeded however and each deposit could be fully examined. Deposits around the edge of the dune floor are continually being exposed as surface deflation spreads laterally, and it is clear that additional deposits are buried immediately outside the study areas.

(C) Site Characteristics

Twenty concentrations of shell debris were located on the two exposed surfaces. *Plebidonax* and *Brachidontes* shellmiddens represent 20 percent of the deposits, and, like those at Canunda Rock, they are mostly monospecific in composition. They do not exceed two metres in diameter and are usually severely eroded, although outer boundaries remain clear.

a. Map



b. Section A-A'

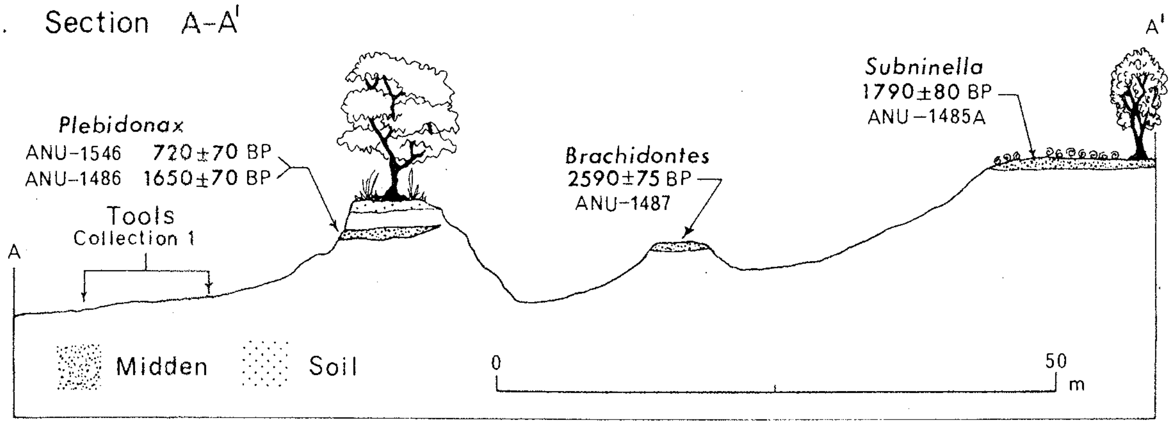


FIGURE 5.7 A. Map of Inland Camps Complex.
B. Section of Camps along A-A' axis.

The remaining shellmiddens surveyed are large mixed concentrations of Subninella, and other reeftop molluscs such as Thais, Haliotis, and limpets. These are usually two to four metres in diameter, although several are 8 m or more across and often contain a compact assortment of shell and knapping debris arranged as a single layer. In these larger middens distinct changes in shell concentration and surface contour suggest that several deposits occur together in the one concentration. Except for this, no pattern of clustering seems to exist between shell middens of any type. Monospecific middens as a group therefore, are smaller and contain far less shell than middens with several species of molluscs.

The descriptions of the lithic assemblages associated with each type of shellmidden come from field observations and one not validated by systematic sampling. Generally, tools and knapping refuse cannot be associated with cockle and mussel deposits with certainty because most of the deposits are no longer in situ. When an assemblage is positively associated however, it is invariably microlithic in character, consisting of small numbers of backed blades, small scrapers and unmodified blades struck from prismatic cores. A difference in lithic assemblages between monospecific shellmiddens could not be determined from these observations.

Lithic assemblages associated with gastropod deposits were easily recognizable as extensive scatters which often were larger than the shellmidden itself. The tools are predominantly large scrapers and planes with single, concave working edges, but other tools are also common. These include large and small scrapers with multiple edges, simple scrapers, and chopper-like implements of different sizes. In one deposit a fragment of a polished diorite axe was found. Flat slabs of water-rounded calcarenite, which had been transported to the site from the beaches, are also common. These do not exhibit surface markings of any kind to indicate their function, although two specimens were recovered elsewhere in the dunes with pecking or grinding on one surface. These may have been used in plant processing or for smashing bone or plant fibre.

In one area, marked on Figure 5.7a by two stars, a thick lithic scatter covers an area of over 50 square metres in direct association with several gastropod heaps, shown on the map as a single deposit. The tools present include a large number of concave scrapers and smaller scrapers with an array of edge morphologies. Decortification flakes and nodules in all stages of preparation form the dominant element in the knapping refuse, which, as elsewhere in the complex, is extensively distributed around the shellmidden. Two small hearths are present in the midden and one of these contained charred and fragmented *Subninella* shell.

The larger *Subninella*/limpet shellmiddens are therefore distinguished by a large assortment of woodworking and other tools and few, if any, microlithic components. Monospecific shellmiddens by contrast are associated with a limited amount of lithic material, which, when present, is predominantly microlithic.

Another common type of site is the collection of blackened stones which lie in small circular heaps on the dune floor. The stones, which are calcarenite or travertine, show no signs of being modified for use. They number less than 100 per site and may be scattered loosely over 2-3 square metres. Most deposits have lost their original stratigraphic context and none could be positively correlated with other deposits on the basis of physical proximity. No fauna were associated with these heaps.

Many deposits in the eastern group, labelled $^{4}27^{58}38$-2, are eroded from a soil layer still partially preserved in remnants of the sand dune which stand isolated above the dune floor. These pinnacles were studied in detail and a section showing their relationships is presented in Figure 5.7b. To the right in the drawing is a large, dense concentration of *Subninella* and other gastropods lying on the surface of a immature soil horizon, with most if not all shell out of original stratigraphic context. However, the shell retains most of its original colour and luster, suggesting a recent date of deposition. At a lower elevation towards the centre of the blowout is a raised pedestal of sand capped by a layer of *Brachidontes*, charcoal, and microlithic tools. The deposit is assumed to be *in situ* because a hearth of ash, charred shell, and charcoal is preserved within it.

To the left of the section is a large dune pinnacle in which two distinct, dark, sandy soils occur in an otherwise featureless sand profile. The top and bottom boundaries of the lower soil are uncharacteristically sharp as if both are unconformities. Both *Plebidonax* and *Subninella* shells are distributed in this soil in distinct clusters forming nonetheless what appears to be a single, continuous midden layer. Pieces of charcoal in direct association with this shell layer were visible in the face of the remnant but no evidence of a hearth or charred shell was found during excavation. In the absence of this crucial evidence, the association of charcoal and either of the two molluscs was regarded as uncertain.

Subninella and Plebidonax shells are scattered down the slope to the left of the remnant for a distance of about 20 m to the dune floor. The cockles probably only slightly outnumber the gastropods, with the total of several thousand over an area of about 30 square meteres. These are believed to be derived from the soil horizon containing these molluscs still visible in the adjacent soil remnant. An extensive scatter of microlithic implements, small scrapers, and knapping debris lines the lower perimeter of this shell deposit. Most of this flint was collected after a close examination of it in the field determined that many of the tools and flakes were struck from cores associated with the assemblage. This surface collection contains about 500 pieces of flint and weighs more than 8 kg. A deep patination and loss of luster on the flint surface indicates a relatively great antiquity for the collection. These tools are known as Collection One, as shown in the section drawing.

(D) Antiquity

The antiquity of each of the campsite types is difficult to determine because of the absence of clear stratigraphic indicators. The Subninella/limpet deposit is partially preserved in a soil horizon, but charcoal in positive association could not be located. Similarly, stratigraphic and structural uncertainty cloud the exact relationship between shell refuse in the Plebidonax/Subninella layer preserved in the buried soil horizon. Quite clearly, the shells are the only datable materials which are indisputably related to the occupation.

Whole Subninella shells were collected from the northeast surface of the dune as depicted to the right in Figure 5.7b. To examine the possibility of recrystalization of the shell carbonate, the exterior layer of each shell was separated from the interior layer and each fraction was dated separately. The outer shell indicates an age of 1790±80BP (ANU-1485A), while the inner fraction has an age of 1730±70BP (ANU-1485B). The age of these two fractions are not significantly different. The reliability of these shell samples for dating the occupation is discussed below.

A charcoal sample was collected from the hearth in the Brachidontes deposit and yielded an age of 2590±75BP (ANU-1487). Because the hearth and shell refuse are associated in situ, this date indicates the age of campsite occupation.

The midden containing Subninella and Plebidonax in the remnants of the buried soil was carefully excavated in search of charcoal fragments. Charcoal and Plebidonax in contact with one another were collected and dated. The age of the charcoal is 720±70BP (ANU-1547) and the age of the Plebidonax is 1650±70BP (ANU-1486). Since 930 radiocarbon years separate these two age estimates, they are clearly not associated and the charcoal date is rejected as an indicator of the age of the occupation. The age of the Plebidonax shell therefore dates the occupation at which cockles were consumed. Since the charcoal may not be related to the campsite occupation, it is also possible that the Subninella may not be associated with the Plebidonax. Table 5.7 presents the number and age of each of the radiocarbon samples discussed.

Sample No.	Material	C^{14} Age
ANU-1546	Charcoal	720±70BP
ANU-1486	Plebidonax	1650±70BP
ANU-1487	Charcoal	2590±75BP
ANU-1485A	Subninella exterior	1790±80BP
ANU-1485B	Subninella interior	1730±70BP

TABLE 5.7 Radiocarbon date list for Inland Camps

Age determinations based on marine shells are widely known to produce antiquities greater than terrestrial charcoal samples of the same age (Gillespie and Polach, 1976). This discrepancy is caused by dis-equilibrium between atmospheric and oceanic isotopic reservoir which varies latitudinally in coastal waters (Mangerud and Gulliksen, 1975). To account for this influence and hence correct for it, a dating project was developed for the Lower South East under the direction of the Radiocarbon Laboratory at A.N.U. The basis for this study are paired charcoal and shell samples collected from contexts in which the two materials can be shown to have been used together during campsite occupation. The sampling procedures, site locations, species examined, and results of this study are fully presented in Appendix A5.2. For purposes of this discussion, it is necessary only to know that the results of the study show the correction factor for Plebidonax on this coastline is 521±83 years, and for Subninella 596±58. When these correction factors are applied to their respective archaeological samples, a corrected antiquity of 1134±98BP is indicated for the collection of Subninella, and for Plebidonax it is 1129±108BP. The antiquity of these two faunal assemblages is therefore identical, although precise contemporaneity of consumption at the same meal is not confirmed. The comparison of these dates and their corrections is presented in Table 5.8 below.

Sample No.	Material	C^{14} Age	Correction		Corrected Age
ANU-1485A	Subninella	1790±80 minus	596±58BP	=	1194±98BP
ANU-1485B	Subninella	1730±70 minus	596±58BP	=	1134±98BP
ANU-1486	Plebidonax	1650±70 minus	521±83BP	=	1129±108BP

TABLE 5.8 Correction of C^{14} ages of shells from Inland Camps Complex.

(E) Discussion

An examination of the archaeological deposits from the Inland Camps Complex shows that the occupation took two forms. The first consists of a small number of morphologically similar shellmiddens characterized by small, monospecific faunal assemblages of either Plebidonax or Brachidontes. The technology associated with this occupation is represented by small numbers of microlithic tools and low amounts of knapping debris. The later occupation, by contrast, is characterized by large accumulations of shellfish middens containing a mixture of gastropods, emphasizing Subninella, and prolific quantities of worked flint nodules and implements. An antiquity of 2590BP has been determined for one mussel deposit and because these types of shellmiddens are morphologically similar to others for the same time period elsewhere in the coastal margin, the occupation is seen to share temporal characteristics in the settlement as a whole. The antiquity of the Subninella middens has not been determined directly, but is suggested to be late on the basis of preservation.

In economic terms, the two occupations reflect differences in both scale and types of activities. The refuse from the two occupations involves the transport of shellfish from the foreshore, but the quantity per midden appears to have increased during the later occupation, suggesting that consumption rates have risen. The same kind of picture is seen in the greater quantities of flint brought into the area, again from shore deposits.

In these ways, the levels of occupation intensity of this middle strip of the dune take on a new character either through greater frequency of visitation, or larger numbers of people. In addition, not only has the amount of worked flint increased, but the technology seems to suggest a diversity of functions consistent with a range of maintenance tasks and possibly food processing operations. The heavy wood working tools suggest that timber was being cut or shaped, and in this respect, the camps' location in the scrub may be coincident with the availability of the wood resources. The slabs, axes, and occasional nodular sandstone pounding/ grinding stones may be related to the crushing or grinding of plant foods, or cracking of bone to release marrow or sinew. Whatever the special function of individual tools in the latest occupation, the variety of tools present suggests the sites may have been staging areas for different processes in the subsistence organization not indicated in the previous occupation.

Uncertainties of faunal affiliations with the late occupation are raised by the presence of Plebidonax about 1134 years ago, and these cannot be resolved without further dating. The presence of Plebidonax and Subninella together in the same meal indicates an exploitation of two separate marine settings, although contemporaneity of the two molluscs is uncertain due to possible stratigraphic disturbance. The practice, in a majority of these sites, of exploiting different habitats is characteristic of the latest occupation and the cockle/snail affiliation is consistent with this. Assuming that the cockle was not consumed with Subninella in the same campsite, the age of 1129BP for another Subninella deposit in the Complex is still in accordance with the picture of multifocus exploitation patterns reflected in the occupation as a whole. This contrasts markedly with the practice of single species procurement typical of the earliest occupation at this site and at Canunda Rock shellmiddens. The only conclusion to be drawn from this evidence therefore, is that the presence of Plebidonax at this time period is, in itself an exceptional use of resources, but that the general character of the occupation is upheld by other attributes seen in the cockle/snail deposit. Plebidonax must then have survived in the beach of the Lower South East until 1134BP. This problem will be considered further at the conclusion of this chapter.

The presence of stone ovens at the Inland Camps Complex could not be explained due to missing stratigraphic context and datable material.

To overcome this, a larger concentration of ovens was located 1.5 km to the southeast in this zone of coastal scrub, and the results of a study on it are suggested to be applicable to this and similar complexes.

OVEN COMPLEX

(A) Introduction

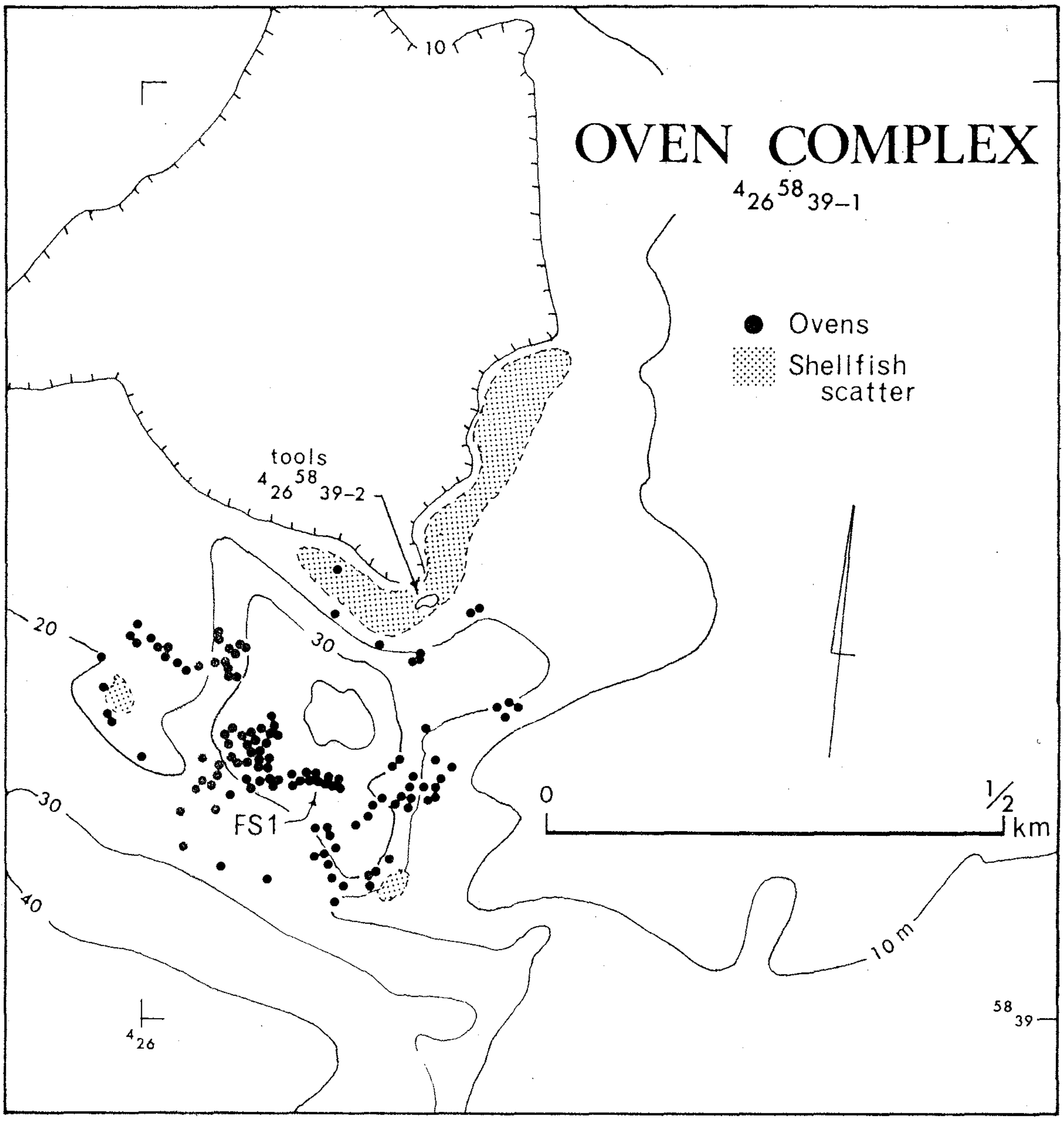
Heaps of fire blackened stone are common throughout the coastal margin wherever suitable stone material is accessible in the dunes. The greatest number occur however, in the central zone of scrub between the coast and the coastal lakes and lagoons. Fourteen, for instance, occur in the vicinity of the shellmiddens in the Inland Camps Complex discussed above and many more have been located in three other areas in the zone. One such area has been labelled the Oven Complex because it contains the densest concentration of burned stone observed in the field. In view of the number and size of these deposits, it is reasonable to consider that they represent a recurrent enterprise requiring considerable investment by coastal settlers of the time. An investigation of a typical group of stone heaps sought to explain their presence in the archaeological record.

(B) Site Setting

The Oven Complex is a large assortment of stone heaps distributed over 3 hectares on a bare calcarenite ridge 1.7 km from the ocean. The foreshore dunes can be seen from the summit of the ridge and in the opposite direction a panoramic view takes in Lake Frome and the northern end of Lake Bonney, with the Woakwine Range filling the background. Sand drifts cover most of the ridge slopes and buried in these are stone heaps and shellmiddens containing mainly Subninella, and lesser amounts of Dicathais, Haliotis, and limpets. Thickets of Myporum insulare (boobyalla) and E. diversifolia (coastal mallee) scrub cover patches of the lower slopes and large dead trees support several eagle nests overhead.

The area was thoroughly searched for archaeological deposits and the locations of these were plotted on a topographic map sheet. One hundred and twenty-one stone deposits were located on the surface, and judging from the number of partially buried deposits, it is likely that an equal number still lie beneath the sand. From the map in Figure 5.8A, it can be seen that the deposits are clustered on the southern or coastal side of the summit. The deposit itself is typically a compact, circular arrangement of blackened stones which range in size from about one half m to 2 m in diameter. The deposits assumed the shape of a low cylindrical cone formed as the surrounding dune surface was deflated by the wind. This process

a. Map



b. Section, stone oven FS1

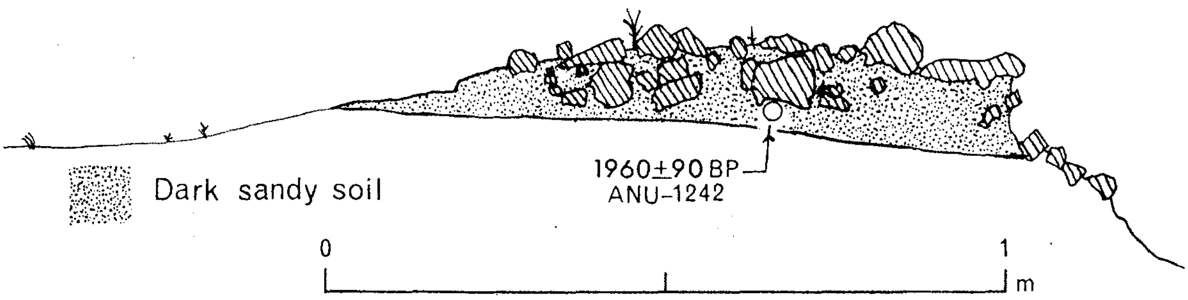


FIGURE 5.8 Map and section of stone oven complex located midway between lagoon and foreshore. Oven FS1, shown in section, is free of food refuse like all others examined. Shellmiddens, of mainly Subninella, and knapping stations are nearby.

elevated the structures above the landscape and caused an apron of stone to form around the perimeter.

On the ground, patters in distribution seem to be present in a number of cases, although poor visibility hampers investigation of this possibility. In one example, a set of six large stone deposits and another set of four smaller ones were found aligned along two parallel axis which were spaced about 2.5 m apart for a distance of 30 metres. The organization of these appears therefore to have a deliberate pattern dictated by the people using it. A similar arrangement was mapped 50 m from the summit on the southern slope. There, 12 deposits of comparable size were aligned in three parallel axes for about 30 m in a staggered fashion to a point where scrub and sand drift obscured the pattern. Deflation had cut into the downhill slope of this arrangement and exposed several heaps in section. One heap of stone on the edge of the vertical face was chosen for excavation and it is labelled FS1 on the map.

In section (Figure 5.8b), the oven consists of a lens of blackened stones buried in a dark soil to a depth of two thicknesses of stone. The surrounding matrix is charcoal-stained sand which darkens in colour and thickens beneath the deposit itself. No evidence of ash as such was found. Evidence that the oven was built in an excavated pit, such as would be indicated by mottling or the presence of intrusive material, was also absent, and furthermore, there was no internal stratigraphy. The evidence suggests instead that the oven was built on the dune surface with the stones piled on the fire, or vise versa. No fauna were associated with the deposit, a feature of all ovens surveyed.

The stones themselves are completely blackened by fire, and do not show significant signs of thermal cracking. Internal colours range from a black on the surface to a whitish gray at the centre which suggests that fire temperatures were only moderately high. The stone is a firmly cemented travertine of the type which forms on the Pleistocene dunes. These are especially common wherever dune sands are missing from the surface of the ridge tops.

Other archaeological deposits in the vicinity include large scatters of Subninella, Dicathais and limpet. An assortment of large concave and straight-edged scrapers and knapping flakes was associated with one of these shellmiddens, and a sample of the assemblage was collected

(Figure 5.8a). This sample will be discussed in Chapter 6. Small, isolated concentrations of tools and knapping debris are also present in low numbers. No direct association exists between any of these deposits and the ovens.

(C) Antiquity

All of FS 1 was excavated in order to collect an adequate amount of charcoal for dating. Small fragments were collected from a location immediately beneath several stones as shown in Figure 5.8b. The age of this charcoal is 1960±90BP (ANU-1242). A direct association between stones and charcoal is not guaranteed by the stratigraphic evidence, and therefore the indicated age of the oven is a maximum.

(D) Discussion

Aborigines in South East Australia traditionally used stone ovens to cook foods and prepare tough plant fibres for processing. Wombat, possum (Beveridge, 1889), and kangaroo (Smyth, 1878; Woods, 1879) are only a few of the meats described as being steamed in ovens. The Buandik are also believed to have constructed ovens for the same purposes (Campbell, Cleland, and Hossfeld, 1945).

The Narrinyeri, who inhabitated Lake Alexandrina, were observed making ovens by Taplin (1873: 42-43). The process involved first a fire to heat the stones. A pit was then dug and the stones were placed hot into the pit to fill the bottom of it level. Green grass was placed over the stones and the meat was arranged on top. A final layer of hot stones covered the meat and this was capped by earth or clay to seal in the steam. Water was poured into the oven through a hole made by a stick. Presumably, the oven was broken into to retrieve the food and the contents scattered around the campsite.

The oven was also used to prepare bulrush, or Typha, both for eating and for use as netting and twine. Angas frequently encountered ovens in use on the lower Murray River, where fish, mussels, crayfish, and bulrush roots form a primary staple. Beneath these ovens, which were also called "kilns", were "roots of bulrush...being steamed between heated stones" (Angas, 1847:58).

On this evidence, the ovens examined in the Lower South East are undoubtedly associated with food preparation in which steam rather than fire was the principle cooking agent. It is impossible with the available evidence to indicate whether plants or meats were more commonly steamed in the ovens, although it is likely that both were involved. Typha was known to be used by the Buandik and in fact it grew prolifically around the shores of Lake Frome (Angas, 1847) only 2 km away. If this plant was utilized by groups occupying the sandhills, it would have been a simple matter to carry bundles of the rush to the ridgetops where the only stone in the area is available.

Whatever the menu was, the compact layer of burned stone found in the dunes today may well have been the lower layer of the oven which was left intact after the food was finally removed for eating. The antiquity of the ovens has been shown to 1960BP in one instance, and if the organization of the ovens indicates contemporaneity, the remaining 11 deposits in this group have the same age.

Repeated occupation of the Oven Complex for the consumption of resources which are not available on site implies the organized transfer of goods. The stone itself, for example, was gathered and carried to the site on which the ovens were to be built, although admittedly, this distance was not more than 50 m at the most. Whether plants or animals were being processed, they would have been transported into the site by working parties of men or women out after food for the day. Judging from the large size of many ovens, the quantity of food cooked may have been enough to feed several people. The picture then is one of food processing which incorporated a locally scarce resource--namely stone--in a multifocus economic operation. In this respect, the ovens contrast with the many small shellmiddens which reflect a single focus by a group in transit.

ABYSSINIA BAY SHELLMIDDEN

(A) Introduction

Archaeological deposits on the seacliffs of the Lower South East have been grouped together according to similar size and contents. These usually extensive layers of reeftop gastropods and flint nodules are deposited in depths up to about a metre, and are sited overlooking large platform reefs in the intertidal zone. Most are as poorly preserved as those at Canunda Rock and Mounce and Battye Rock and hence offer few rewards to this study. One shellmidden at Abyssinia Bay however, possesses a unique stratification which has escaped with only light damage from wind and erosion. Large quantities of shellfish accumulated at the site from repeated human occupation and therefore its morphology is shared by other shellmiddens in the group. Rather than being a single thick deposit however, the midden accumulated during a period of rapid dune formation on the foreshore which sequentially buried distinct habitation surfaces. Thus isolated, these thin layers have generally escaped disturbance from subsequent occupation and are thereby easier to identify and study. The shellmidden at Abyssinia Bay was therefore chosen for investigation to determine the significance of this type of site to the prehistoric coastal settlement.

(B) Setting

Abyssinia Bay is located 2.8 km southeast of Cape Buffon between Stanway Point and Cullen Bay. Extensive reefs at the entrance of the Bay make it an attractive spot for line fishermen and the shallow, reef strewn Bay itself is popular with lobster divers. The Bay is lined by a steep, 9 m high cliff which prevents direct access to the water from above, except at certain localities near the reefs. Extensive calcareous dunes have formed on the cliffs to heights of 7 m or more, and shellmiddens occur in the dune at several locations around the Bay. The Abyssinia Bay Shellmidden is located within the Bay itself, about 150 m from the southern point. The sand dune in which the shellmidden occurs extends inland for one half km, with ground surfaces raising sharply to an exposed ridge of calcarenite, which is the basal surface upon which the dune was formed. Intense ocean winds have cut through the dune at the cliff and have exposed full sections of the occupation layers _in situ_ along the southern boundary of the deposit.

These features can be seen in Plate 5.5b.

The base of the dune rests 10.8 m above the water on a calcarenite cliff and the stratigraphic sequence consists of nine charcoal-stained soil horizons interspersed with a loosely organized sand matrix totalling 7 m in thickness. Loss of sediments from the dune face has caused shells to cascade down the slope and to eventually disappear into the sea as the cliff gradually collapsed. A thick mantle of Subninella and flint nodules protects the front slope from further wind blasts. At least 25 m of the shellmidden is well preserved along the cliffline and towards Cape Buffon, and remnants of it can be traced for another 25 metres. In the opposite direction, almost no shell exists on the valley floor to give an indication of its extent there. However, the few exceptions indicate that it probably once was present. The shell layers can be traced inland for at least 18 m in the windcut section and are well represented throughout the sequence of deposition over this distance. The shellmidden therefore was originally at least 75 metres long and 18 metres wide.

(C) Excavation

A 15 x 8 m grid network of one metre squares was laid over the slope with its long axis aligned north-south, roughly at right angles to the cliffline. Narrow trenches were dug outside the limits of the grid to expose the archaeological sequence and a connecting trench joined these midway up the face. This exposure provided the opportunity to view principal stratigraphic units prior to excavation in order to aid in their removal without disturbance to adjacent or underlying units. Figure 5.9 shows the site under excavation with the occupation horizons exposed in the trench walls.

The objective of the excavation was to remove each natural shell layer in one metre squares within the grid network, and this system is shown in Figure 5.10. Numbered in chronological order beginning at the bottom of the slope, each square was excavated by trowel to the depth of the first occupation layer. The square number would be followed by the number of the layer excavated in it, such that Square 1, Layer 1 was identified as FS 1.1. Since only one layer occurs in the first six squares, as shown in Figure 5.10, a single layer designation is given. In subsequent squares however, the system was modified slightly to accommodate marked changes in shell concentration. For example, little shell occurred in

A.

PLATE **5.5**

B.

A. Hearth 18.4a at Abyssinia Bay contains Subninella and is dated to 1030 BP. Black charcoal denotes basal level of hearth.

B. Abyssinia Bay Midden looking N.W. Horizontal basal layer below screen frame contains no shells or other occupational residues.

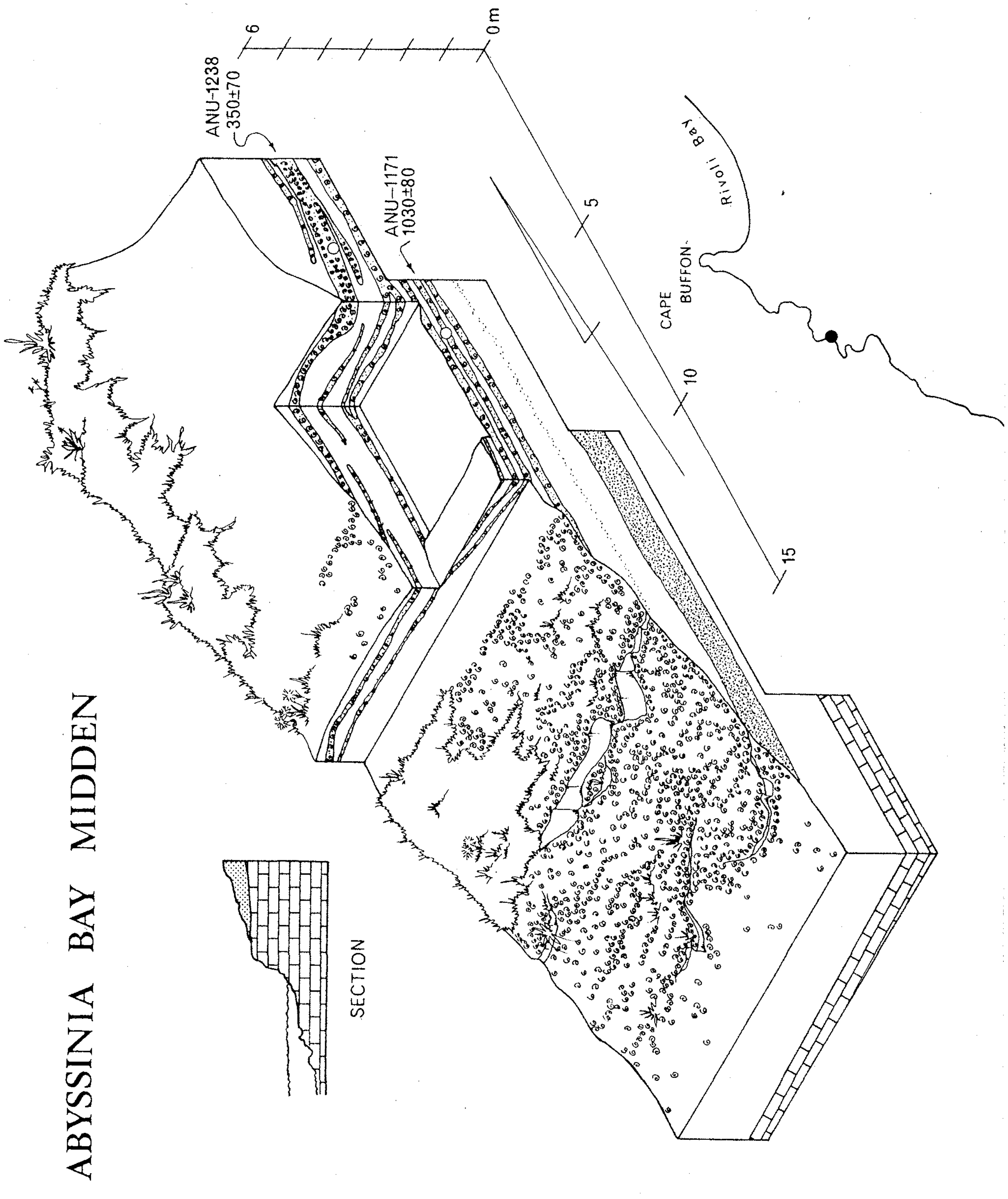


FIGURE 5.9 Diagram of Abyssinia Bay shellmidden under excavation. <u>Subninella</u> is the major shellfish in the layers depicted, while the basal layer is shellfree.

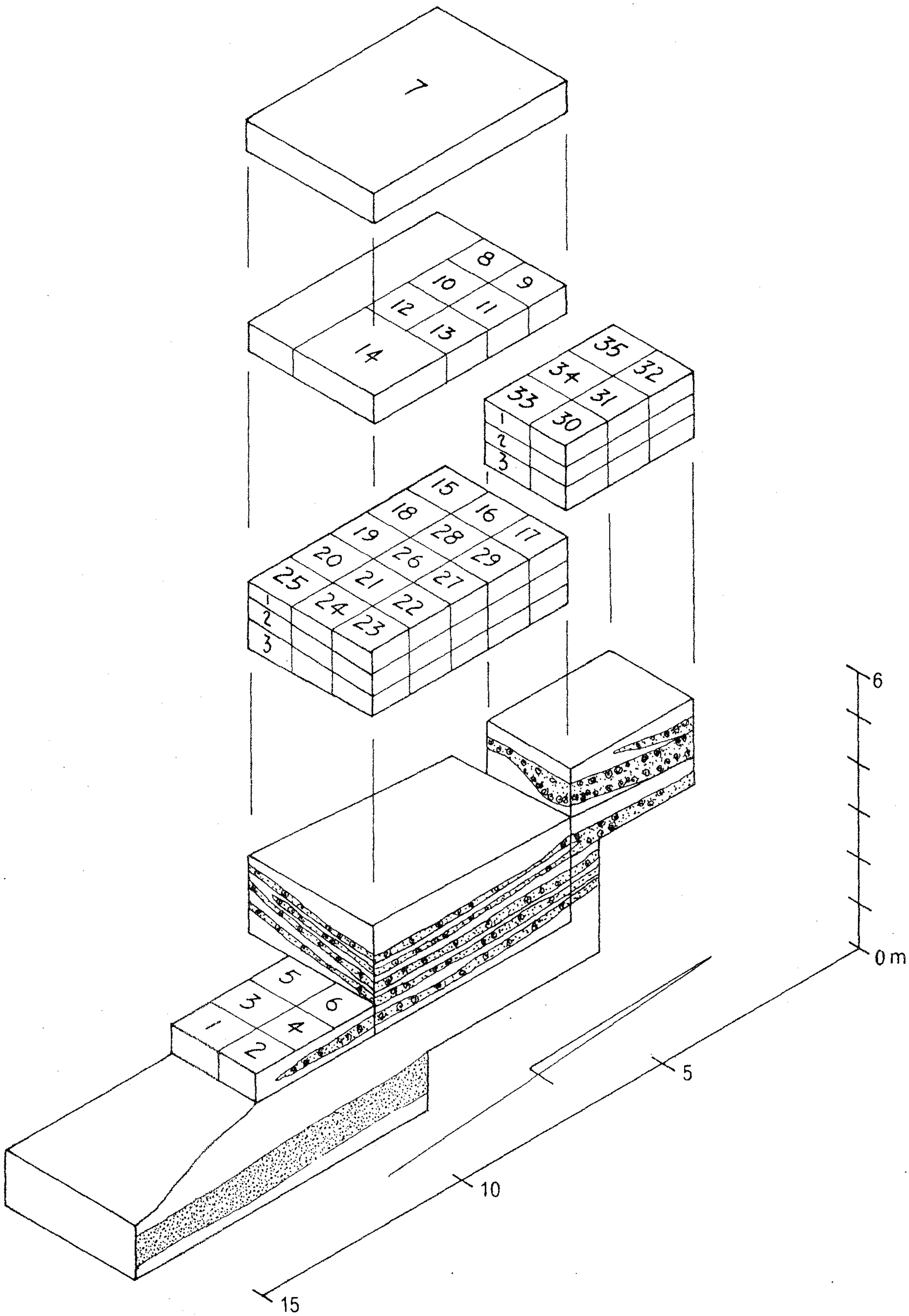


FIGURE 5.10 Diagram of excavation units from Abyssinia Bay Shellmidden shown in exploded view. The numbers refer to one metre squares and individual layers.

Square 7 and it was accordingly established as a 5 x 3 m rectangle one layer deep. Similarly, Squares 8 through 14 were excavated to a depth of a single shell layer in one metre squares, except for Square 14, which was 2 x 2 metres. Commencing at Square 15 however, the square number was not changed with the excavation of each subsequent layer. Only the layer number changed and this procedure applied to Squares 15-34. To further subdivide shell concentrations for analysis, Squares 30 through 34 were quartered into areas designated A through D, and these applied to each layer as it was excavated. Under this scheme, quarter A of Layer 1, Square 30 overlies quarter A of Layer 2, Square 30. Layer designations are shown on the wall of each square in Figure 5.10.

(D) Stratigraphy

The soil profile at the excavation site is typical of the setting. A terra rossa soil is present in the valley floor overlying calcarenite, although only remnants are present beneath the site proper, according to probe information. A dune of coarse grained calcareous sand overlies this to form the primary sedimentary unit, and in this, the only obvious stratigraphy is a series of immature soil horizons. The most striking layer begins this series, is 50-60 cm thick and appears to contain finer sediments than later ones. This basal layer can be traced continuously up the slope for one km and remnants are clearly exposed at various localities along the cliff within one kilometre. A close search of this layer failed to recover a single sign of human occupation, although kitchen refuse and flint is littered across all other soil horizons in the profile. Since charcoal samples from terra rossa soil at Cape Martin (Tindale, 1957b) and at Bevilaqua Cliffs (Campbell, Edwards, and Hossfeld, 1963) both provide dates between 8000-9000BP, this dark, sandy soil horizon above the terra rossa may be Mid-Holocene in origin, or younger.

A sequence of thinner dark soils containing Subninella, charcoal and flint nodules dominates the remainder of the dune unit within a vertical distance of 2.3 m, as seen in Figure 5.9. Except for a single diffuse layer which overlies the basal dark soil and contains no cultural residues, all of the dark soils are associated with occupation refuse. To the rear of the dune these become indistinct and disappear altogether 50 metres further inland. This suggests that occupation may have influenced the formation of the soils. It is likely therefore that natural deposition of dune sands occurred throughout the period of human habitation and that the refuse constitutes a momentary interruption of that process.

From the start of excavation, it was clear that most major shell layers were comprised of concentrations of refuse which overlapped and intermingled horizontally. Together, these formed larger horizontal units, often in association with diffuse scatters of charcoal at the focus of the shell concentration. Solid clusters of hundreds of Subninella opercula, commonly charred, mark these depositional units and suggest the remnants of fires or cooking hearths. These were initially difficult to isolate by excavation because of vague boundaries, incomplete exposure, or disturbance, but these problems were overcome in the course of experimentation with excavation techniques. The contents of a hearth within FS 15.3 and FS 18.3&4, for example, were excavated as a discrete deposit as shown in Plate 5.5a. Only in the upper levels however, were individual deposits isolated as a result of more careful excavation and finer division of the floor scatter.

(E) Antiquity

Charcoal samples from two hearths were collected and submitted for age determinations. These included large fragments from the base of a hearth FS 18.4 which dated to 1030±70BP (ANU-1171), and from FS 30.2B which dates to 350±70BP (ANU-1238). The circles in Figure 5.9 locate the position of these layers. Shells from each hearth were also dated and age determinations for them appear in Appendix A5.2.

To estimate the times of initial and final occupation, it is necessary to extrapolate on the basis of sedimentation rates. This assumes that a constant rate occurs between two time markers, in this case a distance of 1.25 m deposited over a period of 680 years. A rate of 10 cm for every 54 years is derived from this computation. The basal shellbearing layer, which is 35 cm below ANU-1171, may have therefore accumulated 189 years earlier, or about 1220BP. Another way to estimate the age of the initial occupation is to calculate the number of years represented in each layer. Since four layers accumulated in 680 years, each unit represents about 170 years of occupation. At this rate, the first layer was laid down 1200BP. The upper date of 350BP occurs in the basal portion of a thick layer of shellfish and here it is only possible to say that final occupation occurred sometime after this date, probably at the time of European settlement. The occupation then is taken to have spanned the period 1220BP to about 150BP, or 1070 years.

(F) Food Remains

All excavated refuse at the site was sieved through 1/4 inch square mesh screen and washed in the laboratory, but owing to its immense volume, only debris from selected layers was identified. These included layers near the base, in the middle, and on top of the sequence, with the major analysis involving the latter. Four kilograms of hearth debris was examined for plant remains without success, except for finding small fragments of wood charcoal believed to be remnants of the fire itself. In the upper three layers of the midden, preservation of minute quantities of Subninella periostracum, crab parts, and fragments of lobster carapace indicates that conditions are favorable for the preservation of these and other organic residues, including bone. However, no bone was associated with the midden, which is consistent with observations at other cliffline deposits of this type. The consumption of vertebrate foods is therefore unlikely to have taken place on site.

An estimate of the minimal number of shellfish was easily made on the basis of shell count, because a majority of the gastropod species are undamaged. The number of Subninella is based on opercula counts whereas all other molluscs are estimated from shell counts. The representation of chiton, which possesses eight valves, was calculated from the minimum number of anterior valves, which exhibit distinctive dorsal slits. The lobster, Jasus, is represented in the midden by mandible fragments, which, because of their condition, cannot always be distinguished as to right or left elements. For this reason, Jasus has been itemized as mandibles rather than as individual animals. An inspection of whole specimens suggests however, that the minimum number present in each meal is likely to be greater than one half the number of mandibles and in a few instances, it is clearly at least equal to the jaw count.

A list of excavated material from selected levels in the midden is presented in Appendix A5.3, with values expressed in minimum numbers. It is clear from this information that the occupants of Abyssinia Bay enjoyed an exclusively marine menu. The principal foods exploited were Subninella undulata and the Rock Lobster Jasus, both of which would have been common near the reefs below the site. Another common food is Chiton, Poneroplax albida, which is also common at and below low tide in the Bay. Flint, collected from stranded deposits in the surge zone, constitutes another important aspect of campsite debris. An economic analysis of this material will be presented in Chapter 8.

(G) The Meal

From the outset of the excavation, it was clear that the discrete deposits which comprise the Abyssinia Bay shellmidden may represent kitchen refuse from single meals. In order to investigate this possibility in detail, shells were excavated individually to minimize disturbance of the stratum, and layers were carefully exposed with trowel and brush to trace colour patterns and changes in concentration. The evidence uncovered in this manner typically consists of a hearth and shellfish lens without distinct lateral boundaries. One such example, shown in Plate 5.6a, exhibits characteristic clusters of Subninella shells bordering a diffuse charcoal scatter, which is exceedingly thin and devoid of larger pieces of charcoal. The shell lens may be as thick as two or more shells and often has sharp upper and lower boundaries. The total area of this charcoal/shell scatter is difficult to calculate due to highly variable concentrations of the refuse, but considering the soft, sandy matrix in which it is deposited, it is surprisingly compact and seems to remain within a radius of about 1.5 m from the hearth. This evidence suggests that the foods were discarded close to the fire in which they were cooked and that this relationship may have been preserved at the time of burial.

Several methods of cooking and eating Subninella are possible and two techniques may be considered from the data. This large snail is equipped with a dense calcareous operculum which closes firmly against the shell opening once the animal is withdrawn from the water. This must be detached from the foot muscle before the meat can be removed from the shell, and two ways of doing this are feasible. The first is to break through the shell at the lip and pry away the operculum and the animal. There is no evidence on the shell to show that Subninella were being systematically broken to retrieve the meat and in fact, the vast majority of shells are entirely damage free. They must have been prepared in a different way then.

A routine inspection of Subninella shells and opercula indicates that the shells are almost totally free of charring, whereas 50% or more opercula from each layer are charred black and some have been shattered by intense heat. The best explanation for this difference is that heat was applied to the opercula to detach them from the shellfish. After a few minutes in the fire, the cooked shells were removed and the opercula fell back into the fire where they suffered further burning. This process would account for shell charring patterns and the accumulation of opercula around the hearth in clusters. The amount of tinder to cook the molluscs in this way would be low and the quantities of charcoal generated in the fire would be correspondingly small.

If the meals consisted solely of Subninella, the amount of shellfish cooked at the campsite could be computed simply from a study of the size and number of Subninella opercula. Yet because the refuse contains other seafoods which do not possess opercula, a difficulty arises in determining the full complement of foods consumed at any particular meal. This problem is further complicated by the crowded nature of the deposits which hampers delineation of hearth scatter. If, in the course of excavation however, it was determined that the ratio between shell and opercula of Subninella was equal despite dispersal of these two shell parts during occupation, it may reasonably be assumed that the excavation successfully isolated other major ingredients of the meal. It follows that other food remains thus isolated by excavation may also be associated with the same meal. An examination of shell/opercula ratios of Subninella, Table 5.9, from three shell horizons and four hearth scatters shows that the number of shells only slightly exceeds the number of opercula in association. Other food remains associated with the excavated unit are therefore included in the list of foods eaten in the meal.

Excavation Unit	Shell/oper.		Ratio	
FS30-34 Layer 1	763/660	=	1.16	
FS30-34 Layer 2	1712/1568	=	1.09	
FS30-34 Layer 3	4600/4464	=	1.03	
Hearth 1	317/289	=	1.10	MEAN (hearths only)
Hearth 2	552/507	=	1.09	X = 1.02
Hearth 3	712/814	=	.89	Sd = .11
Hearth 4	940/910	=	1.03	

TABLE 5.9

Shell/opercula ratios for Subninella at Abyssinia Bay

Following confirmation that the major portion of the meal can be identified in this way with confidence, four meals were reconstituted from notes and drawings describing the hearth areas isolated by excavation. The material from each was identified and is listed in Table 5.10 with relevant grid and layer designations. The number of Subninella present is based on opercula counts, and the amount of flint is expressed in grams. The tally of faunal remains confirms the importance of Subninella, Jasus, Poneroplax and Haliotis to the diet. Each of these foods are common in the Bay today and could independently contribute significant quantities of meat to prehistoric shellfish gatherers. It is significant that the contents of the meals are derived from different marine habitats and would require different collection techniques in their procurement. The Rock Lobster inhabits the rocky crevices and ledges of the reefs in shallow to deep water and would be captured by divers. Haliotis, on the other hand, lives on rocks and in caves and is obtained by prying the shell away from the stone surface. Subninella also inhabits these areas near the edge of the reefs in shallow water attached to the rock surface or to seagrass. The procurement strategies involved in maintaining this diet can be deduced from a detailed analysis of the rate of procurement of each principal species, and this will be considered below.

The quantity of marine fauna available in the littoral may vary under the influence of climatic conditions, seasonal food shifts, and the effects of both natural and cultural predation. For this reason, the particular menu served at any one time will change, and the selection of foods will further be influenced by the collection techniques of the shellfish gatherers. The mean number of animals for the four meals has therefore been computed to examine this case (Table 5.11). The picture these figures show is one of about 45% variation in the contribution made by the major foods to the diet. Considering the range in size of these meals, these values suggest a regularity of the habitats being exploited as well as success of the collection techniques. Table 5.12 shows the role of shellfish in each of these four meals to again consider the stability of supply. These figures illustrate a primary reliance on Subninella in each of the four meals, with an average of 90.5% contribution. This evidence indicates that the supply of resources was reliable and that the inhabitants of the site were able to overcome relative vageries with appropriate procurement practices.

Meals identified in Abyssinia Bay Shellmidden

	MEAL 1 FS31.1+32.1	MEAL 2 FS33.2D + 34.2
Subninella opercula	289	507
Dicathais textilosa	6	7
Patelloida alticostata	18	6
Patellanax peroni	0	4
Cellana tramoserica	1	1
Haliotis ruber	8	3
Austrocochlea constricta	7	3
A. adelaidae	2	1
A. concamerata	0	1
A. odontis	0	1
Melanerita melanotragus	0	1
Cominella lineolata	0	2
Austrosipho waitei	0	0
Pleuroploca australasia	0	2
Poneroplax albida	15	12
Jasus mandible	5	2
Crab claw	0	2
Flint (wt. in grams)	535 gr.	908 gr.

	MEAL 3 FS34.3A&C+33.3B&D	MEAL 4 FS15.4+18.4
Subninella opercula	814	910
Dicathais textilosa	11	17
Patelloida alticostata	0	31
Patellanax peroni	0	0
Cellana tramoserica	0	9
Haliotis ruber	3	2
Austrocochlea constricta	1	1
A. adelaidae	6	4
A. concamerata	0	19
A. odontis	6	3
Melanerita melanotragus	2	0
Cominella lineolata	4	0
Austrosipho waitei	1	0
Pleuroploca australasia	0	1
Poneroplax albida	13	4
Jasus mandibles	3	4
Crab claw	0	0
Flint (wt. in grams)	2635 gr.	3490 gr.

TABLE 5.10 Contents of four meals from Abyssinia Bay Shellmidden based on counts of minimum number of individuals.

ANIMAL	Mean ± Deviation	Deviation as % of mean
Subninella	630±284	45%
Dicathias	10.3±4.9	48%
Haliotis	4±2.7	68%
Poneroplax	11+4.8	44%
Jasus	3.5±1.2	37%

TÀBLE 5.11 Minimal number of animals from four meals expressed as a mean and standard deviation.

	Meal 1	Meal 2	Meal 3	Meal 4
Subninella	84	92	95	91
Dicathais	2	1	1	2
Patelloida	5	1	O	3
Patellanax	O	1	O	O
Haliotis	2	1	O	O
A. concamerata	O	O	O	2
A. adelaidae	O	O	1	O
A. odontis	O	O	1	O
A. constricta	2	1	O	O
Cellana	O	O	O	1
Poneroplax	4	2	2	O

TABLE 5.12 Percentage of molluscan species from four meals at Abyssinia Bay.

Assuming that the midden developed gradually as a result of repetitive visitation by Aboriginal groups, it is possible with the available data to calculate annual rates of accumulation. This can be done by dividing the shell density into the total volume of the original midden to approximate the total number of animals consumed, and dividing this value by the number of shells associated with an average meal. The following operation illustrates the calculations in determining shell density from excavation data.

Volume of FS 30-34 excav. units	= 3.25m^3
No. of Subninella in excav. units	= 6692
No. of shells / m^3 of dune	= 2059.08 shells/m^3

The volume of the shellmidden can be calculated from the observed distribution of its remnants. This figure allows certain assumptions to be made about the minimal dimension of the dune deposit. It is assumed, for example, that the eight shellbearing layers have a combined thickness of 2.25 m and extend for a distance of 30 m parallel to the cliff and 18 m front to back. Since remnants were in fact observed for over 75 m on the dune surface, the length of 30 m is regarded as conservative. The original volume of the midden is therefore 1215 m^3. The steps in the computation are as follows:

No. of Subninella in midden	= 1215 m^3 X 2059.08 shells/m^3
	= 2.501 x 10^6 shells
No. of meals	= 2.501 x 10^6 shells / 630±45% shells/meal
	= 3971±45%
	= 2184 to 5758 meals
Frequency of visitation	= meals/duration of occupation
	= 3971±45%/1070 radiocarbon years
	= 3.71 visits per year
	= 3.7±45% visits per annum

These data indicate the possibility of regular use of the site by shellfish gathers during the occupation. The calculations are subject to errors derived from content vagaries and, obviously, no data exists to suggest that several meals were not routinely prepared simultaneously. If that were the case, estimates of the frequency of occupation would be lowered. Whatever the specific pattern of use of Abyssinia Bay midden however, it is difficult to escape the conclusion that the Bay was a significant resource area throughout its occupation.

(H) Technology

Knapping debris consisting of flakes, cores, chips and nodules has accumulated on the midden surface as a result of extensive deflation. This scatter was divided into three zones according to surface landmarks and all flint from the bottom two zones was collected and labelled Surface Zone 1 and 2 respectively. The top zone was ignored. This material weighs about 56 kg, and the majority are either slightly modified nodules, or are large decortification flakes. Although this collection has not been carefully examined, it is clear that very few tools are present. This observation is consistent with other middens of this type.

The technological component uncovered by excavation does little to change this picture. Two types of implements stand out. The first is a moderately large, concave scraper commonly made on a decortification flake. The other type is morphologically similar to the first except that less secondary edge retouch has occurred and the flake is often irregular in shape. This industry is sometimes absent from the fireside scatter but when present is disproportionately scarce relative to the amount of flint being worked on the site. This would suggest that either the stone is being processed elsewhere after the cortex has been removed, or that the tools are routinely removed from the site after manufacture. No microlithic component, reflected either by blade cores, backed blades or by geometric microliths, is present in the site.

(I) Discussion

An examination of the Abyssinia Bay occupations has revealed an exclusive focus on littoral resources available in the reefs immediately below the site today. These include faunal assemblages which represent the full range of habitats expected to exist in the Bay, beginning at the upper tide mark and extending downward into the subtidal surge zone. This evidence suggests a variety of exploitation techniques ranging from simple hand collection of shellfish from the reeftop, to procurement of other resources by diving. That this was an intensive pattern of exploitation is demonstrated by the fact that individual meals shared the same menu at different occupations with little significant variation in the proportion of species represented. Although the analysis described has concerned mostly the upper levels of the deposit, an inspection of the refuse in basal layers has revealed no evidence which would challenge this characterization of the economic activity associated with occupation. The occupation as a whole is seen therefore, to have focused on the total range of possible resources at the locality, including flint, shellfish, and crustaceans, in a very concerted way.

The industrial component associated with the occupations appears to be primarily related to flint quarrying rather than to knapping of implements for use on the site. This would suggest that the occupants were in transit and that stone was being transported to other destinations, presumably for further knapping. The tool kit reflects an abbreviated functional character involving scraping or possibly planing. Featuring simple concave working edges, these implements could have been used to straighten or repair digging sticks, spears, or clubs, for example, but probably were not used for basic construction tasks. The absence of fish remains and fish hooks, however, suggests that fish were not consumed on site, and that therefore, spear fishing is not likely to have occurred during occupation.

The intensity of occupation, estimated to be more than 3.7 visits per annum, raises important questions about the possibility of overpredation and the measures, if any, adopted by the inhabitants to avoid it. The exploited molluscan community is situated within a comparatively short distance from the shore under conditions of extreme environmental stress. Despite the vagaries in supply which occur as a result of natural losses, the analysis indicates that successful returns were realized by the shellfish collectors. This means that not only were the collectors competent in their pursuit, but that procurement strategies were deliberately adapted to maintain levels of consumption regardless of momentary downturns in the molluscan population. Possible methods to assure adequate yields of these resources might include coordinated scheduling of visits to allow for replenishment of stocks to take place, improvements in collection efficiencies, or an increase of the range of exploitation to encompass more of the resource. To determine the nature of the strategy, an economic analysis of the food refuse will need to consider the ranging behaviour and ecology of the animals involved. Given the amount of foods consumed suggested by the contents of the meals, this information can also be used to calculate total consumption rates for the settlement, which is an indication of the economic role of the shellfish in the diet.

Because local marine conditions may favor occupation of one site over another, a different deposit must be considered to document variation between similar occupations. Cameron Rock represents a similar deposit in a different environmental setting and is considered below in the context of discoveries made at Abyssinia Bay.

CAMERON ROCK SHELLMIDDEN

(A) Introduction

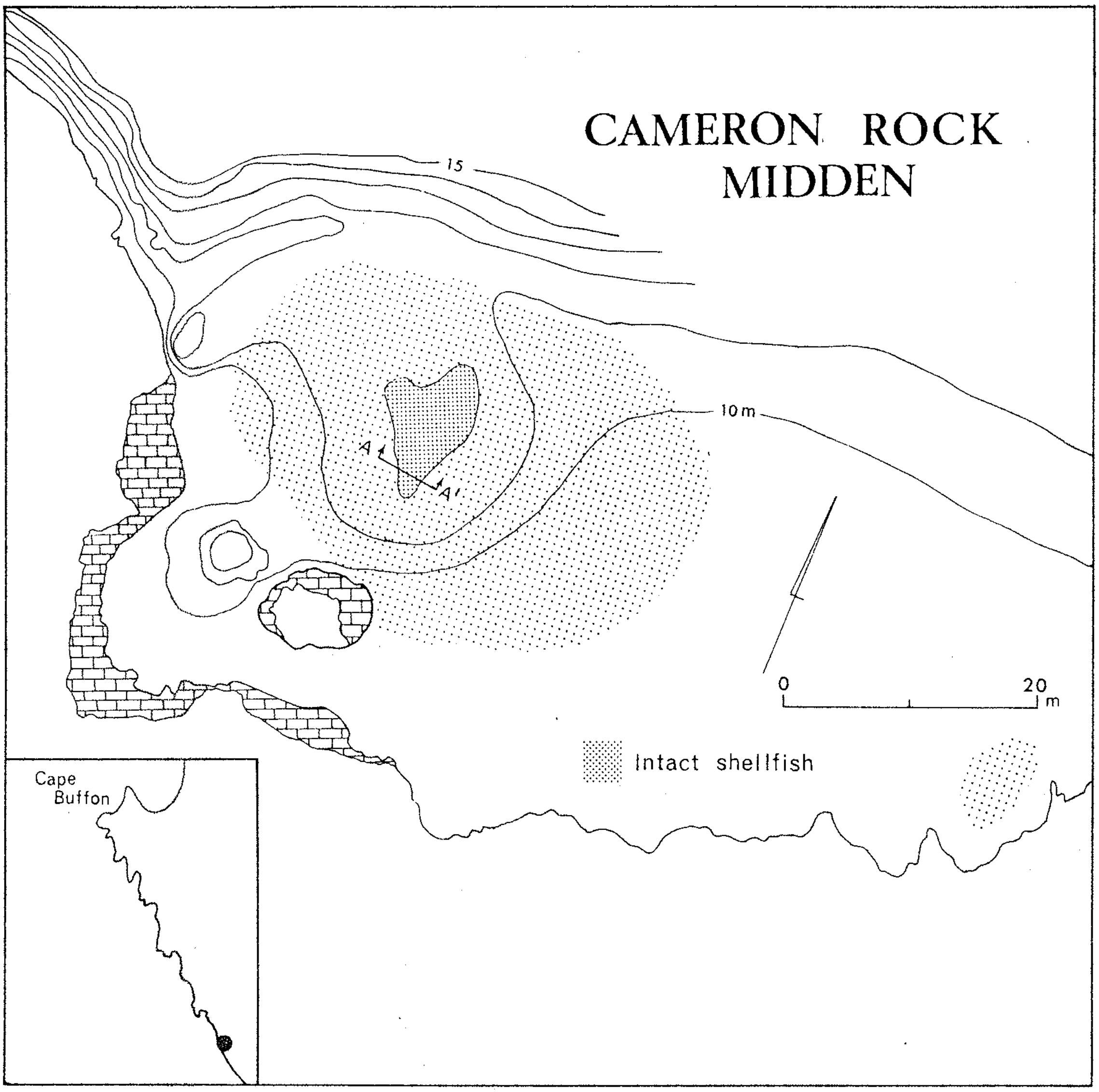
Large clifftop shellmiddens are the dominant archaeological deposit in the Lower South East and their pattern of distribution along the coastline significantly overlaps the distribution of other types of middens. Differences in inshore marine habitats over this distance are expected to influence the character of subsistence activities at any one of these sites, and indeed, may determine the timing of the occupation itself. To examine this influence, and the degree to which site economies differ, deposits situated in contrasting settings may be compared. Since Abyssinia Bay represents a protected environment, a more open location was sought for the second investigation. Cameron Rock, which is 4 km from Abyssinia Bay, met this requirement, and because a portion of the midden was preserved in situ it was chosen for examination.

(B) Setting

Cameron Rock is 6.5 km southeast of Cape Buffon and is a part of an extensive platform reef situated below calcarenite cliffs 4m in height. Ocean winds have exposed a narrow strip of terra rossa soil on the clifftop, removing almost all dune sands around a large shell deposit. Seen in Figure 5.11a a high dune surrounds the site to the north and west, and remnants of it are preserved at the cliffline, and near an opening of a sea chimney. Large deposits of flint nodules occur in the bottom recesses of the chimney and in the upper surge zone of the beach 100 m to the north of the site.

The shellmidden itself consists of two zones of shell overlying calcareous dune sands. The first is a thick layer of undisturbed midden approximately 25 square metres in size, which is covered by loose shell scatter. The second zone is a wide apron of shell and flint debris approximately 40 m in diameter. The site is shaped by deflation into a cone about 2.5 m high. Shell layers have been located in the adjacent sand dune to the northwest, and in the dune remnant at the chimney. Shell scatter also occurs at the cliffline to the east of the site, marked as light stiple on the map (Figure 5.11a). If this shell distribution reflects the original extent of the midden, it was approximately 80 m long and 15 m wide.

a. Map



b. Section A-A' and excavation units

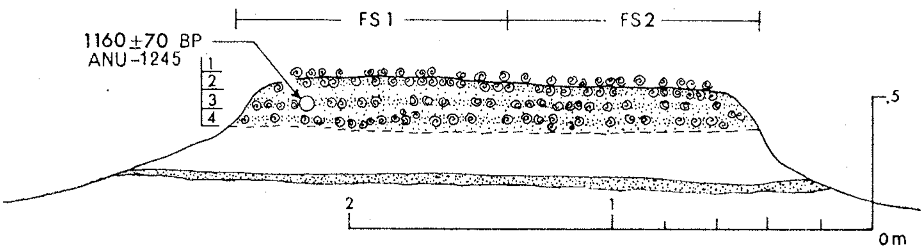


FIGURE 5.11 Map and section of Cameron Rock Midden. Information is derived from physical survey. Note that the lower dark soil illustrated in section, 5.3b, is shellfree.

(C) Excavation

In light of the degree of midden loss, the excavation sought merely to retrieve a representative sample of refuse from each occupation level and ignored delineation of internal structures in the deposit. To accomplish this, an excavation line, A-A', was established over the midden and two one metre squares were marked on the surface, in alignment with the protruding edge of the undisturbed portion of the deposit. The face of the exposed deposit was cleaned and the stratigraphic sequence as recorded prior to excavation.

Midden material was excavated by trowel in four natural layers and screened through a 1/4 inch sieve. Layer dimensions were measured in the course of excavation and selected samples of the tool assemblage were collected from the surface scatter for study.

(D) Stratigraphy and Chronology

The shellmidden occurs in a deflated calcareous dune which overlies a thin terra rossa soil. The dune is a loosely organized shell sand in which two dark, immature soils have formed. The lower one is a thin, diffuse band situated about 30 cm above the base of the dune. It is shellfree. The upper layer, shown in Figure 5.11b, is 35 cm thick and contains cultural material throughout. Unlike the Abyssinia Bay shellmidden, a thick, basal soil is missing from the profile, although a vague organic staining does occur near the base of the dune. An unknown quantity of the deposit is missing from the top.

Four distinct shell layers were recognized in the upper soil horizon and were excavated. The first consists of shell scatter lying loose on the surface of the deposit. Labelled 2,3,4 respectively, the remaining three layers are in situ deposits which were traced horizontally across the two squares. Clusters of shells occurred in each layer, often involving single species. No evidence of a definite hearth was uncovered however.

Charcoal fragments associated with Layer 3, Square 1, were recovered and dated. The age of this charcoal is 1160±70BP (ANU-1215). It is not possible to determine the age of the initial occupation without additional data. Three implements made from bottle glass were collected from the surface of the deposit, and it is possible that these indicate Aboriginal occupation during the 19th century. The stratigraphic evidence for testing this is missing.

(E) Food Remains

All excavated food remains have been identified. The collection is generally well preserved, with the exception of Haliotis shell and crustacean parts, which are usually recovered fragmented. The minimum number of individuals present in each of the four excavated layers has been calculated and this list is presented in Table 5.13. The crab claws have not been identified but are believed to belong to a common variety of rock crab which, at most, weights about 300 grams.

	FS 1.1 FS 2.1	FS 1.2 FS 2.2	FS 1.3 FS 2.3	FS 1.4 FS 2.4	Total	%
Subninella opercula	428	667	176	561	1832	69
Dicathais textilosa	29	72	14	53	168	6
Patelloida alticostata	28	108	30	10	149	6
Patellanax sp.	1	24	6	4	34	1
Cellana tramoserica	13	38	6	229	286	11
Haliotis ruber	1	9	6	3	19	1
Austrocochlea adelaidae	13	46	5	4	63	2
Cominella lineolata	1	1	0	0	2	-
Poneroplax albida	13	48	16	21	98	4
Brachidontes rostratus	1	1	0	2	4	-
Katelysia spp.	0	1	0	0	1	-
Jasus mandibles	2	4	1	3	10	NA
Crab claws	0	8	3	4	15	NA
Flint (grams)	1125	2180	3275	1325	7905g	NA

NA = not applicable.

TABLE 5.13 List of midden refuse from Cameron Rock Shellmidden.
Percentages apply only to the molluscan collection.

From this list, it is clear that Subninella is the most common food consumed at the site and that the limpets, Cellana and Patelloida, along with Dicathais constitute only 23% of the molluscan fauna exploited. Crustaceans seem to be constant items on the menu and because of their meat content, contribute more to the diet than their numbers indicate.

Live colonies of Beaked Mussel, Brachidontes, are rare in the Lower South East and the nearest occurrence is at Portland (Bennett and Pope, 1953), 100 km away. Katelysia spp., which occur in profuse numbers in the lagoon shellbeds between the Robe and Woakwine Ranges, are also locally extinct. The low frequency of these two molluscs in the Cameron Rock shellmidden suggests that the animals either survived in low numbers throughout the period of occupation or that shellfish gatherers ignored them.

In the absence of more definitive evidence, shell density may be used as an indicator of occupation intensity which can be compared with other deposits. To accomplish this for Cameron Rock midden, the number of Subninella in each excavated layer was divided by the volume of the layer to provide the density of shell per m^3. Table 5.14 presents the steps in this computation. The mean shell density in the deposit is 1948 shells/m^3.

Units	Dimensions	Vol. of unit	No. shells	Density
FS1.1+2.1	1.9 x 1 x .06m	.11m^3	428	3754 shells/m^3
FS1.2+2.2	1.95 x 1 x .16m	.31m^3	667	2137 shells/m^3
FS1.3+2.3	2.0 x 1 x .10m	.20m^3	176	880 shells/m^3
FS1.4+2.4	2.0 x 1 x .16	.32m^3	561	1753 shells/m^3
	Totals	.94m^3	1832	$\bar{x}$ 1948 shells/m^3

TABLE 5.14 Mean Shell density of Subninella for Cameron Rocks Midden

(F) Technology

Three large scrapers and a calcarenite slab exhibiting pecking in the centre of one face were the only implements recovered by excavation. The pecking in the soft carbonate material may have resulted from crushing ochre or shell since traces of both appear on the surface. The tool assemblage observed on the surface featured simple, concave scrapers and in general, the knapping refuse consists of a high number of large, angular flakes in respect to smaller flakes. Most of these appeared to be decortification flakes, and in this way the industry at Cameron Rock is consistent with many other clifftop industries observed in survey.

(G) Discussion

The evidence from the Cameron Rock shellmidden reflects an economy oriented exclusively to a wide range of littoral resources, including both material and foods. Of the foods, Subninella, Haliotis, Jasus, and crab are the most significant fauna exploited. The fauna represent the full range of inshore marine habitats available, and it is clear from the density of refuse that the subsistence economy continued to depend upon these resources throughout the occupation of the site. We can conclude from this information that resources at Cameron Rock formed an important element in the settlement strategies of shellfish gatherers in the area as a whole.

A comparison of faunal lists from Abyssinia Bay and Cameron Rock reveals only slight proportional differences between principal foods, but no differences in subsistence economies. Subninella represents 90% of the molluscan foods at Abyssinia Bay, for example, whereas it drops to 69% at Cameron Rock in favor of Cellana and other limpets. The relative proportion of limpets and periwinkles also varies between sites with some species being present in only one of the sites. These differences involve sympatric species which have been observed in different proportions on the same shoreline. Since the composition of rocky shoreline communities is highly variable even within local settings, the contrast in faunal lists is seen as a reflection of normal ecological differences and is not significantly influenced by cultural selectivity. The character of the food quest at these two sites is therefore taken to be identical. On the basis of dated evidence, this subsistence pattern appears to have developed about 1300BP and continued until about the 19th century.

In view of the comprehensive range of fauna exploited in the rocky shoreline of the Lower South East after 1300BP, it is reasonable to assume that the absence of Brachidontes indicates that the species was not available. This suggests that environmental factors influenced the choices of foods consumed, and it follows then that middens containing significant amounts of the mussel must predate the clifftop occupations.

BOOMAROO PARK COMPLEX

(A) Introduction

The discovery that lagoon molluscs are not common in the archaeological records of shellfish gatherers was unexpected and required an explanation. If the lagoon outlet was narrow for most of the occupational history, restricted tidal flow may have caused instability in lagoon mollucan communities and hence low food supplies for man. On the other hand, these resources may have been all but ignored by Aborigines for reasons unknown to us today. To resolve which of these explanation is more correct, it was obviously necessary to date the exploitation and to correlate this evidence with the paleoecology of the system derived from a study of the fossil shellbeds discussed in Chapter 2. The Boomaroo Park Complex was then chosen for this study in the likelihood that its occupation would be associated with an early phase of exploitation when the lagoon was open. Situated on the inland shoreline of the lagoon, it could be compared with the midden fauna on Domaschenz Ridge on the seaward side of the lagoon. The results of this examination are presented below.

(B) Setting

Boomaroo Park shellmidden complex is an assortment of small, discrete heaps of shellfish on the surface of a beach ridge located 4 km east of Guichen Bay as shown in Figure 5.12. About 65 similar ridges have been formed seaward of this ridge, and another 15 parallel the Woakwine Range inland of the site. The vegetation cover includes sparse stands of *E. diversifolia* and *Myporum insulare* and low grasses which are being grazed by sheep. About 10 years ago, the dune ridge lost its cover near Boomaroo Park Station, leaving about 6 hectares of the dune exposed in a deeply eroded condition. As a result, buried shellmiddens came to light and any destruction caused to them by artefact hunters has occurred only recently.

The conditions under which these ridges were formed are an important concern of this study. Sprigg (1952) has examined this ridge system extensively and considers that development has occurred under the influence of cyclical aeolian processes. This is suggested on the basis of the regular size and shape of the ridges and the fact that they were formed well above the tide zone, with surface elevations of 8-10 metres high. It is also apparent that rapid stabilization of fresh sand additions by

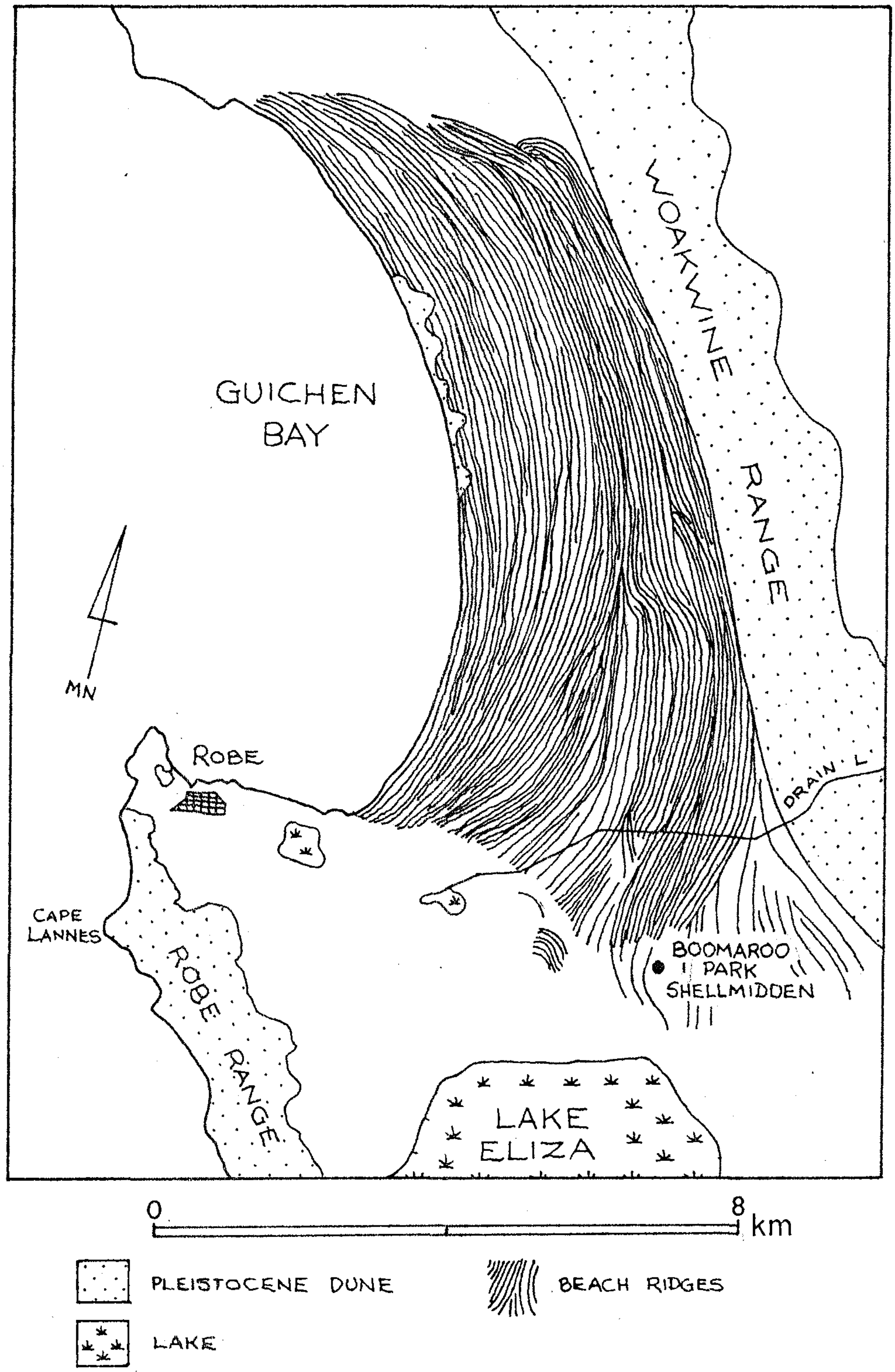


FIGURE 5.12

Map of Boomaroo Park Shellmidden in relation to beach ridges in Guichen Bay near Robe.

colonizing vegetation has occurred. This evidence is seen in Drain L, which cuts through the series 300 m north of Boomaroo Park. There, the buried immature soils associated with stabilization outline the original contour of the ridge system in an overlapping configuration, which suggests that surfaces accumulated in a seaward direction. Materials buried in these soils include organic residues derived from standing water, flotsom, and shellmiddens, and these would be approximate contemporaries of ridge formation. It follows then that the shellmiddens were buried near former foreshores and the position of the campsite coincides with the approximate location of the foreshore at that time period.

(C) The Deposits

A total of 63 discrete heaps of shellfish occur on the surface of the dune associated with a dark, immature soil matrix believed to have once been the original dune soil cover. These deposits of shellfish range in size from about 1 to 2 m in diameter, constitute single lenses on the surface, and are generally well preserved with a minimum of scatter around the perimeters. The fauna form an exclusively lagoon and bay assemblage of both mixed and monospecific composition including Hormomya, Ostrea, Katelysia and Pecten. The most frequent deposits are monospecific heaps of Katelysia or Hormomya, although other types are clearly abundant. No pattern of clustering occurs, as at the middens at Canunda Rock foreshore for example, but middens with similar fauna do appear together in the same general area of the complex. A thorough search failed to find lithic assemblages associated with the deposits and after a day's effort, only four large flakes were recovered at all. The shell from three deposits were sampled, but the complex as a whole was not sampled systematically, nor were the deposits mapped or measured in detail.

(D) Antiquity

Large remnants of the dune are still preserved by scrub and partially exposed middens are eroding from a black soil from within these. One such area was located in which two or three concentrations of Hormomya could be easily discerned near the surface. The area was carefully trowelled to remove the loose debris from the surface, and in the process concentrations of charcoal were uncovered in association with charred mussel shell. This deposit appeared therefore to be in situ and the charcoal and shell were removed for dating. The age of the charcoal is 3150±80BP (ANU-1484).

(E) The Fauna

The molluscs preserved in this complex inhabit rocky and sandy beaches in the calm conditions of bays or lagoon mouths. The abundance of Katelysia would suggest that the calmer setting of the lagoon rather than the bay itself was the principal focus of shell collecting. This conclusion is consistent with the location of the site near the margins of the lagoon outlet. No other fauna are associated with the middens.

(F) Discussion

The evidence from this site indicates that a variety of molluscs inhabiting similar lagoon mouth and protected bay settings were exploited about 3150 years ago. It is believed that the camps were formed close to the foreshore and were buried relatively soon after abandonment when a new phase of dune formation occurred. Evidence for this conclusion is in the form of stratigraphy, lack of disturbance of the middens themselves, and the presence in the buried soil of beach flotsom. If this conclusion is correct, the mouth of the lagoon at that moment in time would have been approximately 3.5 km wide.

It will be remembered from a study of the fossil shellbeds that optimal growth conditions prevailed unchanged in the centre of the lagoon 20 km from the northern exit. For this to have occurred, effective tidal exchange must have occurred throughout the length of the lagoon. The dated evidence at Boomaroo Park would then indicate that as early as 3150BP lagoon molluscs were abundant throughout the lagoon, including both entrances. Under these conditions, the Robe Range from Beachport to Robe was an island.

On the basis of this evidence, occupation of the Robe Range would expected to be hindered by the water barrier separating it from the mainland. The absence of older shellmiddens would be a logical consequence of limited accessibility under these conditions and this possibility has already been suggested for the Range elsewhere in this discussion. Access to the inland shores of the lagoon was in no way limited during this period however, and the absence of shellmiddens of lagoon molluscs in this area remains unexplained.

DOMASCHENZ RIDGE SHELLMIDDEN

(A) Introduction

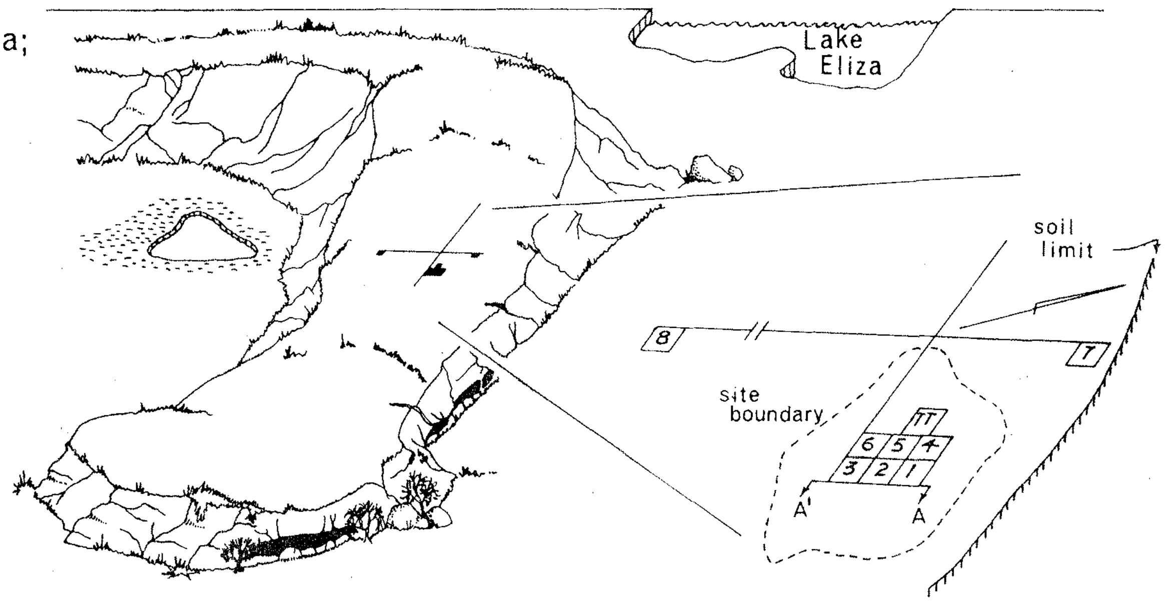
In 1969, a large quantity of flint tools and flakes in association with lagoon molluscs were exposed by winds on the surface of Domaschenz Ridge. The majority of the lithic material was stained red and most of the types of tools present have been assigned to Early Holocene industries of the area (Tindale 1957a; 1968). Mixed with this component however was a microlithic industry consisting of backed blades and small tools which were not stained red and these did not appear to belong to the first industry. In the absence of clear stratigraphic evidence, the relationship of the lagoon fauna to either of these industries was unclear and the situation posed two questions of interest to this study. If related to the older industry, which has an antiquity of 8600BP at Cape Martin, the molluscan assemblage represents the oldest evidence of shellfish gathering in the region, and, further, would be inexplicable at this site on geomorphological grounds. If on the other hand, the molluscs were consumed by people using a recent tool kit, the age of the occupation may correlate with the terminal phase of lagoon exploitation. Domaschenz Ridge was excavated to resolve this question and to date one of the few campsites on the Robe Range in which lagoon molluscs occur *in situ.*

(B) Setting

Domaschenz Ridge (Figure 5.13a) is a narrow arm of the Robe Range which projects into the lagoon between Lake Eliza to the north and Lake St. Clair to the south. The slopes of the ridge rise abruptly from the flat plane of the lagoon floor to an elevation of about 12 m above mean sea level. Its summit is a moderately flat, wide stretch of treeless dune which is constantly buffeted by strong oceanic winds. An almost unbroken horizontal line of caves and undercut ledges have formed in calcarentite at the base of the ridge, suggesting that waves from the lagoon were active agents in forming the landscape. Extensive, shallow fossil shell deposits of *Hormomya*, *Ostrea*, *Pecten*, and other lagoon molluscs merge with the ridge base line at an elevation of about 50 cm below mean sea level. This picture is typical throughout the interdune corridor and in this case indicates that Domaschenz Ridge was once almost completely surrounded by tidal waters in which shellfish were abundant. To the south and west of the ridge, as

DOMASCHENZ RIDGE MIDDEN

a;



b; Section, A-A', East face

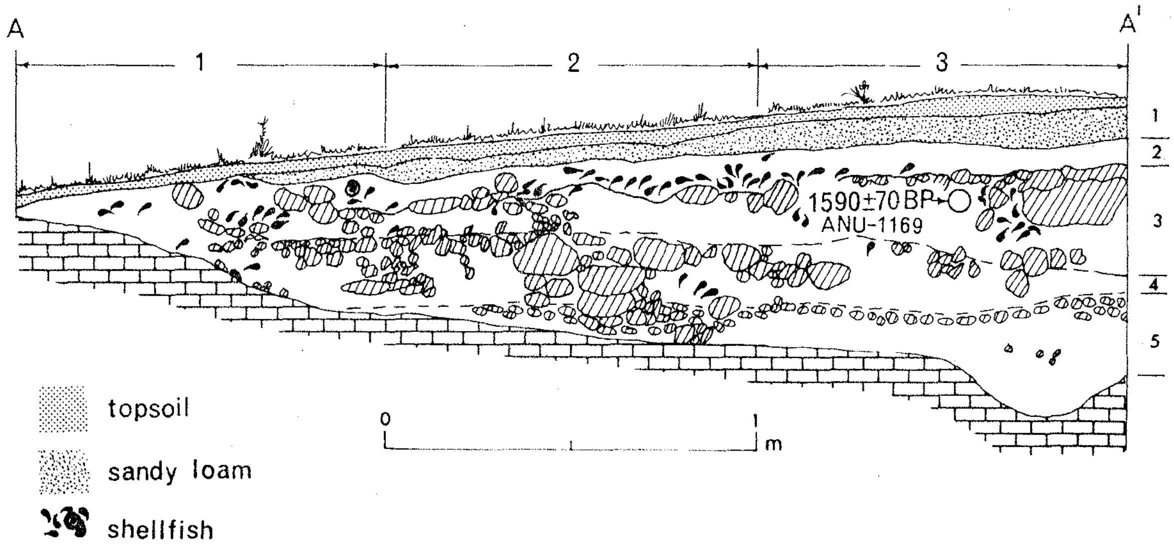


FIGURE 5.13 Map and section of Domaschenz Ridge Shellmidden.

illustrated, small feshwater lakes develop each season on the lagoon bed, and duck or other water fowl chose these for feeding in preference to more saline lakes nearby.

(C) Site Deposit

The archaeological deposit occurs in a shallow sandy soil on the ridgetop and is exposed downslope from the summit on a deflated surface measuring approximately 10 m by 100 m in size. Strong wind has cut away the topsoil along a sharp boundary, leaving flint and shells on the surface of a thin terra rossa soil. Several thorough collections of this material yielded at least 17 kg of flint, including 96 large red stained implements. Tools of this type and colour are common in the area, associated with red soils. A few molluscs were also slightly stained red, whereas a collection of about 50 flint pieces were not red stained, but rather retained original colours of brown, blue and grey. No pattern in the distribution of midden material could be found however, nor was there any evidence of a hearth exposed on the surface.

It was clear from probe information that terra rossa soil lay beneath the topsoil on the ridge and that the two industries may be mixed together near the surface without obvious stratigraphic separation. A portion of undisturbed soils containing midden material in situ was chosen upslope from the exposure to clarify this situation by excavation. The down-slope limits of this soil and the approximate boundary of the shellmidden, determined by probing, are shown in Figure 5.13a.

(D) Excavation

In 1972, a one metre square test trench (T.T.) was excavated on the ridgetop by arbitrary levels to examine the cultural deposits in the soil profile. Located in Figure 5.13a, this trench penetrated the full soil sequence to a depth of 65 cm, terminating on an irregular calcarenite surface. An unusually thick layer of Hormomya and a microlithic tool assemblage were recovered during this operation, but in the process the trench walls were damaged by sheep, which brought the work to a premature halt before detailed studies could be completed.

In the following year, two intersecting baselines were positioned over the deposits roughly in line with the ridge, and a grid system of one metre squares was marked on the surface. Eight one metre squares were chosen for excavation, with Squares 1-6 positioned over the main concentration of shellfish, and Squares 7 and 8 placed beyond the midden perimeter. These were numbered in the chronological order of excavation. Layers were removed by trowel and brush according to visible stratigraphy and surfaces of each layer were traced into adjacent squares before excavation of the next layer. As shell concentrations emerged, they were cleaned and photographed. A set of nested screens with 1/2 and 1/4 inch square mesh apertures was used to sieve the sediments in order to reduce the amount of breakage which commonly occurs on single screen systems.

(E) Stratigraphy and Chronology

Two basic soil units are present on the ridge and these are shown in Figure 5.13b. The upper unit consists of a topsoil 4 cm thick, and the lower layer of a dark sandy loam about 4-6 cm thick. The loam is loosely organized and is easily distinguished by its dark brown colour and sharp upper and lower boundaries. Both layers contain fragments of shellfish and tiny flint chips in small numbers, all of which are likely to have been introduced by aeolian processes.

The second, or basal soil, is a thick, wedge shaped unit of calcareous sand with a zone of nodular calcarenite at the base. Black organic residues in its upper zone suggest pedological development to a depth of 10-15 cm below the surface of the unit. Soil colour lightens to grey or cream below this zone and stratification is absent. The size of the nodules increases with depth and a distinct thin layer of cemented sand overlies the basal calcarenite surface.

The cultural debris occurs as distinct lenses within 10 cm of the top surface of the second unit, in a black sandy soil underlying the sandy loam. The lenses vary in thickness from 2 to 10 cm, and in section may merge with one another horizontally, although most are laterally distinct. Dispersion of shell both vertically and horizontally is common however, and shells found in the calcarenite nodule zone are isolated and therefore probably are intrusive. Numbered to the right of the section drawing, the excavation Layers 2-5 refer to the basal soil unit, and Layer 1 is the top unit of loam and topsoil. The cultural deposits therefore occur in Layer 2 and the upper portion of Layer 3 and appear to have formed on a single surface.

Charcoal from a deposit of charred shell in Square 3 was collected and dated. The age of this charcoal is 1590±70BP (ANU-1169) and its position in the stratigraphy is illustrated in Figure 5.13b.

(F) Faunal Remains

All faunal remain were identified according to excavation levels, but because of poor preservation, special care was required to assure correct identifications and minimum number counts. The shells of Subninella and Hormomya are the most decomposed, as is seen in surface pitting and a generally high degree of fragmentation. This condition is caused both by post-depositional erosion and by excavation damage. To facilitate identification of the species, the fossil shell beds below the ridge were sampled thoroughly for all species and this collection was used as a comparative reference. Minimum number counts were made on complete umbos in the cases of bivalves, and on columnellas in the case of gastropods. Approximately half the umbos of Hormomya however, are too fragmented to accurately count. The practice adopted to compensate for this was to divide the number of fragmented umbos in half and accept this number along with the number of whole specimens for the count. The numbers of mussels from this site are consequentially approximations only. A complete list of fauna is presented in Appendix A5.4. No vertebrate fauna is present in the deposits.

From this list, it is seen that the most abundant molluscs are Hormomya, Katelysia, Hipponyx and Zeacumantus. Both the mussel and clam as well as Zeacumantus are exclusively lagoon animals, whereas the small limpet, Hipponyx occurs in both lagoon and open ocean. Subninella prefers slightly protected ocean reefs and would be expected in a lagoon only in small numbers. It persists in each layer of the site however, although all specimens are small. This list nevertheless is a typical expression of the faunal assemblages which inhabited the lagoon shoreline below Domaschenz Ridge.

The size of molluscs provides a relative indication of their contribution of meat to the diet, but in this instance again, excessive fragmentation made quantitative measurement of this impossible. To provide a general guide, molluscs throughout the size range found in the fossil shellbed were compared with partially complete archaeological specimens. Hence, it is possible to say that Katelysia are relatively small individuals for the species and that Hormomya are generally large. On this basis, the mussels are probably adult individuals in the main, whereas the clam are juvenile.

Two molluscs in the collection deserve special attention owing to their numerical superiority. Zeacumantus is a tiny snail which inhabits shallow shorelines in weeds, or the bottom of calm tidal pools, in large numbers. It occurs in the fossil beds literally in the millions and because of its size, is not expected to have been purposely collected for consumption. Some specimens in fact are heavily abraded and rounded and could not have been brought into the site alive. It is therefore possible that most of the animals were inadvertently collected attached to aquatic plants which were then placed in the fire. Hipponyx is also a small gastropod which commonly adheres to larger molluscs such as Subninella and various mussels. Its presence in the deposits could also be explained then by coincidental rather than deliberate exploitation.

In the course of excavation, Hearth 6.3A was isolated and its contents were carefully investigated in detail. The deposit is a 5 cm thick lens of shellfish and charcoal measuring 50 cm by 130 cm in size. It was discovered that charred Subninella and Hormomya shells lying near the charcoal in the centre of the hearth were associated with blackened calcernite nodules. This relationship suggests that the hearth and refuse were in situ, and that the contents of the meal were spread around the hearth. A study of these remains would therefore reveal the selection of foods being sought by the occupants at a single campsite event.

The hearth deposit was traced into Squares, 2 and 5 and it was collected separately in each square for identification. Table 5.15 presents the contents of this meal. From an examination of this fauna, it is apparent that the primary species exploited were Hormomya and Katelysia spp., which are nonsympatric animals living in the lagoon tidal zone. We can conclude from this information that the diners exploited different micro-habitats for foods consumed in this meal.

Molluscs	FS5.3A & 6.3A
Subninella undulata	26
Subninella operaula	28
Dicathais textilosa	01
Hipponyx conicus	54
Zeacumantus diemenensis	140
Hormomya erosa	585
Katelysia spp.	190
Ostrea angasi	8
Mytilus planulatus	9
Equichlamys bifrons	0
Dentimitrella spp.	15
Isoclanculus dunkeri	6

TABLE 5.15 Minimum number of shells in one meal from Domaschenz Ridge Midden.

(G) Technology

The lithic collection recovered by excavation consisted of 87 flakes and chips and at least 27 implements. The assemblage is entirely a microlithic industry featuring a range of microliths, unworked blades, small blade cores, and several varieties of small scrapers. Decortification flakes and other types of large flakes were absent, suggesting that initial tool preparation did not occur at the site. On-site knapping may have been confined to repair or maintenance work, and judging from the absence of large scrapers or planes, heavy woodworking was not a part of this operation. Red stained implements were likewise not present in association with the shellmidden. The tool assemblage is discussed further in Chapter 6.

Three small red stained flakes were excavated however, although none was directly associated with the midden deposit. One was recovered in the light coloured sands of the nodular calcarenite zone of Square 3. The other two were associated with a sandy red basal soil in Square 7.

The older technological component is known only from surface collection and was not examined in detail. The entire collection consists of patinated, red stained flint material which is characteristically large and angular. The implements are all large, unifacial scrapers and other heavy tools, with extensive edge trimming. No microliths, blades, or blade cores are red stained. On typological grounds, this industry is probably similar to the Wyrie Swamp technology and is likely to have a comparable antiquity.

(H) Discussion

An examination of the occupation residues of Domaschenz Ridge has revealed two distinctive components. The earliest consists of a technology which is distributed widely in the area and may relate to heavy wood working tasks. Insufficient data exist to comment on the nature of this focus, or the possibility that other technological or economic processes are not also involved.

The ridgetop was occupied again about 1590 years ago by shellfish gathers whose economic focus was on a number of molluscan communities in the lagoon below the site. The occupation is likely to have been brief, but the number of shell deposits would suggest that either several groups camped together on the site, or that recurrent visitation occurred for the purpose of shellfish collecting. The site environs include a variety of ecological settings in which other foods, such as waterfowl and kangaroo, would have been available, and it is possible that the Domaschenz Ridge shellmidden represents one of a number of specialized economic foci.

The latter tool kit is exclusively microlithic, as is expected for deposits of this antiquity, and reflects small scale extraction and maintenance activities. The absence of heavier tools or evidence of large scale knapping would suggest that the group was not processing a large range of resources at the site, but rather may have been in transit. The specialized nature of the focus then suggests that the group was possibly small, and in this respect, the Domaschenz Ridge shellmidden resembles the shellmiddens behind Canunda Rock.

The presence of a suite of lagoon molluscs in the diet at 1590BP proves that the lagoon had not closed by that date and that the wide range of animal and plant resources around it were available. It is not possible to comment with confidence about the relative stability of the lagoon environment, and thus to predict the extent of economic reliance upon it. The fact that distorted mussel shells are common in the deposit and large Katelysia are absent, would suggest that shellfish populations were under stress, but this could have been local and would not necessarily have restricted economic activity generally. We can therefore conclude that the lagoon closed sometime after this occupation and that despite the availability of lagoon shellfish, the resource was not significantly exploited on the shores of the Robe Range.

NORA CREINA SHELTER

(A) Introduction

Rockshelters occur only around the lagoon shoreline and many have been occupied only briefly . As a type, these deposits are believed to represent a late phase in the settlement since occupation could have only occurred after tidal waters ceased to lap at the entrances of the shelters. Two such sites, excavated on the seaward shores of Lake George and another on Lake Robe, seem to reflect diverse economic strategies, although no quantitative details of the occupations are available. The Nora Creina Shelter was chosen to provide this detail. Emphasis will therefore be placed on the economic character of the whole deposit rather than on aspects of individual phases of occupation within the shelter.

(B) Setting

The town of Nora Creina is situated on a shallow Bay 20 km southeast of Robe (see Figure 4.4). The Bay itself, which is about one kilometre deep, is a unique feature on this otherwise open, coastline. It is about 3 km long and is lined by a sandy beach which arcs around the Bay and ends in high cliffs at both points. Its entrance is protected by a line of partially submerged reefs, except for two small openings large enough to permit boats to pass through at high tide. Its waters are shallow and sediments continue to accumulate on the beaches. A sheet of low sand dunes ring the forebeach for a distance of about one half kilometre inland and in this area small solution caves have formed in calcernite outcrops. The sediments in these were searched by probe, and cultural remains were located in one chamber about 300 m from the beach.

This shelter opens to the west, facing the sea. It consists of three shallow chambers arranged in an arc roughly 50 m in length. The largest of these is approximately 4 m across, 5 m deep, and up to 90 cm high. The slope of the walls as determined by the probe, suggest that the floor of this chamber was larger in the past. The chamber floor plan is shown in Figure 5.14A. with a schematic cross-section of the deposits.

Occupation debris includes Subninella shells scattered on the surface of all chambers, and is buried to a depth of 1.1 m in the largest. The sediments are dry and powdery, and organic material is well preserved. The relative lack of roof fall in the deposits plus the fact that they were apparently undisturbed suggested that excavation might provide useful data on midden contents.

(C) Excavation

In 1972, a 1 x 2m test pit was excavated to a depth of 60 cm in levels 15 cm thick. Although this pit did not reach the base of the deposits, stratification was clearly visible on the wall profiles, and excavation ceased in order to open a larger area of the deposits for closer examination of the natural strata.

In the following year, a grid network of one metre squares was imposed on the surface of the deposits aligned with baseline A-A', and five squares were nominated for excavation. The position of these is shown on the floor of the chamber in Figure 5.14a. The backfill in Trench 1 was removed to expose the stratigraphy and Squares 2-6 were excavated in layers according to the stratigraphy visible in each square. Measurements of elevations were taken from Station 1, which was an optical level. The excavated material was screened through a nested pair of 1/2 and 1/4 inch square mesh screens, washed, and all of it identified.

The numbering system for the grid units consists of a square designation number followed by a number for each layer excavated. Hence the number FS3.3 refers to the third layer in Square three. Specific concentrations of debris, such as a hearth or shellfish, however received a letter designation attached to the layer number in order to distinguish local concentrations from whole layers of refuse. For this reason, two excavated samples with different numbers may belong to the same stratigraphic layer. Correlations between layers in different squares is presented in Figure 5.14b. Plate 5.6A shows the excavation trenches and exposed deposits, with the chamber on the right.

(D) The Stratigraphy

The cultural deposits, shown in Figure 5.15, occur in a pure aeolian sand which extends below the base of the refuse for at least 1.5 metres. The midden layers against the inner wall of the chamber consist of black organic residues of shell, charcoal, ash and plant remains buried to a depth of 1.1 m. The boundaries of individual layers become diffuse towards the entrance of the shelter and merge outside the roofline, where they thin to a single layer about 20 cm in thickness. Layer definition is lost

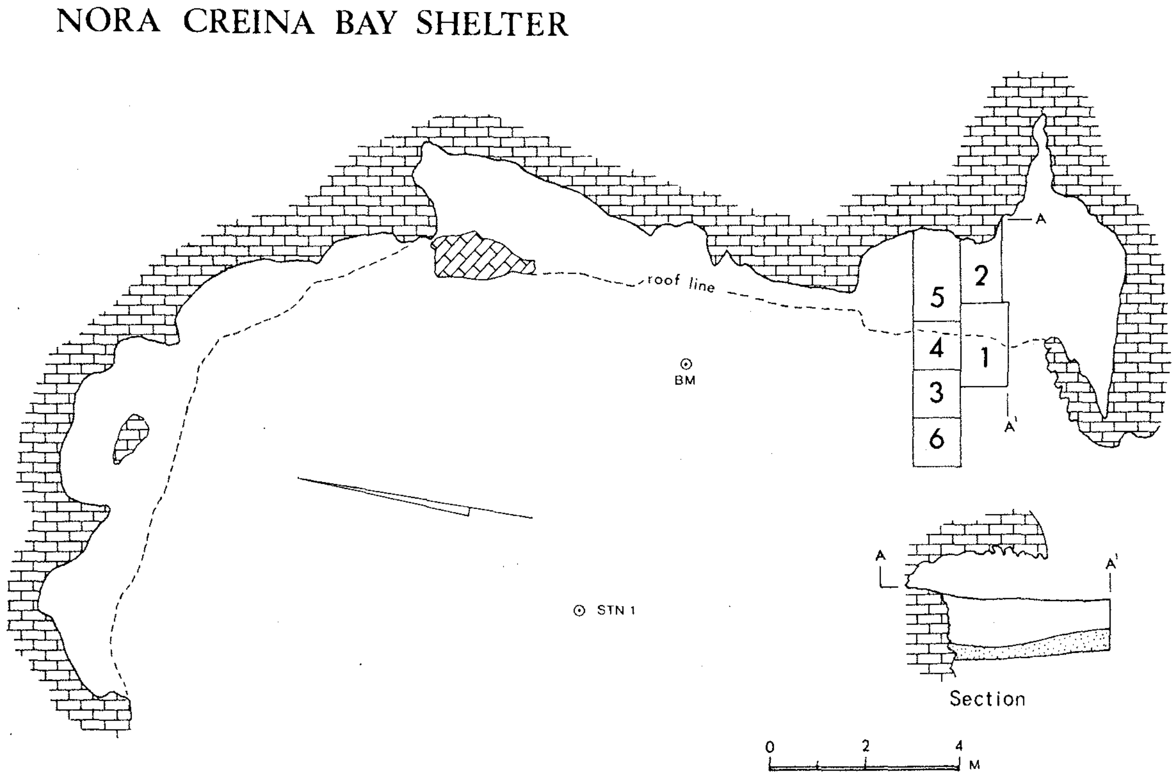


FIGURE 5.14a Plan of Nora Creina Bay Shelter

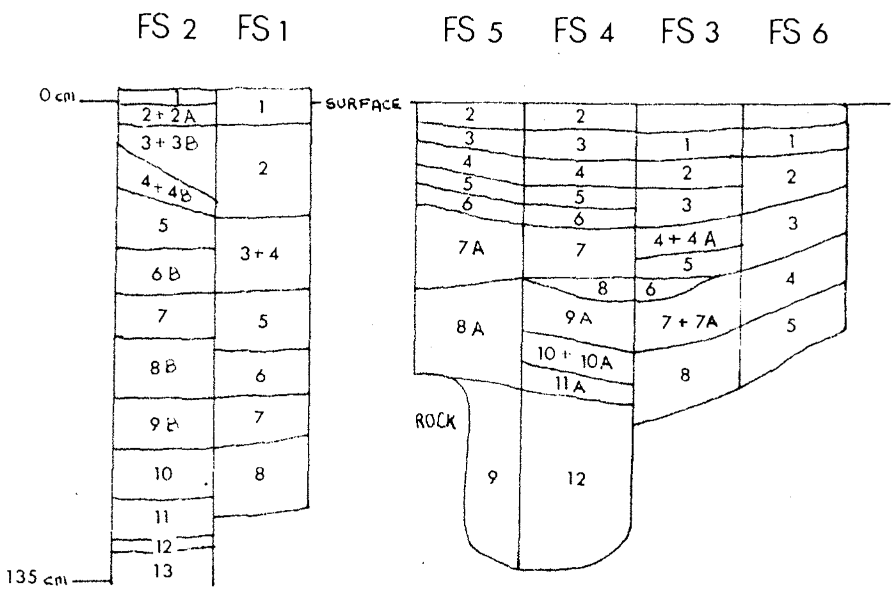
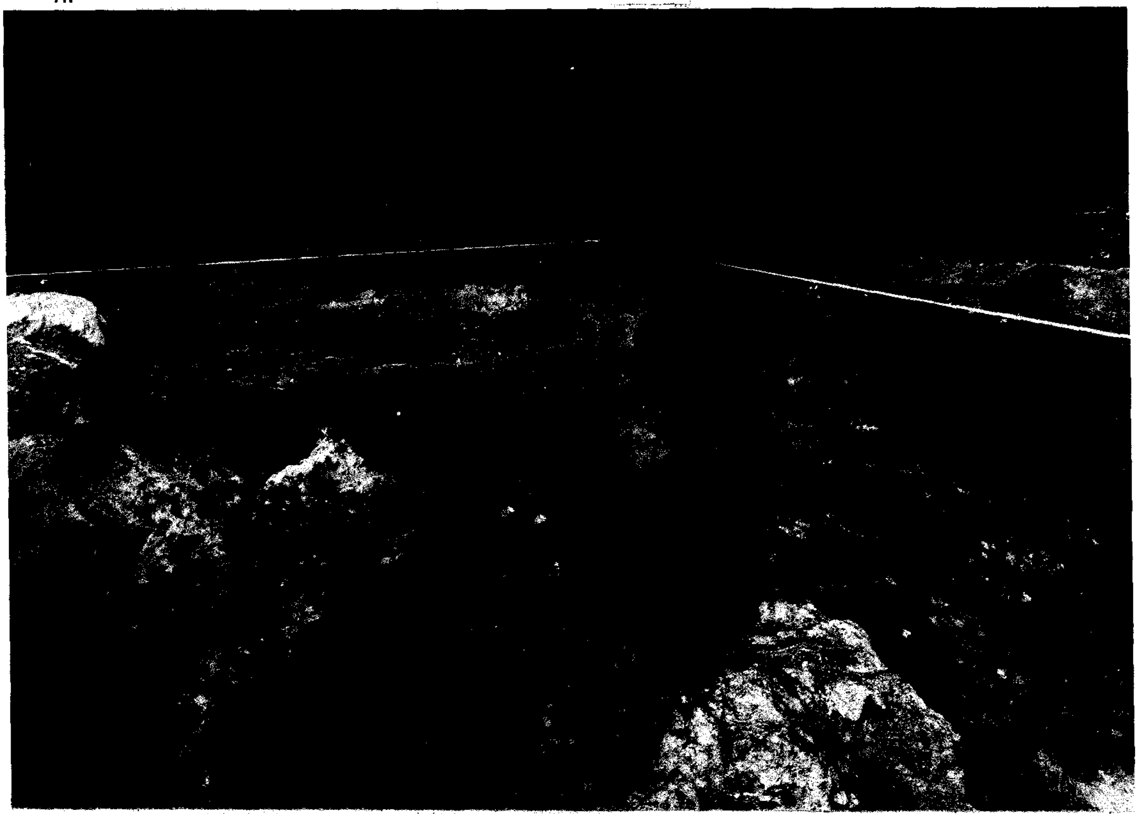
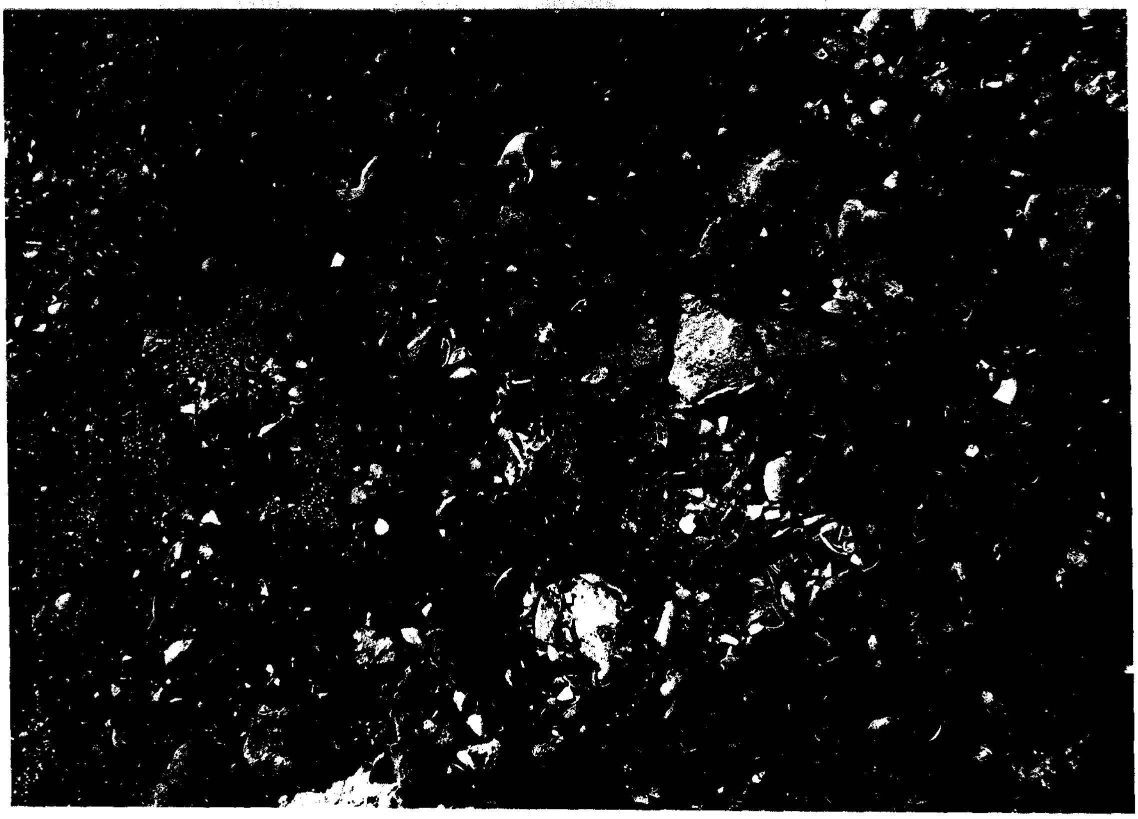


FIGURE 5.14b Section of excavation levels at Nora Creina Bay Shelter

A.



B.



A. View of Nora Creina Bay Shelter looking east into chamber with the main section profile seen to the right in the photograph. Grid 5 appears in the centre.

B. View of Hearth 6.3a at Domaschenz Ridge with <u>Hormomya</u>, <u>Katelysia</u>, and <u>Subninella</u> shells visible in centre of photograph.

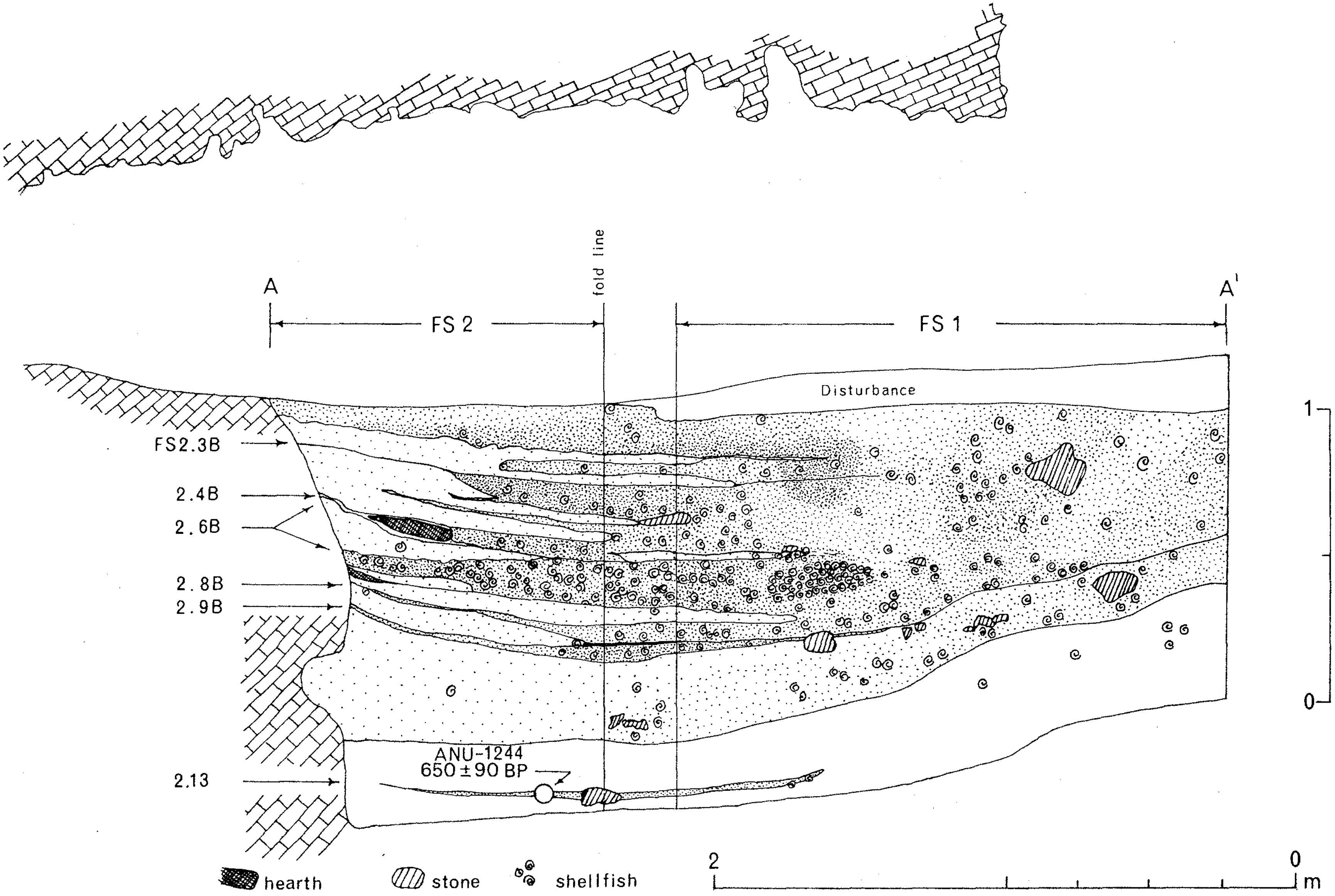


FIGURE 5.15 Section of south face, squares 1 & 2 at Nora Creina Bay.

altogether beneath the dripline and the sediments become damp at that point. Roof fall is minimal throughout the sequence, although irregular projections of calcarenite from the buried walls and floor of the chamber in Squares 5 and 4 have greatly interfered with the accumulation of refuse in those areas.

Like the middens at Abyssinia Bay and Cameron Rock, the deposit at Nora Creina consists of numerous hearths and pockets of shellfish which appear to be the remnants of individual meals. These could be detected in plan as well as in section, but because of inadequate exposure, a complete list of their contents could not be obtained. Nevertheless, sedimentation rates appear to have been rapid enough to bury midden debris with a minimum of post-occupational disturbance. Hence discrete deposits are preserved. For example, two hearths of yellow ash and other organic matter were preserved _in situ_ in the sequence seen in Square 2. Furthermore, in FS2.9A, a bundle of flint nodules, a large abalone shell, and a large slab of travertine were found secreted in a crevice with the slab and shell positioned face to face. As a consequence of rapid burial therefore, at least 8 distinct depositional layers can be identified from the profile drawings, each representing one or more occupations.

The surface of the deposit has been disturbed recently by duck hunters. The extent of the damage is restricted to a zone across the floor of the chamber to a depth of about 10 cm.

(E) Antiquity

Charcoal fragments from a thin lens of charcoal, fishbone, and shellfish, labelled 2.13 in Figure 5.15, were collected for dating. This layer is 25 cm below the main occupation deposits and appears to be the refuse of a single cooking hearth. The age of this charcoal is 650±90BP (ANU-1244).

It is not possible with the data available to indicate the duration of occupation. No European artefacts are present in the final shellmidden layer and this suggests that occupation ceased before A.D.1850.

(F) The Faunal Remains

The organic remains in the deposit are well preserved throughout the sequence of habitation. Bone has not been attacked by bacterial action, shells still retain their lustre, plant stems are firm although bleached, and periostracum still adheres to some shellfish. Because of this, the contents of the midden may more accurately represent the range of resources consumed than is often the case in more open deposits.

All faunal material has been cleaned and identified. A list of these is presented in Appendix A5.5. Molluscs are expressed as minimum numbers, and mammals and crustaceans are listed according to anatomical parts only. The number in parentheses with Jasus refers to mandible parts.

An examination of this list of fauna by grid units reveals that fish remains are confined to the lower third of the deposit and that other vertebrates occur generally in the upper two-thirds. To investigate this distribution pattern, Table 5.16 summarizes the faunal remains from Squares 1 and 2. The number of shellfish for each genus is expressed in this table as a percent of the total number of shellfish in the strata indicated in the column heading. The vertebrate remains are itemized only on the basis of their presence. Hipponyx and Zeacumantus are believed to be coincidental by-products of exploitation and are not considered in the summary.

	FS1.1-5 FS2.1-7		FS1.6-8 FS2.8-13	
Molluscs	NO.	%	NO.	%
Subninella	1553	67	359	56
Dicathais	45	2	11	2
Patelloida	256	11	85	13
Patellanax	94	4	12	2
Haliotis	9	0	2	0
Austrocochlea	210	9	109	17
Melanerita	17	1	4	1
Cominella	8	0	1	0
Austrosipho	5	0	0	0
Pleuroploca	11	0	1	0
Poneroplax	60	3	30	5
Brachidontes	3	0	0	0
Hormomya	8	0	2	0
Katelysia	25	1	23	4
Ostrea	4	0	1	0
VERTEBRATES				
Rat	+			
Macropid	++		+	
Possum	++			
Lizard			++	
Seal	+			
Fish			+++++++++++	

TABLE 5.16 Faunal list from Squares 1 and 2.

This Table shows that Subninella, periwinkles, and limpets are the primary molluscs in the diet and that their proportions remain approximately equal for the duration of the occupation. Preferences in shellfish selected for consumption has therefore not changed significantly during the occupation.

Fish consumption on the other hand appears to have changed abruptly to consumption of terrestrial vertebrates, although no stratigraphic break exists to indicate this in the soil profile. When all excavated vertebrate remains are considered, the picture is only slightly changed in favor of a gradual replacement of fish by mammals. In light of this apparent shift in focus, we may consider the reasons fish are absent from the diet. A few specific comments about the habitats being exploited may help to resolve this issue and reveal the nature of the economic focus in general.

At least two types of fish occur in the deposit, and the most common one is Mugil foresteri (Yellow Eye Mullet); the other has not been identified. Also known as Coorong Mullet, this species inhabits freshwater lakes and streams in South Australia (Scott, Glover, and Southcott, 1974) and is particularly common in the less saline reaches of the Coorong today (Glover, pers. comm.). Its ecology is poorly understood, but given the tolerance of fluctuating salinity displayed by its current distribution, the fish could have inhabited either the lagoon or Nora Creina Bay in the past. Fishermen who catch this mullet on Lake George today, however, report that the local fish is not caught outside the lake despite the fact that it probably visits coastal bays at certain points in its life cycle. If this is true, the presence of mullet in the shelter may indicate exploitation of the lagoon rather than the Bay.

Other species present in the deposits also prefer lagoon habitats. These include the molluscs Katelysia, Hormomya, Zeacumantus, and Gazameda, the last two being the strongest indicators of lagoon habitation in the fauna list. These molluscs are strongly represented as fossils in the lagoon and are naturally deposited 300 m from the shelter. The possibility that these genera may have colonized by Bay cannot be overlooked however. Members of the genus Katelysia can inhabit localities close to the open ocean (Cotton, 1961; Macpherson and Gabriel, 1962), as can Hormomya (Guiler, 1955). For those situations described in the literature, the setting is estuarine and for this reason, a lagoon exploitation best fits the data.

Other fauna definitely inhabit the open ocean, or at least could have survived at the mouth of the Bay, and not in a lagoon. The best indicator of this is the Rock Lobster, Jasus, which is represented by 7 mandibles, and sea urchin. Subninella did survive in the lagoon in the past, as is indicated by fossils, although it would have been too uncommon to be a reliable resource at any one locality. Seal is mobile and could have been taken from almost anywhere in the tidal zone or above.

The remainder of the fauna are terrestrial and could have been procured almost anywhere within the coastal margin. In certain cases, such as with rats or possum, it is possible that the animal got into the site without the help of man. However, the bones of Macropus, one rat, and Dasyurus are charred, which suggests that they might have been cooked.

Because of the extent of compaction of the deposits, it has not been possible to fully document the diet at any one meal. That the meal included a mixture of foods is indicated however, in the faunal lists in which discrete concentrations are designated by a letter in the grid reference number. For example, in FS4.9A, fish and shellfish were found together; in FS5.7A, snake and shellfish were also present; and so forth. If these are the discards from single meals, their association suggests that a range of resources were being exploited simultaneously.

(G) Technology

A wide range of materials were used as implements at Nora Creina (Appendix A5.6). The lithic component is entirely flint and of the 109 pieces excavated, 15 are small scrapers with simple edge trimming, 2 are utilized flakes, and the remaining 92 are flakes and tiny chips. Decortification flakes and nodule fragments are present in the site and at least 11 pieces (from different levels) have been joined together again. Other tools include a bone awl, several travertine slabs, pestle-shaped objects, a large Haliotis "scoop", and other suspected shell implements. These are further considered in Chapter 6.

It is apparent from this material that tools were manufactured in the shelter from nodules collected from the foreshore flint deposits, which are common in the area. No evidence of microlithic blade manufacture is evident in the form of cores or unworked blades. In general, the industrial focus seems to be directed to small scale maintenance tasks and possibly food processing. The scoops, slabs, and abraded pestles are more likely to relate to domestic chores around the campfire, and the distribution of these implements in the sequence indicates regular use of the shelter for similar purposes.

(H) Discussion

The character of the faunal remains at the Nora Creina Shelter reflects an occupation oriented to several primary resources. These include a variety of marine molluscs, fish, and crustacea, while terrestrial resources such as marsupials, reptiles, and rodents broaden the menu still further. Considered together, this list of fauna represents the full range of animal foods which might be expected to be present in the vicinity, with the possible exception of waterfowl. Since these foods formed a mixed menu at mealtime, the shelter may be described as a habitation site to which Aborigines repeatedly returned to conduct daily tasks normal to overnight camping activities such as sleeping, preparing food, and even stashing away equipment for future use. The technology of these tasks may have involved maintenance of equipment on a small scale and a range of household activities centred around food processing. The economic focus of the occupation of the shelter is therefore a broad spectrum exploitation of resources available in the immediate environs.

Confinement of occupational refuse to within the floor space of the shelter raises some questions about the nature of the habitation itself. Almost no midden debris occurs outside the entrance to the cave and, in fact, layers of debris terminate abruptly just outside the dripline. This would suggest that the shelter floor was not swept clean to maintain adequate room for accommodation. Since the headroom in the chamber at the time of final occupation was no greater than 90 cm, it would appear that the discomfort of occupation under these conditions may have been compensated for by the shelter afforded by the cave. It is possible therefore that occupation was particularly sought during inclement weather.

In light of the broad spectrum use of resources, the near absence of three molluscs in the deposits is significant at this time period. Brachidontes was exploited earlier in the settlement as has been seen at Canunda Rock and the Inland Camps Complex, but is insignificant at Nora Creina 600 years ago. Likewise, Hormomya and Katelysia are present in low numbers although they were consumed about 1590 years ago only 3 km away at Domeschenz Ridge. This suggests that widespread changes in the marine biosphere have occurred and that the molluscs are indeed temporal markers as discussed previously. Although precise dates are not indicated, it is likely that the lagoon closed at some time during the last millennium and that the sudden disappearance of lagoon fish reflects this.

SUMMARY CONCLUSIONS

An examination of the range of archaeological deposits in the coastal settlement of the Lower South East is completed and we can now consider some of the general economic patterns uncovered in the investigation. The marine environment has been a significent influence on human occupation of the coastal strip and it is helpful to review again the major changes in the evolution of the coastline in South Australia.

The most dramatic changes took place during the Early Holocene as a result of the Flandrian Transgression. About 15 km or more of the continental shelf was inundated when the sea reached its present level at about 6000BP, at which time the modern morphology of the coastline began to take form. The interdune corridor between Robe and Cape Banks was submerged, forming a great marine lagoon, and both Rivoli and Guichen Bays evolved sometime thereafter. Vast, shallow swamps formed further inland for a distance of up to 80 km as water was impounded between Pleistocene dune ranges by restricted drainage.

Thereafter, sedimentation played an important role in shaping the coastal environment. Supplied by immense submerged dunes, reworked sand accumulated on the beaches and gradually migrated to the edges of the lagoon where it was deposited as extensive beach ridges, across the exits of the lagoon. The ensuing lagoon closure occurred in stages, in which a large lake and swamp formed first south of Cape Buffon while tidal conditions prevailed north of Beachport, separating the Robe Range from the mainland by tidal backwaters. At sometime after 1590BP however, the lagoon below Domaschenz Ridge was closed and was replaced by a number of saline lakes. During the course of this evolution, Aboriginal populations encountered significant changes in the availability of coastal resources, and their behaviour would have been affected accordingly.

The economic data examined in this study reflect the changes in resources, and a summary of the dated evidence, presented in Table 5.17, reveals the extent of this. Two principal subsistence economies emerge from this list; one involving swampside exploitations, and another associated with coastal subsistence. Swamp habitation occurs early in this record and this evidence will be summarized first.

Occupation of the swamps appears to have coincided with the initial accumulation of water at 10,000BP near the Woakwine Range. Wyrie Swamp, an occupation dated to between 10,200BP and 8000BP, reflects a strong reliance upon an assortment of swamp resources, including duck, aquatic plants, and possibly insects. Belonging to the Core Tool and Scraper Tradition, the stone tools are characterized as large flake implements struck from flint nodules and extensively trimmed around most of their edges. The wooden tools include a variety of boomerangs, spears, and pointed sticks which closely mirror the types of tools used in the swamps by the Buandik 8000 years later. It is significant however, that the spearthrower and the shield, believed to be integral parts of late prehistoric settlement in Australia, are missing from this inventory. Nevertheless, a similar lithic assemblage occurs in basal horizons at Cape Martin (Tindale, 1957b) and Domaschenz Ridge and has been located at numerous sites within the swamp system. It is reasonable to view the widespread distribution of this industry in the swamps as an indication of intensive utilization of aquatic resources during the Early Holocene. That this picture pertains equally well to the Buandik suggests that the swamps were a major element in the subsistence economies throughout the Holocene.

The earliest acceptable evidence of an economy oriented toward coastal resources is a Plebidonax midden at Bevilaqua Cliffs with an antiquity of 5824±130BP (corrected here for C^{14} disequilibrium - see Appendix A5.2). Although shellfishing at a slightly earlier age has been suggested from shell scatters at Cape Martin and Bevilaqua Cliffs, stratigraphic and geomorphic uncertainties render these claims suspect and they will not be considered in this discussion.

Two occupation phases can be recognized in the coastal economies on the basis of distinctive archaeological characteristics. An Early Phase is identified on the ground as small, monospecific deposits of either Plebidonax or Brachidontes occurring predominantly near the hinddune and in small numbers in the sandhills 2 km inland. Dated to the period 5800 to about 1300BP, sites belonging to this phase include lower levels at Bevilaqua Cliffs, Canunda Rock, Mounce and Battye Rock, and basal layers in the Inland Camps Complex. Tools are commonly associated with these deposits in low numbers and are typically microlithic, with a few larger implements also present. The Late Phase in the occupation took place after 1300BP and is characterized by large shellmiddens at the clifftops and in the sandhills and a few as far inland as 12 km. These middens are composed of primarily Subninella, Cellana and other modern reef gastropods. Sites

SITE	ANTIQUITY	ECONOMIC FOCUS
Nora Creina Shelter	650±90BP	Marine and Lagoon molluscs; fish, marsupials; rat; lizard; crustaceans
Bevilaqua Cliffs	760±50BP	Marine gastropods
Shelter 1	?1000BP	Marine and Terrestrial resources
Shelter 2	?1000BP	Marine, lagoon, and terrestrial
Lake Robe Shelter	?1000BP	Marine, lagoon molluscs; duck, swan; marsupials
Abyssinia Bay	1200BP	Marine molluscs; crustaceans
Cameron Rock	1300BP	Marine molluscs; crustaceans
Cape Northumberland	1470±120BP	Marine gastropods
Domaschenz Ridge	1590±70BP	Lagoon molluscs
Inland Camps Complex	1134±130BP*	Marine gastropods + Plebidonax
Oven Complex	1960±90BP	Terrestrial animals, aquatic plants
Inland Camps Complex	2590±75BP	Brachidontes (mussel)
Canunda Rock	2990±70BP	Brachidontes (mussel)
Boomaroo Park	3150±80BP	Lagoon bivalves
Canunda Rock	3800±90BP	Plebidonax
Mounce and Battye Rock	3870±80BP	Plebidonax
Bevilaqua Cliffs	5829±130BP*	Plebidonax
Cape Martin	8700±120BP	Lagoon molluscs?
Bevilaqua Cliffs	8250±60BP	Plebidonax?
Wyrie Swamp	7930±160BP	Swampside resources
Wyrie Swamp	10,200±150BP	Swampside resources

* corrected date

TABLE 5.17 Radiocarbon date list for archaeological deposits in the Lower South East.

exemplifying these traits studied here include those at Abyssinia Bay, Cameron Rock, Nora Creina Bay, Cape Northumberland, the Belt Site, and the upper horizons at Bevilaqua Cliffs, Cape Martin, and the Inland Camps. Site technologies differ significantly from those of the Early Phase in that large quantities of flint material are associated with deposits at the foreshore and in the sandhills, and that the microlithic component is either scarce or is absent altogether. Technologies in clifftop shell-middens are invariably functionally simple, whereas those elsewhere reflect a variety of different functions ranging from woodworking to domestic chores around a cooking fire.

The character of the coastal economy has therefore shifted since its emergence. The deposits seem to have increased in size, the diet has changed to a mixture of seafoods, and resources appear to have been transported more frequently away from their source. Most significant is the decline in the use of microliths. During this period, the technology continues to show attributes of the Small Tool Tradition, with the single exception of the disappearance or decline in the use of microliths. This pattern is seen in open middens such as Abyssinia Bay and Cape Northumberland (Tindale, pers. comm.), in habitation sites such as Nora Creina and other shelters, as well as at a vast number of surface scatters in the sandhills, which on the basis of faunal types belong to the Late Phase. The most recent firmly dated microlithic industry in the district in fact comes from Domaschenz Ridge, with an age of 1590BP.

The only significant exception to these distinctions occurs at the Inland Camps Complex in questionable stratigraphic circumstances involving adjacent surface scatters. There, a microlithic assemblage is present on the perimeter of a large scatter of Subninella and Plebidonax. As dated in an adjacent soil remnant, these shells have an antiquity of 1134BP (corrected for C^{14} disequilibrium). If the shellfish and lithic material are associated, this deposit represents the youngest microlithic assemblage in the coast economy. Inconsistencies in patination of the flint and its unconfirmed stratigraphic context make this age determination for the lithic assemblage unreliable however.

We can conclude from this evidence that quantitative and qualitative differences exist between Early and Late Phase deposits which require explanations. Faunal assemblages have so far served to distinguish occupation phases and it is now appropriate to consider the validity of this approach and the paleoenvironmental significance of the dietary succession.

The succession of marine molluscs reflected in the diet consists of nonsympatric animals whose presence in the same meal would not be expected unless simultaneous collections were made at different localities. In light of the evolution of the coastal morphology, the transition from cockle to mussel and finally to a mixed reef suite of gastropods can be explained on paleoenvironmental grounds. Colonies of Plebidonax would have first settled in sandy beaches during the Mid-Holocene, but declined in number as more rocky conditions evolved near the cliffs. Once reefs were exposed in the tide zone, Brachidontes colonized in increasing numbers at the expense of clam populations. Stability in substrate sediments and dissection of the reefs would then provide the necessary habitat diversity in the littoral to support a variety of molluscs, crustaceans, and fish. The diet of the Late Phase therefore seems to represent the products of a successful adaptation of a variety of marine communities.

The morphological changes affecting the coastline did not follow a strict serial evolution however, but rather several distinct habitats often coexisted, as in the modern situation. As a result, remnants of Plebidonax populations were able to survive until the beginning of the Late Phase, as is shown for example in 1134 year old cockles at the Inland Camps Complex. Likewise, the existence of Subninella, Cellana, and Dicathias deposits at Canunda Rock associated with the Early Phase occupation suggests that these molluscs were available at the same time exploitation of cockles and mussels was being emphasized. The cultural implications of these two observations is only apparent however, when the major patterns in resource selection are considered more fully. It will be remembered, for example, that Early Phase shellmiddens typically contain single species of bivalves and that Late Phase deposits are comprised of many gastropod species. Both the existence of monospecific deposits of gastropods during the Early Phase and the mixture of cockles and gastropods during the Late Phase, suggests then that distinct food collection practices characterize the two phases regardless of the availability of the same molluscs. This evidence suggests therefore that resource stability may not have been the only factor in economic development.

Other data further support the contention that subsistence strategies may have operated independently of specific improvements in resource supply. The strongest evidence of this is the near absence of estuarine middens in the lagoon. Considering that shellfish were prolific in the lagoon at least as early as 3100BP, as is shown at Boomaroo Park, the consumption of these foods only at the lagoon exits remain inexplicable unless the shellfish were unpalatable or their consumption was barred for cultural reasons. Since the molluscs were in fact eaten elsewhere on the lagoon shores and therefore seem acceptable for consumption, we can only conclude that these potential resources were purposely ignored. The primary economic focus must then have been directed elsewhere while the lagoon remained tidal.

If the Late Phase economic development is correlated with increasing productivity in the littoral, the transition towards greater consumption rates should be reflected in the early levels of the clifftop middens. Occupation intensity might be expected to build gradually and the range of seafoods exploited to increase as specific animal and plant communities successfully adapted to the reef habitats. The analysis has shown however, that the menu does not significantly change throughout the occupation of, for example, Abyssinia Bay, and that compared with the early exploitation of seafoods in the Early occupation at Cameron Rock, the collection is similarly intensive across a wide variety of resources. Furthermore, the occupation density is as high at the bottom as at the top in the case of Abyssinia Bay. This suggests that the fauna had successfully adapted to the reefs prior to the Late Phase of occupation. The organizational skills and procurement strategies suggested by the Late Phase occupation were then developed during the Early Phase. This implies that either the broad-spectrum coastal focus emerged as a necessity or that earlier access to marine resources was in some way hampered.

Indeed, the near absence of Early Phase sites on the Robe Range north of Rivoli Bay raises the distinct possibility that tidal waters restricted access to the coast in that area. As the island was gradually joined to the mainland by the process of sedimentation, occupation intensity may have increased accordingly. By contrast, there is little evidence that occupation of the Robe Range south of Rivoli Bay was governed by limitations in physical barriers. To begin with, the first beach ridges formed in the Bay spanned the lagoon mouth from Cape Buffon, effectively closing the exit and providing a landbridge adequate to allow unrestricted movements of Aboriginal groups to the coast. Similarly, the exit at the opposite end of the lagoon at Cape Banks has always been too narrow to permit tidal flushing of the interdune flats. Since these changes are most likely to have occurred shortly after the final Mid-Holocene sea level adjustment, the marked change in occupation represented by the Late Phase deposits cannot be correlated with improved access.

Nor is the transition an illusion due to factors of differential preservation. The oldest dated shells, Plebidonax are remarkably well preserved in the carbonate soils of the Lower South East, and this is true of almost all shellfish deposits on the surface despite exposure to the weather. While many perishable materials are undoubtedly missing from the occupation record, significant quantities of shellfish have not been destroyed by an aggressive soil chemistry.

Erosion of the seacliffs would also have destroyed earlier deposits at the foreshore, giving prominence to the later material and its pattern of deposition. If recurrent occupation of the cliffline was common in Early Phase habitation, traces of this should appear below the large Late Phase shellmiddens. An inspection of extensive soil profile exposures at Abyssinia Bay and elsewhere on the Robe Range however, has failed to locate significant amounts of shellfish belonging to the Early Phase occupation. This suggests an abrupt emergence of recurrent occupation patterns at the cliffs. This means, that while loss of some Early Phase shellmiddens has occurred, the patterns of campsite distribution characterizing each phase are still detectible. A comparison of these will therefore not be significantly distorted by differential preservation.

Several basic questions can now be considered. The emergence of the Late Phase occupation appears to indicate a marked change in consumer behaviour which cannot be related entirely to environmental factors. The difference between the two phases pertains as much to an apparent increase in the amount of resources being consumed as to qualitative differences arising in the types of sites being occupied. For instance, Late Phase deposits occur at the coast, in the sandhills, and near the lagoon, whereas the only Early Phase sites occur near the sea or in the sandhills. This suggests that a re-organization of subsistence strategies has occurred which transcends the role of marine resources in the economy. Camps reflecting a variety of activities do not appear until after 1300BP, and shelters around the former lagoon shoreline were inhabited only after tidal conditions ceased to exist in the area. This evidence implies that the reorganization originates on a large scale and may involve either an increase in population, a higher frequency of visitation, or both. This could have been accomplished by expanding the duration of seasonal visitation, or by intensifying the exploitation by more effective organization and procurement skills which would allow more resources to be included in the menu.

It is apparent from the dated evidence and the reconstruction of late prehistoric subsistence strategies that the Late Phase occupation pertains to the Buandik habitation. A variety of site types, ranging from single focus to multifocus activities and including habitation camps, appears in the archaeological record and seems to be distributed in a pattern consistent with predictions made from consideration of the modern ecology. Primary occupation debris occurs in the sandhills or near the lagoon, and this reflects the greatest spectrum of economic activities. It is appropriate therefore to integrate the archaeological, ethnographic, and ecological information pertaining to the Buandik and compare its traits with those of the Early Phase occupation. The objective will be to explain the process of the economic shift in terms of its origins and strategies.

In order to attempt this, it will be necessary to first identify the basic shellfish gathering group in each phase and to monitor its behaviour in terms of size, organization, and membership. The primary depositional unit from which this information can be calculated is the refuse from individual hearths which have been isolated by excavation. From a biometric analysis of the food remains, changes in food procurement practices can be related to changes in faunal assemblages and can be assessed in terms of adaptive advantages. Converted into caloric values, the contents of the meals can also be compared through time for clues to changes in the size of the group dining at the campsite. Similarly, the character of the tool kit and knapping debris may indicate the composition of the group, and this information can be used to deduce whether or not the focus might be a specialized operation associated with large scale exploitation.

The primary aim of the following analysis will be to describe the behaviour of the Early Phase shellfish collectors. Growth rings of Plebidonax will be used to determine the season of occupation and to decide whether a single large group briefly inhabited the coastal margin, or a small group operated near the beaches over a longer period of time. Since these deposits are generally dispersed on the landscape, a direct comparison of the amounts of seafood consumed during the two phases is difficult to calculate on the basis of midden size alone. To overcome this obstacle, the gross number of meals in which shellfish occur will be computed with the assumption that increases in shellfish consumption in particular indicate growth of seafoods in the menu generally.

The changes in subsistence technologies uncovered in this study include the introduction of the Small Tool Tradition during the Mid-Holocene and a subsequent loss of its microlithic component after 1300BP. Since these events mirror the picture seen in the region as a whole, it must be assumed that fundamental adaptive advantages are being realized by prehistoric hunter-gatherers. If this is true, the whole tool kit, both its lithic and nonlithic components, must be considered in order to describe the direction this evolutionary development took. The Wyrie Swamp wooden tool collection provides an opportunity for this question to be examined for the first time in Australia. The following chapter presents the tool kits for each site with special reference to manufacturing techniques, in order to show that changes occurring in the way tools are made implicate simple but profound advantages for the hunter and stone worker.

CHAPTER SIX

THE SUBSISTENCE TECHNOLOGY

INTRODUCTION

The steady decline in tool size and increase in design complexity in Holocene technologies has been noted in the Lower South East, beginning at Wyrie Swamp. This is likely to reflect the attempts by prehistoric populations to modify and improve their capacity to effectively exploit the environment under conditions in which existing technologies proved inadequate. To explain these modifications, it is necessary to compare site assemblages at different points in time and assess their relative merits. Because the stone knappers are clearly combining different raw materials to acquire new tool designs, the manufacturing techniques would be expected to reveal the nature of the advantages sought in tool construction. Recovery of this information is generally difficult to achieve however, because all but the lithic component has usually been destroyed, and even the functions of individual tools are difficult to recognize archaeologically. In the lower South East however, the tool kit is preserved in association with other relevant campsite debris and the techniques of manufacture can be readily reconstructed from this evidence. Furthermore, the recovery of wooden implements predating the Small Tool Tradition provides an unparalleled opportunity to compare that portion of the technology which is most valuable in reconstructing the extractive capability of prehistoric hunter-gatherers. It is thus possible with this material to comment on the developmental aspects of subsistence technologies as a reflection of coastal adaptation.

To achieve this, each site assemblage excavated during this research will be briefly described in terms of its morphological characteristics. The typological terminology used is taken from McCarthy (1967) and Mulvaney (1975) and is based entirely upon non-metrical attributes. Site assemblages occurring primarily as surface scatters, as for example at Canunda Rock, were sampled selectively in the interest of time and preservation of the deposit. As a result, the number of complete tool kits from individual campsites is limited, and the description therefore rests with the results of detailed inspections made at the time of collection. The majority of information however, was obtained from reassembly of large quantities of flakes and implements onto the cores from which they were struck. By tracing the manufacturing procedure in this way, some insight is gained into the industrial nature of campsite activities and, through this into technological efficiencies.

With elucidation of developmental processes as its principal aim then, this study does not attempt a more traditional description of subsistence technologies in which quantitative attributes and morphological characteristics play a central role.

Because the elaboration in tool kits suggests a growing dexterity on the part of stone makers in obtaining new shapes, it will be necessary to first consider the possible influence the raw material may have on this development. For this information, we can turn to the physical properties of the flint used in manufacture.

LITHIC PROPERTIES

Almost all flaked stone in the Lower South East is made from a nodular flint which is readily available in the foreshore in great quantities. The best choices are solid cobbles about 10-15 cm in diameter which have lost their cortex in the surf. The flint flakes in an exceptionally uniform, predictable manner, permitting the tool maker great latitude in achieving the edges and morphologies required. Bulbs of percussion are well defined, and fracture surfaces are unusually smooth and free of step flaking. Sharp edges are easily produced, and the material responds well to both pressure and percussion flaking techniques. Imperfections such as fossils and voids do occur frequently, but do not appear to significantly influence the knapper. In every sense, the flint provides an excellent medium for the manufacture of a wide range of implements.

Dr. G. Taylor, formerly of the Department of Geology (ANU), has described the petrology of the flint on the basis of two thin sections from Wyrie Swamp. His report is as follows:-

Light Grey Chert:

> This specimen is a fine grained, dense rock with numerous (30%) replaced fossils including gastropods, spicules, foraminerifers and polyozoa. The texture is visible, with some areas being "porous" and containing fossils, other patches are "dense" with few fossils. In some cases, the "dense" material forms envelopes around larger fossils. The rock has been wholly silicified and all fossils replaced by SiO_2; voids in fossils are completely or partially filled by chalcedony and in a few rare cases (1%), filled partially by quartz and opaques.
>
> Clays ---- 85% (now silicified)
> Sesquioxides ---- 5% (opaques and semi-opaques)
> Chalcedony ---- 5 - 10%
> Quartz ---- -- 1%
>
> Note: locally the percent of SiO_2 is higher but overall is low.

Dark Grey Chert:

> This specimen is a dense, clay rich rock containing 96% clay/sesquioxide matrix with about 5 - 10% fossil material (forama and ostracods with a few ? polyozoa). The whole rock has been silicified and all $CaCO_3$ replaced by SiO_2, mainly as chalcedony. The material identified as chalcedony makes up about 3% of the rock. It is very fine, and to separate it, crushing to 5 - 10 microns would be necessary.

Flints from the area labelled HA000-HA002 have been analysed by XRF and their mineralogy is reported by Smith and Ward (1975). Five heavily charred samples of flint from Wyrie Swamp have been submitted to Dr. A. Mortlock (Department of Physics, ANU) for future thermoluminescentage determinations.

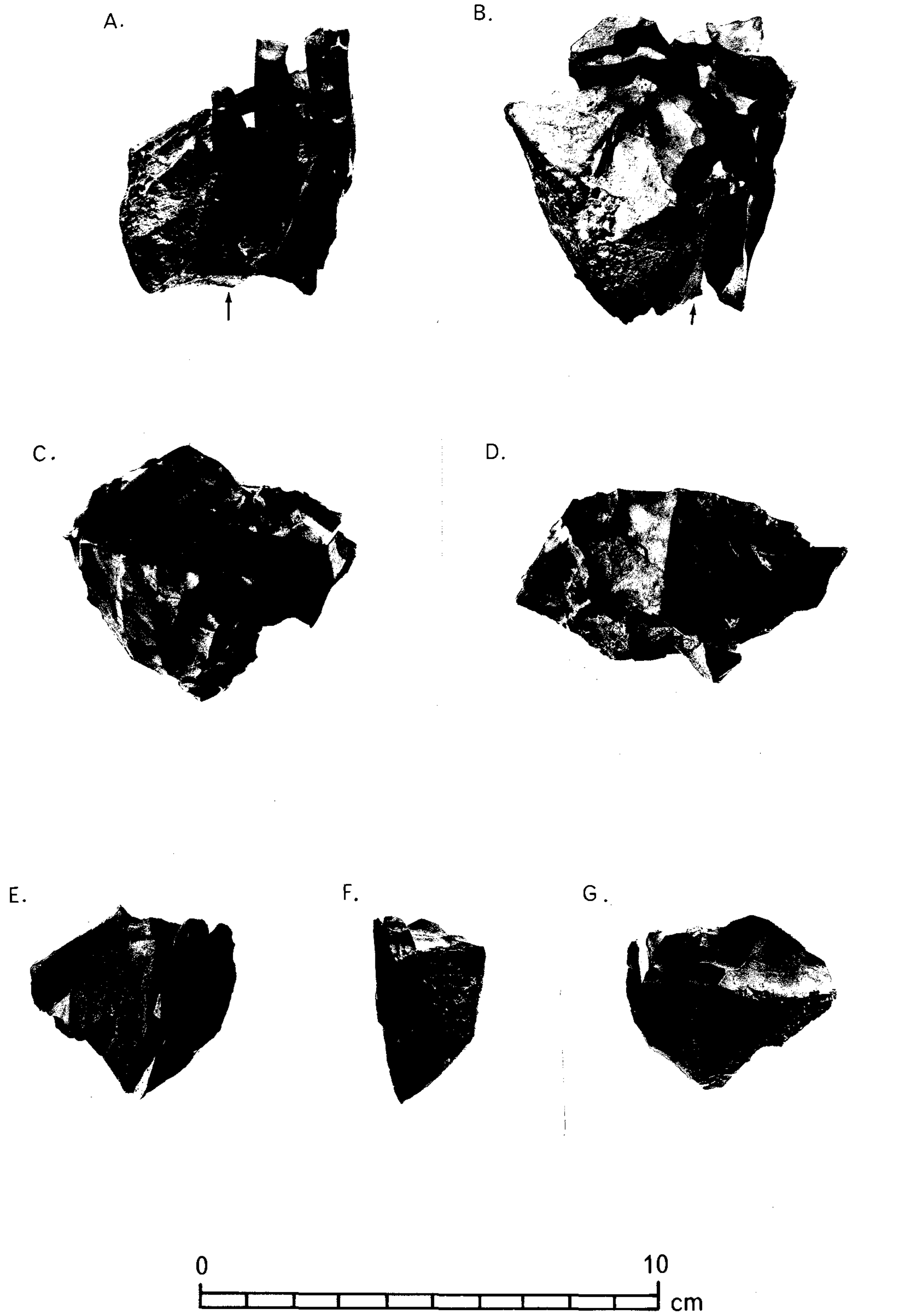
TOOL MANUFACTURE

A routine inspection of lithic scatter associated with individual shell heaps was made to discover evidence for manufacturing process. After reconstruction of the knapping operation, flakes and implements could be reassembled onto the core from which they were struck. From the onset it became clear that the basic elements of the tool kit, mainly microliths and scrapers, were being formed, used, and then recycled into new ones all within a short span of time. Two methods by which this was done seemed to have developmental significance and were studied at length in a number of collections.

The first method involved the preparation of a core to create a large platform from which blades were struck. Shown in partial reassembly in Plate 6.1 c&d, the core measures several centimetres across and five or more centimetres high, and as usual was made from the centre of the nodule. As blades were struck from the core edge, a fluted surface was formed at angles less than 90 degrees to the platform, thus creating a classic prismatic core as described for other parts of the world (Sanger, 1968; Bordes, 1968). Because the process eventually results in battered core edges or distortion to the fluted face, either the platform or the fluted surface must be rejuvenated to continue production. The percussion damage which accompanied blade removal, consisted of minute flaking around the core edge. This can be mistaken for purposeful trimming, but in fact it is the product of dispersed shear stresses from the striking instrument.

The blades manufactured in this way are generally uniform in width and thickness, and possess sharp lateral edges. For this reason, they can be easily shaped by pressure flaking. This process, which has been called chimbling (Dickson, 1973) produces a blunted edge by simply rotating the edge of the tool over a hard surface under slight pressure, causing steep retouch to either end of the blade or to one of the lateral edges. Microliths struck from prepared cores are generally recognized by their low triangular or trapezoidal profile, by the crushed step flaking associated with back preparation, and by confinement of retouch to the edges of the implement. Examples of backed blades made in this way have been found in younger middens at Canunda Rock (Figure 6.3 j&m) and at Domaschenenz Ridge (Figure 6.7 b&c), whereas they are uncommon in the initial stages of the Early Phase of occupation.

PLATE 6.1



A, B: Edge-prepared core (no. 2.0.6) from Inland Camps. Arrow indicates direction of blow to remove edge. A second prepared edge can be seen at right angles to arrow (b.).

C, D: Prepared core (no. 2.0.5) from Inland Camps showing fluted surface and associated flakes.

E, F, G: Edge-prepared core (no. 2.0.12) from Inland Camps showing blades reassembled on to core. Remnants of edge preparation seen in F, and scars from preparation of platform are visible in G.

The second technique for blade manufacture involved detachment of a prepared edge, which originally was made for other purposes. The sequence, shown in Figure 6.1 a-c and which is based on a reassembled core (Plate 6.1 e-g), began with extensive retouch to the lateral edge of a suitable core by percussion flaking, as illustrated in Figure 6.1 a. The edge angle at this stage is steep and the flake scars from retouch extend into an area a centimetre or more wide along the dorsal surface. The edge formed in this manner was then detached from the core by a burin blow directed to the platform and parallel to the edge, and often left remnants of the prepared edge at the distal end (see specimen 6.1 b). The procedure was repeated with the preparation of a second edge along the scar left by the first blade, and a second and sometimes a third blade was detached. Occasionally, the second prepared edge was only partially removed , as is seen in specimen 6.1 g, and the fluted surface had to be struck off to rejuvenate the core.

Microliths shaped prior to removal from the core can be recognized by high, angular profiles, the presence of small primary flake scars across the backed dorsal surface, and the survival in many specimens of at least a portion of the bulbar surface. Distal ends tend to be naturally more pointed than proximal ends, but secondary pressure flaking after detachment often obscures the nature or origin of this evidence. A preliminary grouping of blades made by the two manufacturing techniques on the basis of morphological grounds suggests that a marginal overlap in qualitative attributes occurs, but that height/width ratios may be distinctive.

It would be reasonable to expect that edge rejuvenation was aimed more at reclaiming worn edges than at blade production, and was therefore of little consequence to manufacturing development generally. This assumption can be discounted however on several lines of evidence. First, there is the evidence, shown in Plate 6. le-g, of at least 7 blades being detached from a core tool without a useful working edge being achieved in the process. This is a very common fate for core implements, suggesting that blade production is the chief objective once the primary edge has been removed. Then, there are the numerous microliths prepared before detachment (Figure 6.3 d&f) which have had both lateral edges retouched after removal, indicating the utility and popularity of edge prepared blades. Furthermore, rejuvenation by-products, such as detached fluted surfaces (Figure 6.1 g) decidedly exhibit remnants of two prepared edges, showing that the practice of

Process

a-c Stages in preparation of core edge to manufacture blades

Products

d-f Microliths produced on core and detached from Cânunda Rock *Plebidonax* campsites

By-products

g-i Fluted faces of core removed to rejuvenate core

FIGURE 6.1 Manufacturing process for edge-prepared blades. Figures a-c drawn by K. Conover, d-i by W. Mumford.

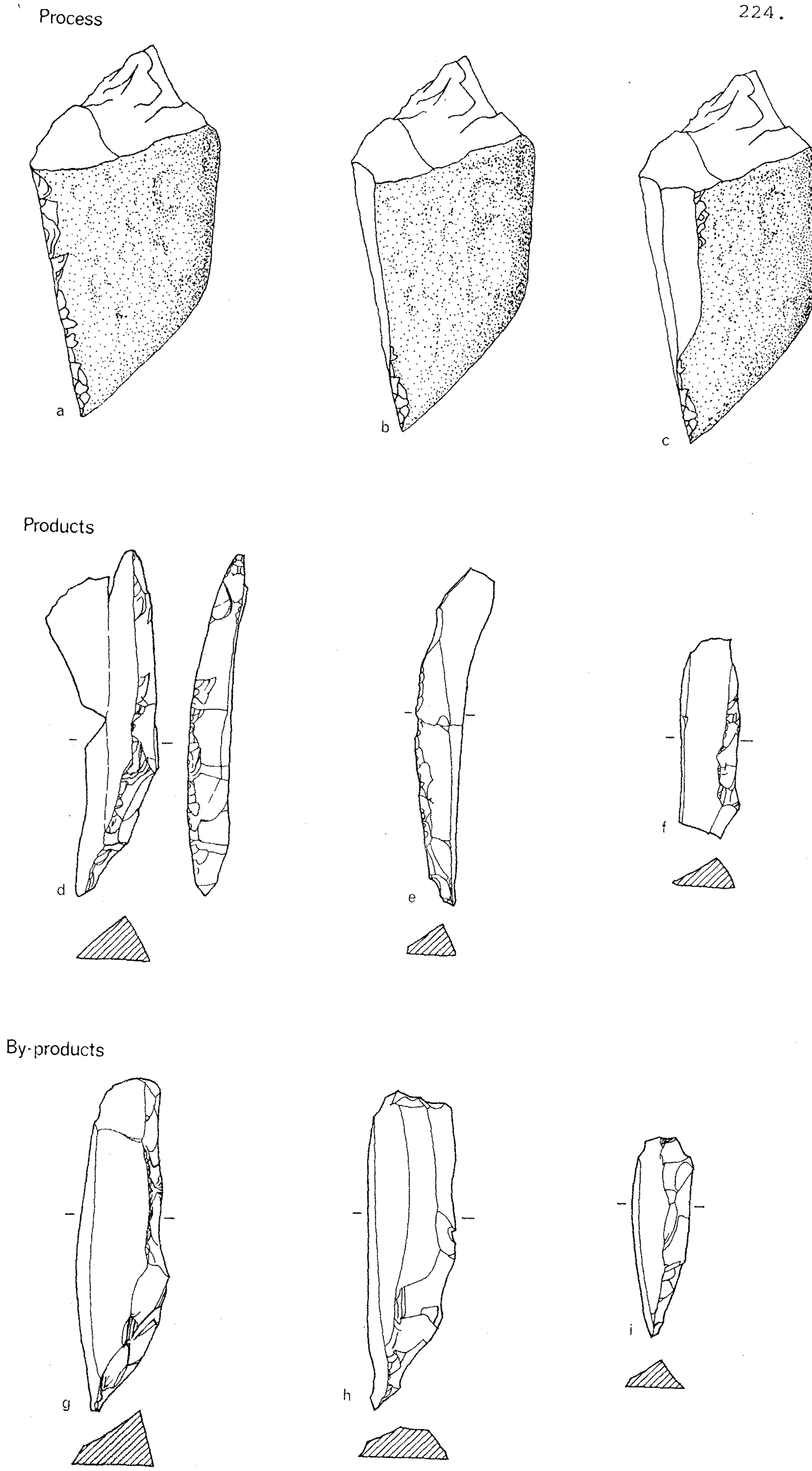


FIGURE 6 Blade manufacturing process.

shaping edges prior to detachment had merits to the tool maker. This evidence would therefore indicate that the prepared edge technique was a premeditated attempt to turn existing implements into new ones by reclaiming used edges and recycling the otherwise disused core.

Seen in its entirety, the manufacturing process appears to be exceptionally opportunistic, and there is no reason to expect the function of a particular implement to be necessarily revealed either by its morphology or its wear patterns. Microliths made from the edges of wood working implements for instance, will exhibit edge damage not related to their f unction as barbs. At the same time, blade cores with steep, fluted surfaces frequently exhibit minute crushing, abrasions on the edge of the core, and edge undercutting, which suggest the routine use of cores as wood working implements. The by-products of blade production are also reused extensively as awls (see Figure 6.3 n), small scrapers, or backed blades (see Figure 6.1 f). The great versatility observed in the knapping of stone therefore leads to the conclusion that the knapper literally set up an assembly line operation through which raw materials were processed in the most economical manner. Under these circumstances, typological distinctions tend to be blurred in the absence of information about the functional objectives sought by the knapper.

The difference in representation of implements made by these two manufacturing processes may underscore the developmental significance of elaboration in the Small Tool Tradition. Although microliths are not common in Plebidonax middens at Canunda Rocks for example, the most prominent were shaped on the core before removal. Assemblages associated with the later Brachidontes middens on the other hand not only appear to contain more microliths, but suggest the prepared core technique definitely had increased in popularity. Therefore, one technique did not replace the other, and it is clear that the two were ultimately combined to expand the capabilities of the tool maker. In this light, the edge-prepared core technique appears to be the older of the two blade production methods.

TOOL KIT DESCRIPTIONS

a) Wyrie Swamp (10,000 - 8000BP)

Wyrie Swamp tools are made from large core flakes with straight to slightly convex lateral edges and convex distal ends. Tool sections fit roughly into two categories: those with pronounced, high dome shapes, and those with moderately low, plano-convex profiles and uniform thicknesses. The latter are the most common and are shaped by elaborate primary and secondary edge retouch to both lateral edges and the distal end. Dorsal surfaces are marked by large primary flake scars and cortex is present in an estimated 10 percent of the collection. No evidence of bifacial retouch occurs and repair or noticeable damage to edges is minimal. To this extent utilized flakes and localized retouch are rare. In the sample of over 120 implements from the swamp, the outstanding feature of the assemblage is that almost all tools possess remarkably sharp edges in usable condition even now. The emphasis of the tool maker was therefore clearly on maintenance of the tool edge.

Although the composition of the Wyrie Swamp lithic assemblage has not been studied, and therefore cannot be described here, several tool types stand out. Specimen 6.2a for instance, is a common blade form with a pointed to rounded distal end and moderate edge angles ranging between 50 and 70 degrees. Edge damage is minimal and secondary retouch is continuous around the edge except at the platform. O'Connell (1974) has described a similar implement type used by Aborigines in Central Australia for the preparation and consumption of native yams.

Specimen 6.2b is a robust core flake with extensive, steep retouch on the distal end opposite the striking platform. The cortex remains on a portion of the dorsal surface, and a large primary flake has been removed at the striking platform prior to detachment. The edge angle is approximately 80 degrees and no evidence of undercutting occurs. Specimen 6.2c closely resembles this type in overall morphology although it is less massive. The removal of a thick primary flake from the dorsal surface creates a thinner section at the proximal end. These implements are believed to have been used for wood working.

Specimen 6.1d is represented by at least three implements with identical shapes. The distal end is blunted with steep primary flaking, whereas the lateral edges possess characteristically different edge angles. The right edge is relatively low and sharp with continuous retouch occurring throughout its length, and the left edge mirrors this

Wyrie Swamp (10,200-8000BP)

a.	Large flake tool;	FS0.0.90
b.	Large flake tool;	FS18.1.4
c.	Large flake tool;	FS0.0.83
d.	Large flake tool;	FS0.0.92
e.	Large unifacial chopper;	FS0.0.69
f.	Utilized flake;	FS29.2.4

FIGURE 6.2

Stone implements from Wyrie Swamp. Those with numbers in each decimal place were excavated. Drawings by W. Mumford.

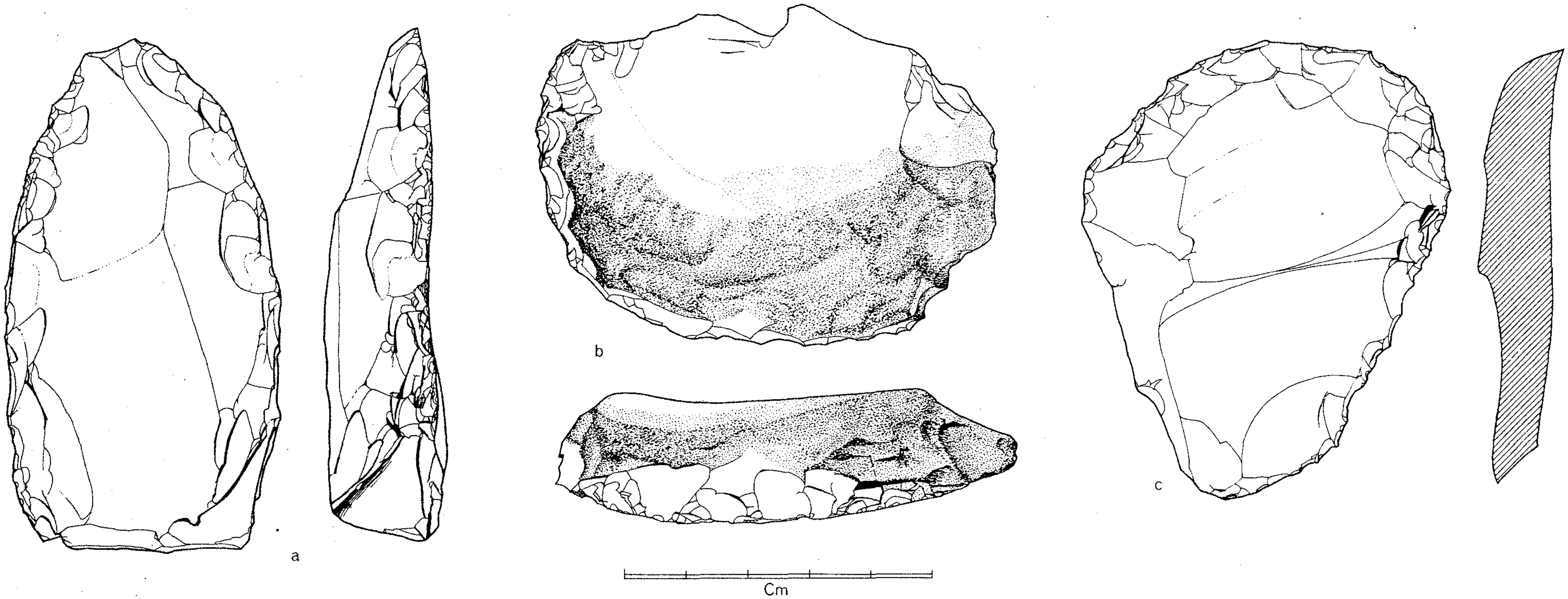


FIGURE 6.2 Flake tools from Wyrie Swamp.

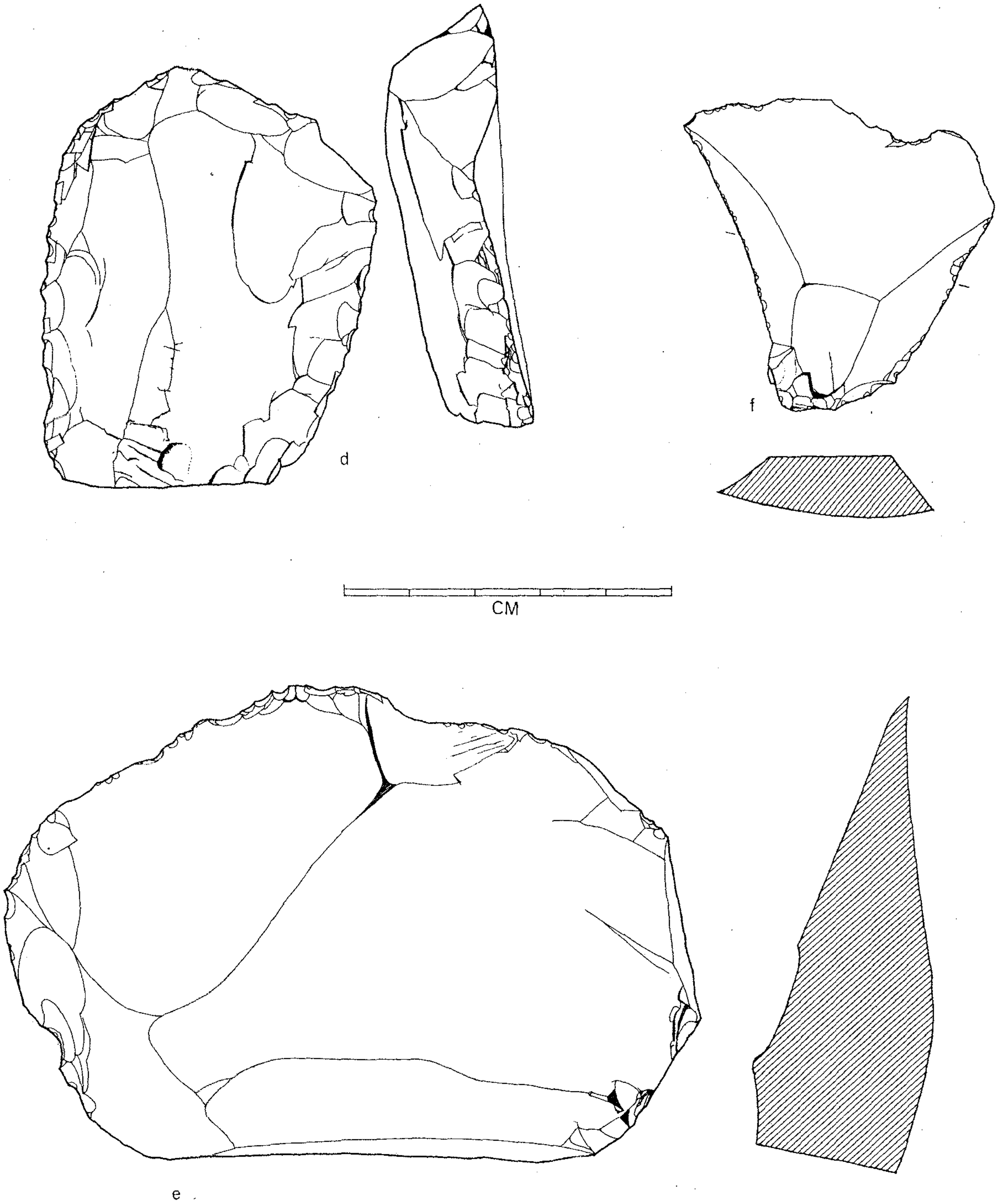


FIGURE 6.2 Flake tools from Wyrie Swamp.

at a steeper angle. The bulb is unaltered in each specimen.

The instance of minor edge alteration is low in the collection, and two implements are shown to illustrate this case. Specimen 6.2e is a large primary flake with localized unifacial percussion flaking to the left lateral edge. Crushing or step flaking has not occurred. Specimen 6.2f is a simple, exceedingly sharp flake with minute chipping on three edges, suggesting utilization as a cutting implement. Of all the implements recovered, this is the only candidate which could have been used to finish the wooden spear barbs found in the peat.

The category of tools not shown, exhibit robust, steep edges and less formal shaping of the flake. While these are highly variable in size, they are believed to have been used to plane and debark timber. When considered together the stone tool assemblage reflects the general economic character suggested by the boomerangs, spears, and digging sticks associated with the occupation around the water's edge. In this light, it is entirely possible that the Wyrie Swamp technology represents a typical Early Holocene tool kit with which Aborigines were able to effectively exploit the aquatic environment of the Lower South East.

b) Canunda Rock (4000 - 1300 BP)

Where they are present, tool kits associated with Plebidonax and Brachidontes middens are predominantly microlithic and can be located only by careful searching. Because most of these deposits are isolated on the surface of the sand dune, it has been possible to routinely inspect a large number of heaps, in order to describe the range and type of tools present, without resorting to sampling and destroying the sites. From the onset of the study, two types of manufacturing techniques were identified in this way and were verified once detached blades and flakes were reassembled onto cores of nuclei. It was the object of the survey in fact to note the presence of evidence for each technique and to assess the relative quantity of debris which was manufactured by either. In many instances, assessments were made only after on-site reassembly, but, of course, the shellmidden itself was rarely disturbed to obtain this information.

The tool kits associated with Plebidonax middens (Fig. 6. 3a,f) contain a mixture of backed blades, geometric microliths, blade-like implements, and a few scrapers of different sizes. Of these, microliths prepared prior to detachment from the core are the most common, with others, such as geometric microliths, produced by preparation after removal being notably uncommon. Two specimens (d,f) exhibit the characteristic extensive, steep lateral edge retouch of the edge prepared technique, and, because each exhibits bilateral pressure flaking, these are clearly backed blades. Others (Fig. 6, 3a-c,4) however, illustrate vividly the popularity of the blade removal technique, although no definitive evidence on the tool itself indicates use or construction as a backed blade. Since the classical prepared cores and geometric microliths are uncommon in these sites, it is assumed that a correlation exists between geometric microliths and prepared core techniques. Small, steep edged scrapers (Fig. 6,3g), large chopper-like implements about the size of two closed fists, and small aeolian slabs form another component of the tool kit of secondary importance in terms of numbers. The types of microliths identified include Bondi, Woakwine, and asymmetric forms.

Although these shell heaps frequently cluster in groups of 3 to 8, the tool kit associated with a given deposit is not duplicated in neighboring heaps. Some will be stone free, while others are related to a stone knapping station a metre or two away. In some instances, reassembly has resulted in joins between flint found in two different heaps. This suggests that the campers at each heap may have been related

Wyrie Swamp (10,200-8000BP)

a.	Large flake tool;	FS0.0.90
b.	Large flake tool;	FS18.1.4
c.	Large flake tool;	FS0.0.83
d.	Large flake tool;	FS0.0.92
e.	Large unifacial chopper;	FS0.0.69
f.	Utilized flake;	FS29.2.4

FIGURE 6.2

Stone implements from Wyrie Swamp. Those with numbers in each decimal place were excavated. Drawings by W. Mumford.

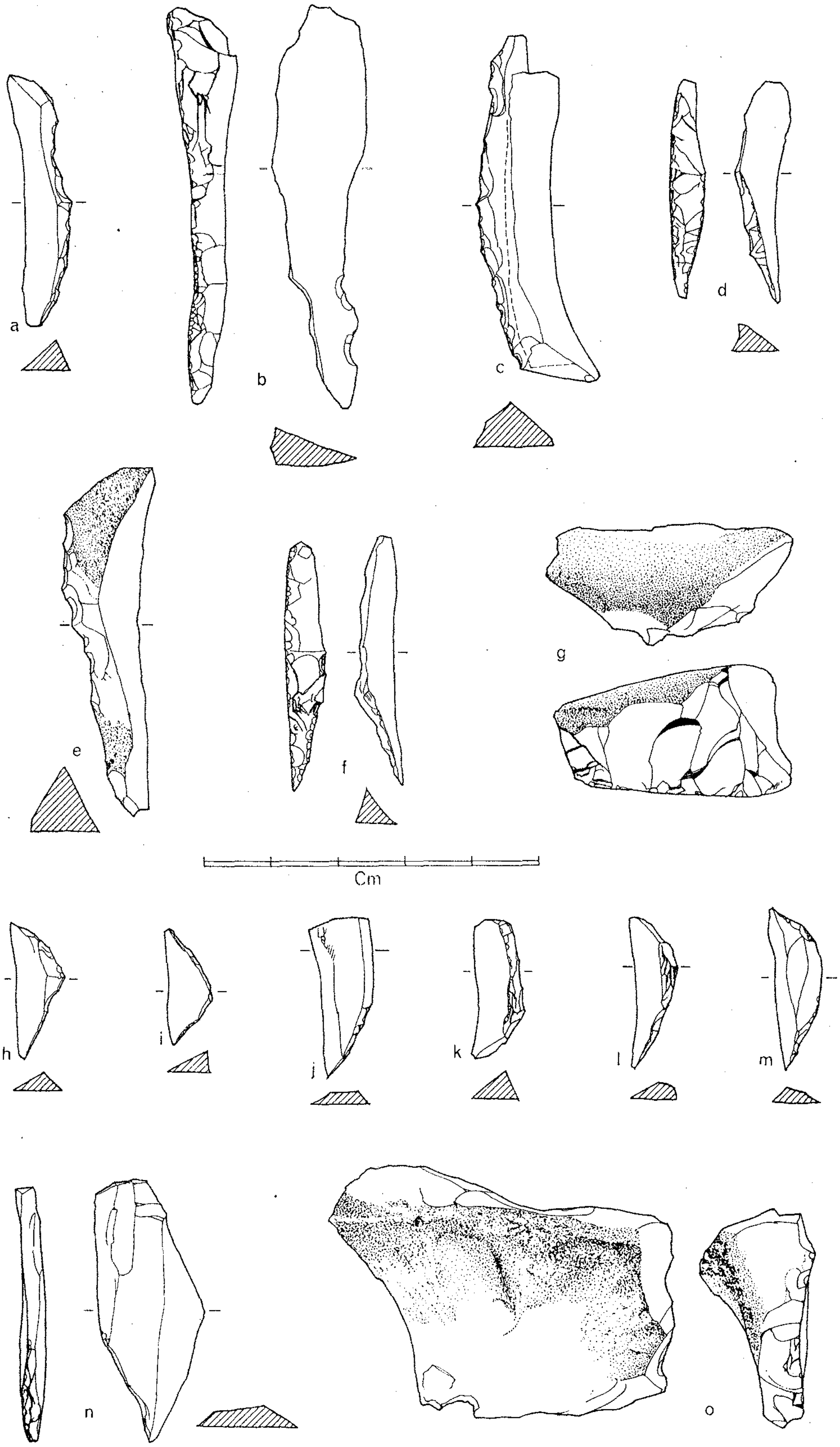


FIGURE 6.3 Early Phase implements from cockle (a-g) and mussel heaps (h-o) from Canunda Rock.

in some way Using the flint's distinctive coloration to identify waste from particular nodules, the number of nodules at individual camps has been estimated to range from one to nine, with the average probably being two or three. Larger tools, such as choppers, or aeolian slabs are not distributed in any particular way around the middens, but instead occur in low numbers and in random patterns. This may indicate that no particular camp was function specific, or that the implements were being shared. In one case, two nodules had been completely broken down by knappers and the debris was intermingled in the refuse of three adjoining middens and a fourth heap several metres away. Although the reassembled units were too incomplete to trace the knapping sequence, the occupational sequence could have been reconstructed if manufacture had also been sequential. Whatever the pattern of visitation however, this evidence clearly proves that most tools were manufactured on site and that some were brought in for replacement, with the microliths having the greatest turnover rate.

Like the previous tool kits, those at Brachidontes middens feature a mixture of microliths, scrapers, and various items used around the hearth. A difference was emerging however, and to illustrate this (Fig. 6.3h-o), a single hearthside assemblage (FS 1), dated to 2990BP, has been selected. Paired geometric microliths (h&i;l&m), a backed blade (k), and the geometric microlith (j) are each being produced within the focus of one campfire. The emphasis of the knapper seems to be the production of a variety of artefact types made predominately on blades prepared after they had been detached from the core. The practice of detaching a prepared edge from its core is clearly indicated (k), and in fact continues in these campsites; but the prepared core technique has definitely gained popularity and more microliths occur in these middens than was the case earlier. It is common, for example to find 8 to 12 of these artefacts within the scatter of a single shell heap, and the number may be much higher if entire deposits are sieved. Similarly, small scrapers (Fig.6.3o) are a more common element in the tool kit. The type of tools and their number is highly variable between middens however, and in this way Brachidontes campsites are like the cockle midden assemblages. The lithic inventory for selected sites at Canunda Rock appears in Table A6.1 of the Appendix.

Similar campsites located behind the foreshore at Cape Banks and at more southerly localities further inland are believed to belong to the Early Occupation Phase and are noteworthy in this discussion in two ways. Firstly, even though only slightly larger than those at

Canunda Rock, these shellheaps contain hundreds of microliths and unworked blades manufactured from prepared cores. Local artefact collectors in fact claim to have removed large quantities of the implements over the last 50 years (McCourt 1975). With the primary focus devoted to the production of a single implement, presumably over the course of a single visit, the camps reflect the terrific rate at which microliths were consumed. The term factory site is especially appropriate, and since microlith production is likewise the central theme in the camps at Canunda Rocks, we might regard them all as factory sites. In light of their accumulations at the foreshore, lagoons or swamps, and in the ranges however, the microlith is probably not tied to a specific economic activity.

c) Inland Camps (2000 BP to Contact)

Although occupation of the central zone of the sandhills began earlier, the majority of the campsites can be assigned to the initial stages of the Late Phase occupation, and these therefore relate to the Buandik. The tool assemblages selected for discussion from this zone will then belong to the period of transition from Early to Late Occupation, during which time significant economic and technological changes had occurred. Two types of assemblages occur.

The first is a surface scatter of lithic debris associated with Plebidonax and Subninella shells located at the base of an eroding dune surface. Labelled in Figure 5.7 as "Collection 1" and dated to 1130BP, the collection consists of numerous types of microliths, scrapers and knapping debris, plus multipurpose tools. An estimated 350 pieces of flint were collected, and 55 were selected for identification. Many hours were devoted to reassembling portions of the collection in order to reconstruct the kanpping procedures employed at the camp. (Figure 6.1 was based on the material from this site .

A sample of the collection (Fig. 6.4) consists of microliths, rejuvenation flakes, and scrapers, which, taken as a whole, resemble tool kits described for Canunda Rock assemblages. On closer inspection however, the microliths have taken on a greater complexity and variability in shape which is the result of increased use of pressure flaking in the final stage of manufacture. Hence, geometric microlith 6.1e, which was prepared before detachment from the core, is further shaped after detachment by pressure flaking on distal and lateral edges. Although this practice has been noticed in earlier kits, it appears now

Inland Camps surface collection ("Collection 1")

a.	Geometric microlith;	FS .0.4
b.	Geometric microlith;	FS .0.3
c.	Geometric microlith;	FS .0.31
d.	Geometric microlith;	FS .0.35
e.	Geometric microlith made from rejuv.flake;	FS .0.17
f.	Rejuvenation flake;	FS .0.18
g.	Backed blade made from rejuv. flake;	FS .0.13
h.	Steep edge scraper;	FS .0.60
i.	End scraper;	FS .0.68

FIGURE 6.4

Representative selection of implements believed to be associated with Early Phase/Late Phase transition period (2000-1000BP) from Inland Camps Complex. Drawings by W. Mumford.

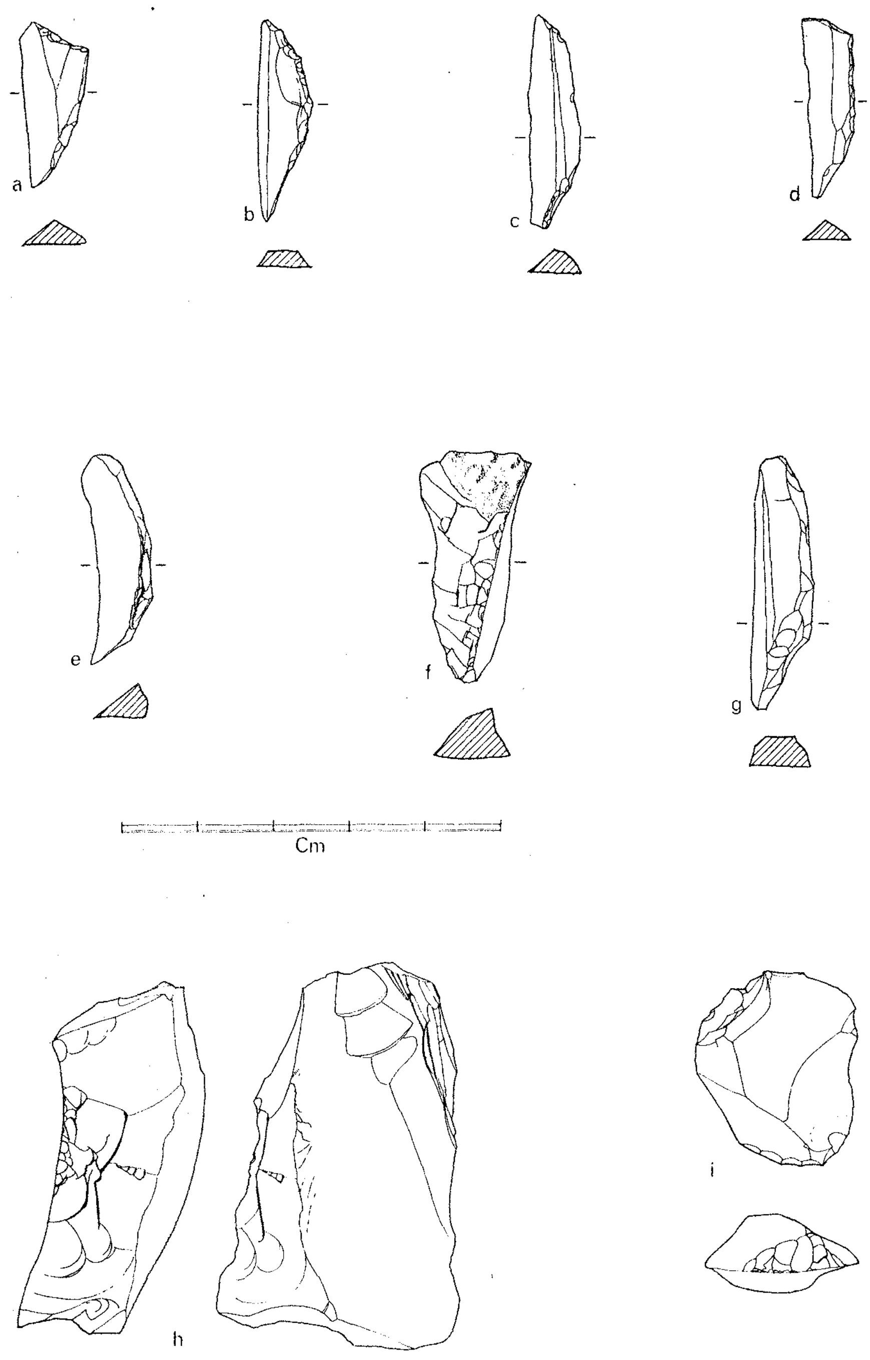


FIGURE 6.4 Implements from Inland Camps Complex, Collection 1 representing Early/Late Phase transition.

to be the rule rather than the exception. Another microlith (d) is a rejuvenation flake with lateral pressure flaking the length of the edge. Other forms (f) appear to have been rejected due to awkwardness of the shapes created by faulty knapping. The tool kit seems to be acquiring new forms of microliths within the context of a single campsite by a skillful combination of manufacturing techniques. This would seem to imply that new design modifications are taking place. Excatly what these are remains to be described, but the knappers in this Inland Camp are exerting more control over their lithic material than previously was the case.

For a single campsite deposit, the range of different tools and debitage connected with different knapping techniques is unusual relative to campsites near the foreshore at Canunda Rock. At least 15 rejuvenation flakes, each with one or more blade scars were counted; a number of simple scrapers with localized edge dressing are present; and 23 microliths have been identified in various stages of fragmentation. Three prismatic cores, from which numerous small blades have been struck, showed evidence of edge damage suggesting they might have been used to crush or pound. Another core (no. 23) displayed wearing and rounding on the core edge consistent with use as a scraper or plane, and yet there can be no doubt of their role as blade cores. This pattern of multiple use of the cores would suggest that a more intensive processing is taking place at the site, and that the site technology is possibly more complex than is revealed in the morphological traits of the tools.

This pattern is also reflected in another tool deposit located amongst a scatter of reef gastropods in the Ovens Complex (Fig. 5.8). Labelled as Site $^{4}26^{58}39$-2, the deposit was confined to an area 7 x 3 m on the dune surface and did not appear to be associated with ovens or hearths, although shellfish were clearly intermingled in loose association. All lithic material within an area measuring one third of the site was collected, and a sample appears in Figure 6.5. The total collection contains 211 pieces of flint, and of these 66 are implements while the remainder are large flakes and portions of nodules. The large implement-to-flake ratio is consistent with large tools being made on site, although flakes from the cortex were not as common as expected. This may either be a sampling error (a sieve was used for recovery), or may suggest that manufacturing operations were initiated elsewhere.

The collection consists mainly of large, steep edge scrapers with single (Fig. 6.5b) or multiple edges (c,d) struck on this flakes.

Inland Camps surface collection ("Collection 1")

a.	Geometric microlith;	FS .0.4
b.	Geometric microlith;	FS .0.3
c.	Geometric microlith;	FS .0.31
d.	Geometric microlith;	FS .0.35
e.	Geometric microlith made from rejuv.flake;	FS .0.17
f.	Rejuvenation flake;	FS .0.18
g.	Backed blade made from rejuv. flake;	FS .0.13
h.	Steep edge scraper;	FS .0.60
i.	End scraper;	FS .0.68

FIGURE 6.4

Representative selection of implements believed to be associated with Early Phase/Late Phase transition period (2000-1000BP) from Inland Camps Complex. Drawings by W. Mumford.

Ovens complex surface collection

a.	Large, straight edge scraper;	FS1.0.53
b.	Large, snub nose scraper;	FS1.0.48
c.	Large, concave scraper;	FS1.0.47
d.	High, convex scraper;	FS1.0.44
e.	End scraper;	FS1.0.35

FIGURE 6.5.

Representative selection of implements associated with Late Phase occupation kitchen refuse from site $^{4}26^{58}39$-2, Ovens complex. Drawings by W. Mumford.

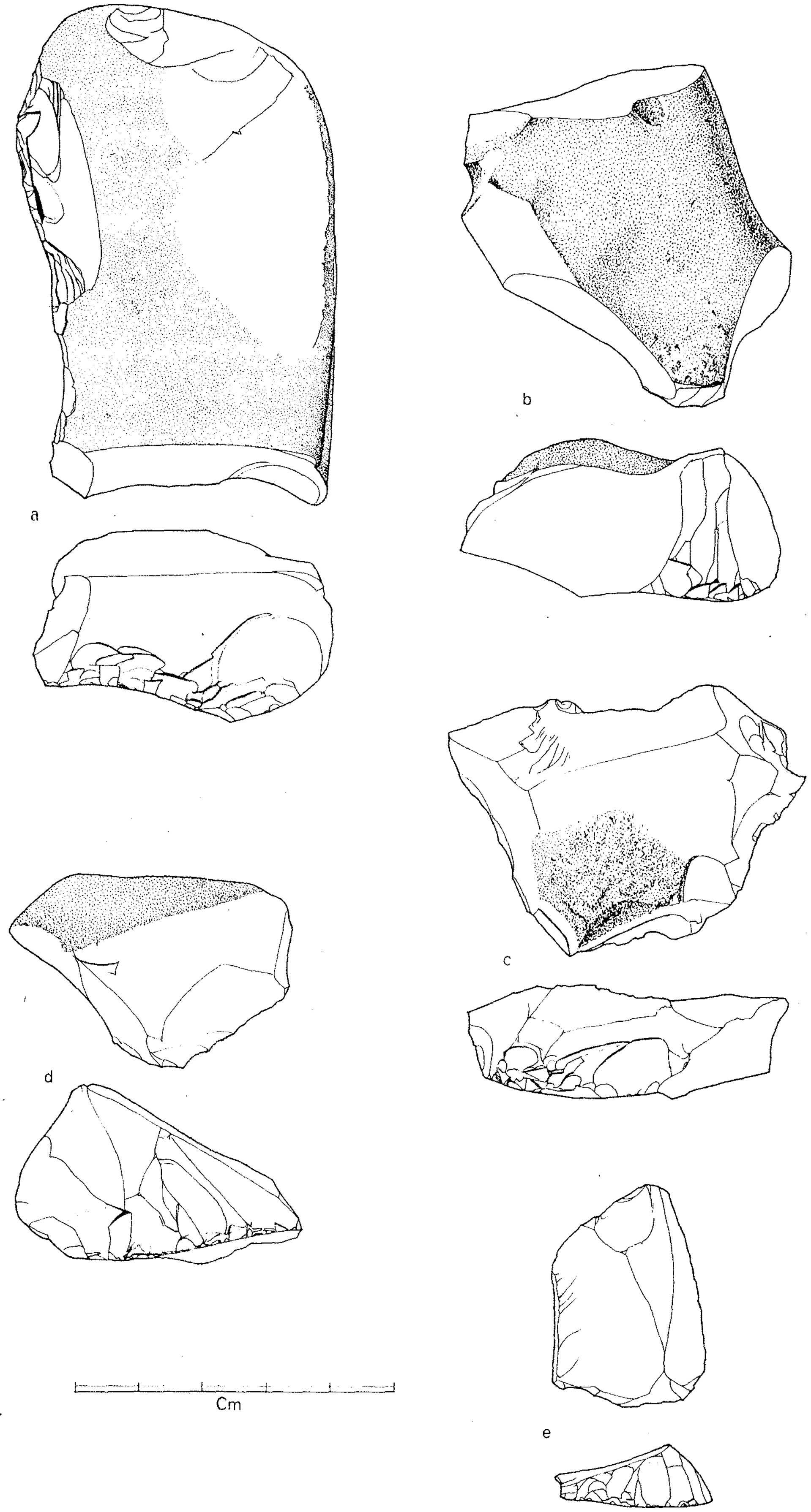


FIGURE 6.5 Implements from ovens complex.

The working edges characteristically protrude from the body of the scraper and are formed by high fluted surfaces and symmetrical, small curvatures. Edge angles closely approach 90 degrees and wear does not appear pronounced. Larger tools (6.5a) with bifacially worked edges are common and may have been used for chopping or pounding. Smaller scrapers (f) with precise edge trimming are also frequent tools in these camps.

Not all the tools in the site are steep edged scrapers or choppers however. Two small scaler cores are present, and one has been partially reconstructed. It has yielded small, broad flakes, struck from opposite platforms sequentially, and it is not a bipolar core or fabricator. Although these cores are common in the Inland Camps, their distribution in the Early Phase is inadequately known. Large broken nodules with severe crushing of prominent edges are also common, and possibly were used to break down other nodules being knapped. To this group may be added small nodules with distinct percussive damage to one or more edges. Low numbers of flat aeolian slabs may be associated, although they are not present in this particular sample. These are usually about 20 cm long and 15 cm wide and owe their shape to wave action in the littoral where they are found. Surface scarring associated with use is rare in this artefacts. Occurring in the loose sands near hearths the slabs could provide a hard working platform on which to prepare foods, crush bones, to grind ochre We can see from this range of tools that the subsistence technologies of the Inland Camps reflect a full and diverse economy.

d) Clifftop Middens (1500 BP to Contact)

The clifftop middens constitute the greatest single archaeological manifestation in the coastal margin, contain the largest amount of stone material,and still they reveal the simplest lithic technology uncovered. Abyssinia Bay midden will be used as an example of campsites in this zone. Excavated lithic material is listed in Appendix A6.2.

There are only two types of tools in the clifftop middens and both are scrapers (Fig. 6.6). The most common are steep edge or high-back (Tindale 1957:117) scrapers (a,d,e) which are identical to those described for the Inland Camps assemblages. They almost invariably possess a single, fluted working edge with an angle approximately 90 degrees. The other is a hatted adze stone (Tindale, ibid.) The working edge consists of a row of shallow flakes which are trimmed periodically

Abyssinia Bay Shellmiddens (1300BP to Contact)

a.	Steep edge, snub nose scraper;	FS18.1C.1
b.	Simple Scraper;	FS20.1.1
c.	Utilized flake;	FS31.3C.1
d.	Steep edge, multiple edge scraper;	FS33.3A.1
e.	Steep edge scraper;	FS30.3C.1

FIGURE 6.6

Representative selection of excavated implements from Abyssinia Bay Shellmidden (Late Phase). Most common implement is the simple, utilized flake. Drawings by W. Mumford.

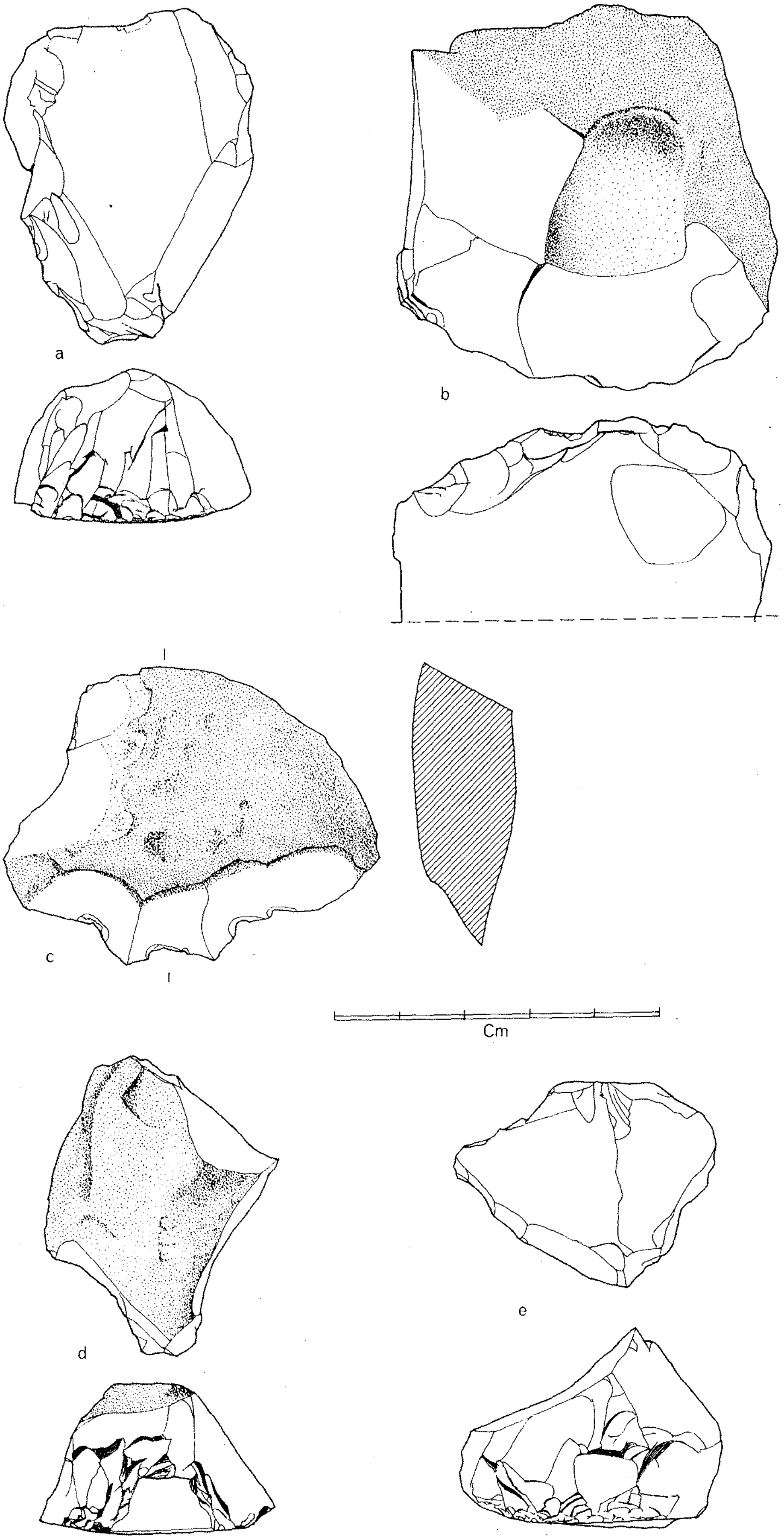


FIGURE 6.6 Implements from Abyssinia Bay.

to reclaim use of the implement as it wears. This form is uncommon in the Abyssinia Bay collection and is not illustrated. By far the most common flake implements are irregularly shaped flakes (b,c) which exhibit no convincing evidence of deliberate shaping to wear. These and wasted flakes and nodules make up the great majority of lithic material on the site. Technological activities at these sites therefore are exceedingly limited relative to contemporaneous deposits elsewhere. In light of the types of seafood refuse preserved in the deposit, it is reasonable to propose that the site economy did not require a special technology and that what is present reflects occasional generalized maintenance of wooden tools. The major and possibly only focus then involves the acquisition, consumption, and partial processing of marine resources from the immediate environs.

f) The Lagoon Setting (1590 BP)

The most striking character of the Domaschnez Ridge technology is the blending of manufacturing techniques to produce a wide array of tool sizes and shapes. (Fig. 6.6a-i). Edge-prepared blades (6.6a,b,d) have been pressured flaked after detachment, and the degree of control in shaping microliths (c,g,i) is emphasized by very fine trimming to lateral edges as well as to proximal and distal ends. The knapper is attempting to extract very small tools (f) and to precisely create scrapers for special uses (e,h). Like the technologies of the Inland Camps, the inventory is a comprehensive one in which the tool user seems to have had full control over the material and was attempting to skillfully apply his tool kit to a special task. If similar campsite assemblages at Canunda Rock dated to 1000BP are used for comparison, a greater range of sizes and shapes is seen to emerge. The subsistence technology at this time then is assuming a very versatile, specialized character which suggests that the tool makers are more than simply gathering shellfish.

g) Nora Creina Bay Shelter (650BP to Contact)

The dietary remains left by the occupants of Nora Creina Shelter reflect exploitation of many different resources in the immediate area, and, as such, the subsistence technology would be expected to show a versatility as great as that seen on Domaschenz Ridge.
Examination of the stone tools at Nora Creina (Fig. 6.7j-n) reveals only small, multiple edged scrapers.
As in other assemblages, the scrapers (j,l,m) exhibit exceedingly fine secondary flaking around a symmetrical edge, while other types of scrapers (k,n) have received less attention in shaping. In the inventory of excavated implements (Appendix A5.6), the only other tools

Domaschenz Ridge Shellmidden (1590±70BP)

a.	Backed blade made from rejuvenation flake;	FS3.3.1
b.	Backed blade;	FS3.3.2
c.	Geometric microlith;	FS2.3.6
d.	Backed blade;	FS4.3.1
e.	Small steep edge scraper;	FS4.2.1
f.	Exhausted core scraper;	FS2.3.5
g.	Backed blade;	FS2.0.11
h.	Small scraper	FS2.0.2
i.	End scraper;	FS2.0.10

Nora Creina Bay Rock Shelter (650±90BP)

j.	Convex scraper;	FS1.7A.1
k.	Convex scraper;	FS1.9.1
l.	Multiple edge scraper;	FS1.8.1
m.	Scraper;	FS4.2.3
n.	Scraper;	FS4.2.2

FIGURE 6.7

Representative selection of excavated implements from Domaschenz Ridge Shellmidden (terminal Early Phase) and Nora Creina Shelter (Late Phase). Drawings by W. Mumford.

FIGURE 6.7 Implements from Domaschenz Ridge (a-i) and Nora Creina Shelter (j-n).

of note are shell scoops, a possible shell cutting tool, and a roughly shaped bone awl or chisel. Naturally formed aeolianite and travertinous cylinders are pecked at their ends from pounding, and an aeolianite slab (FS 4.8A.1) has deep central packing to both faces. No microliths or manufacturing debris associated with blade production could be found in the deposit. Because this component has played a prominent role in almost all site technologies since 4000 BP, and therefore might be expected at Nora Creina, it must be concluded that geometric microliths and backed blades were no longer being made.

DISCUSSION

It is clear from the evidence described above that Holocene technologies in the Lower South East have undergone dramatic changes in morphological development and manufacturing style. The basal tradition at Wyrie Swamp for example is characterized by large, extensively trimmed flake tools probably formed by percussion techniques only. There is no evidence that the primary implement, once formed, was substantially altered during its life. The tool kit associated with post Mid-Holocene campsites in the sandhills, by contrast, contain much smaller implements fashioned from either flakes or blades by both pressure and percussion flaking techniques. What is more, new forms such as microliths, awls, and small scrapers have been created by a process in which larger implements are sequentially recycled into forms probably functionally different than the original tool. Considered side-by-side then, these two traditions reflect differences in the extent to which raw materials are utilized and new morphological characteristics are produced.

On closer inspection however, the creation and subsequent trimming of rejuvenated edges in the Early Phase occupation appears to represent a possible developmental link with the Australian Core Tool and Scraper Tradition. The rejuvenated edges found around the oldest campsites at Canunda Rock (Figure 6.2 a-f) for instance, are morphologically identical with the edges produced by the Wyrie Swamp tool maker, the only difference being their detachment. This suggests that large tools were employed around the campsites, but were reduced and reworked in the normal process of maintenance and repair. If this was the case, the steady decline in basic tool size witnessed in Holocene technologies continent wide literally materialized within the course of a single campsite event. Once tools began to be recycled during the Early Phase, the addition of the prepared core technique not only markedly increased the number of microliths produced, but enabled a greater variety of forms to be achieved by simple pressure flaking methods. These innovative measures enabled a greater flexibility in the manufacture of specific lithic forms, economized on flint resources being transported, and freed the knapper of many of the limitations imposed by the flaking properties of the raw material itself. Central to this dynamic experimentation with technique, skill, and resource is the microlith itself, and it is the retooling to produce this implement which represents the most dramatic departure from previous technological processes.. It is on the microlith then that this discussion must concentrate for an understanding of adaptive significance of technological elaboration in coastal adaptation.

Although direct evidence of the function of microliths in prehistory has yet to be firmly documented, it is widely believed that their primary role was as barbs or tips on spears. The strongest support for this claim, apart from the microliths suggestive shape, is the presence of resinous material on a number of excavated specimens in New South Wales (Mulvaney,1975:228;McBryde,1974:Plate 62). Positioned with its back set in resin on the shoulder of the spear, and blunted on the trailing tip so as to assure a firm hold in the target, the microlith becomes an effective barb. Assuming that this inference is correct then, the microlith is seen as a functionally prominent element of the composite spear, and it is towards an explanation of this use of lithic barbs that we must turn.

The composite spear was a universal feature of coastal adaptation in late prehistoric Australia, and it played an essential part in fishing and hunting wherever intensive use of marine resources occurred. The Buandik, for instance, clearly had stone tipped spears, as shown in drawings (Plate 6.2-19) by Angas (1847) in which irregular stone flakes were set into gum. The most common spear in 27 illustrated by Angas are short composite spears consisting of grass tree or reed mainshafts and fire-hardened foreshafts. Some of these, such as that shown in Plate 6.2-7, do not have barbs of any description; but most are depicted with a single wooden or bone barb lashed to the spear with sinew. With its posterior tip blunted and drilled to receive the hook of the spearthrower, or midlah, the composite spears could be hurled like a dart at high velocity with astonishing accuracy. Regardless of the success of the throw, the extreme stresses endured on impact would invariably result in serious damage to at least the tip of the spear, as has been reported by witnesses of such a throw. (Gould,1970;O'Connell, pers. comm.).

PLATE 6.2.

NATIVE WEAPONS AND IMPLEMENTS
(facsimile by G. F. Angas 1847)

1. *Mulabakka*. A wooden shield used by the Mount Barker tribes, and those on the Murray scrub. It is made of the inner layer of the gum tree.

2-3. Carved wooden shield from the Darling River area. Ornamented with red and white paint.

4. *Wakkalte*. Shield made of bark, and painted. Used around Lake Alexandrina and amongst tribes of the Coorong.

5. *Pangkiye* or boomerang. Used by the natives near Rivoli Bay.

6. *Marpangye*. A weapon used in fighting around Lake Alexandrina.

7. A warrior throwing the grass tree spear, (*Kyah*) by means of the *Midlah* or throwing stick.

8. *Kariwoppa*. A bundle of emu feathers used as a challenge, fastened on the top of a spear and sent by one tribe to another before a fight.

9. *Kalduke*. Worn as an ornament by young men. It is made of human hair.

10. *Warpoo*, or dagger. Is made of hard wood.

11-13. *Midlah*, or throwing stick, cut out of wood and used for throwing the smaller kinds of spears. The knob of the handle is cemented with the gum of the grass tree while the end of the spear fits on to the kangaroo bone hook fastened to the stick by sinews.

14. *Mulabakka*. A bark shield.

15-18 *Wirri*, or fighting club. This is the most general weapon in the hands of a native, and is used both in offence and defence. It is made of a hard wood. Those which are large and straight are generally used for fighting.

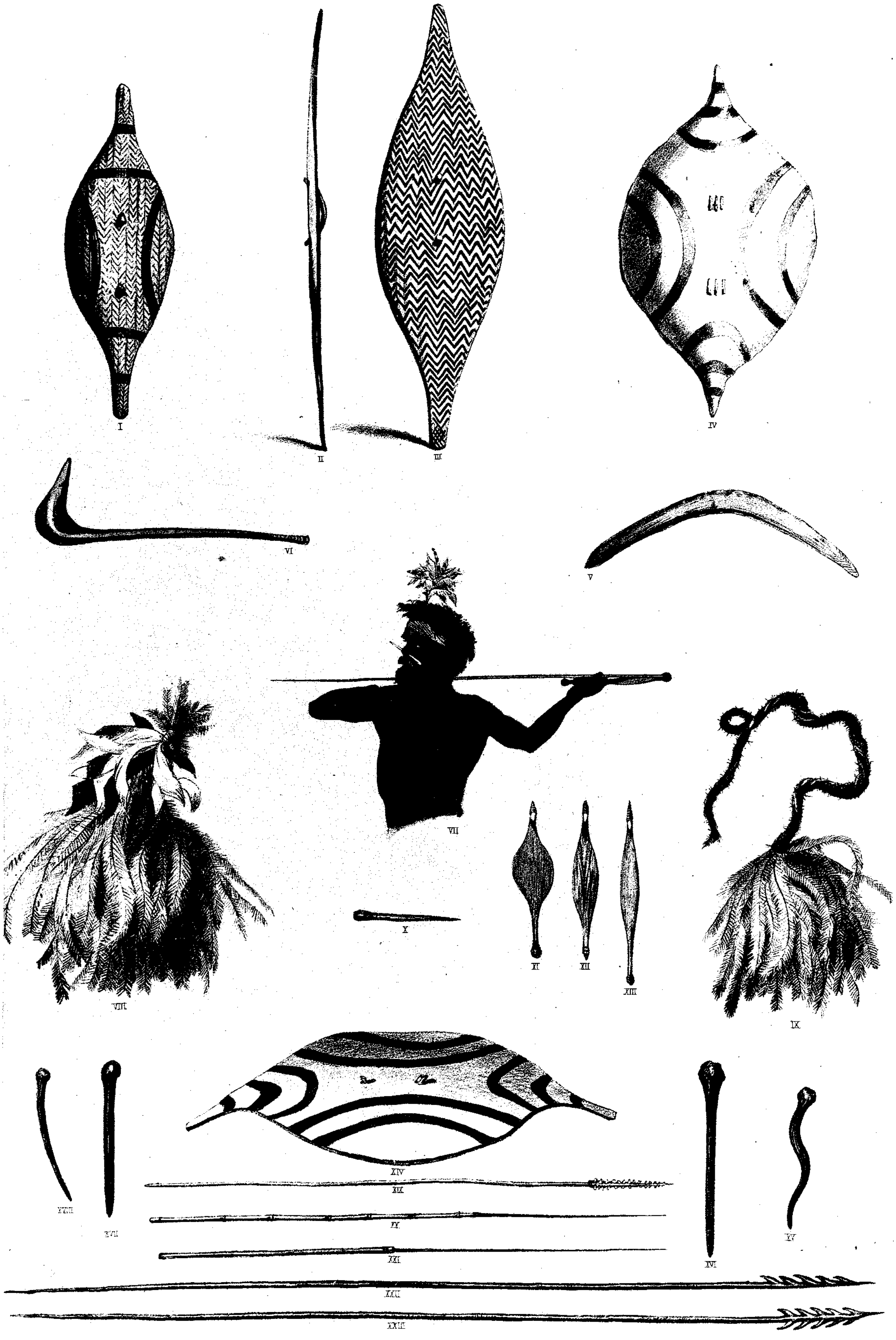
19. *Kyah*. A small spear, barbed by pieces of sharp quartz, or glass inserted into grass tree gum.

20. *Kootpee*. A reed spear.

21. *Yarnde*. Grass tree spear. The foreshaft is made from the tea-tree and is hardened in the fire. This and the preceding spears are thrown by the *Midlah*, and are about 2 metres long.

22-23. *Uwinda*. Barbed wooden spear, 3-3.5 metres long and made of the gum tree. They are thrown by a throwing stick.

PLATE 6.2



In light of the great turnover rate of spear parts, the incorporation of different materials and prefabricated elements of the composite spear seems to offer advantages over single piece construction techniques. Attached to the flexible mainshaft, the hardened spear tip can easily be replaced when it has been shattered without resorting to replacement or serious modification of the spear itself. Even the barb, which assumes an important role in many large hunting spears used on kangaroos (Gould,1970), is subjected to constant damage and therefore has a comparatively short life span. The adoption of separate, specialized spear elements appears to be a simple and effective method for overcoming problems inherent in its use with the spearthrower.

There are also rigid specifications to be met in the design of spears adapted for use with the spearthrower. In studying this aspect of spear collections in museums, Palter (1977) has concluded that spearthrower projectiles were designed with a remarkably consistent centre of balance regardless of the type or origin of the spear. In the case of the lighter reed spears in particular, this could have only been achieved with the addition of a hardwood foreshaft, which gave the spear a greater mass at its front end. As has been shown by experiment however, optimum performance of the spear can only be reached by trial and error, with the most minute changes in balance noticeably influencing the flight behavior of the spear. For Aborigines in the Western Desert, Gould (1970) has described the lengthy learning process followed by young males in acquiring knowledge of how to make and use spears with the spearthrower. It becomes clear then, that use of the spear and spearthrower require a mastery of the most exacting craftsmanship and design requirements before the spear bearer can become a proficient hunter.

To the spear hunter at Wyrie Swamp 10,000 years earlier, this attention to design appears to have been unnecessary. Of the three spears recovered by excavation, two had a single barb each. The most distinguishing feature of this spear is the fact that the delicately crafted barb is fashioned from the mainshaft itself and that composite construction was not practiced. As a consequence of damage in use therefore, the entire front end of the spear including the barb must be refashioned at the expense of the length and balance of the already comparatively short spear shaft. To provide for this inevitability, the shoulder behind the barb, as shown in Plate 5. 2B, appears to have been maintained at a diameter equal to the height of the barb, thus assuring sufficient wood for repair and adjustments to balance. With a cross section at the shoulder resembling a teardrop, repair would have involved removal of the excess wood behind the barb, the cutting of the barb itself, and sharpening of the tip. Given the great care with which the fragile barb must be carved, it is reasonable to suggest that the introduction of hafted barbs significantly eased the burden of constant repair during the hunt and lessened the pressure to supply suitable lengths of spear shaft. The creation of the microlith, with its back surface roughened to facilitate attachment and its form precisely shaped, would be the most direct solution to this problem. The hunter had merely to remove the edge of his stone wood working implement and shape it slightly to fit the spear. What remains unexplicable however, is the microlith's relatively sudden appearance across the continent accompanied by significant elaboration of other hafted implements, such as the tula and elouera adzes and various stone projectile points.

The one implement directly associated with composite spears described in the ethnography, and which is missing at Wyrie Swamp, is the spearthrower. Of the 28 wooden implements recovered in the peat, not even the simplest straight sticks or shafts could have served as crude levers for throwing spears. Nor is there a receptacle in the end of the one complete spear to accept the hook of a spearthrower. Furthermore, over the 2000 years of occupation represented by an estimated 3700 wooden implements, no evidence has emerged to suggest that composite spears were manufactured in the tool kit. On the basis of its absence at Wyrie Swamp, and in view of the substantial changes occurring in subsequent subsistence technologies therefore, I believe the elaboration associated with the Small Tool Tradition is directly attributable to the introduction of the spearthrower.

The development of a new method of casting a spear with greater force over greater distances would have a predictable impact on existing technologies. Not only would it have led to extensive structural modification of hand thrown spears, as Palter concludes (1977:171), but in addition it would have necessitated the creation of a larger spear repair and manufacture kit including notching awls, end scrapers, and possibly grooving tools to facilitate anchorage for the microlith and resin hafts. In addition, with a growing commitment to construction of hardwood spearthrowers, as well as to preparation of increased quantities of timber for spear shafts, the advantages of hafting stone adzes become all the more apparent in the wood working process. Under these circumstances, the pressure to recycle stone and to reincorporate lithic discards into the tool kit is a logical outcome of the complexity of composite tool construction. The elaboration in both manufacturing techniques and morphologies witnessed in Early Phase tool kits would then be viewed, according to this hypothesis, as a consequence of the need to construct and maintain composite spears. This procedure conceivably would take place slowly and would involve an expansion of spearing technologies in search of optimal use of local materials and more effective application of spearthrowing techniques.

The emergence of the spearthrower serves to explain the impact and dispersal of many elements of the small Tool Tradition. The spear, in its many forms, with the spearthrower represent generalized hunting techniques which offer advantages in almost any situation. Therefore the wide acceptance of microliths might be expected to have occurred relatively quickly. But because the accompanying tool kit was constructed to meet certain design specifications, existing technologies would have been modified in nearly identical ways wherever they appeared. While it cannot be denied that elaboration of an non-utilitarian nature may have followed the adaptation, the underlying factor in the success of the spearthrower must mainly rest with the increased capacity for composite tools to more efficiently manipulate the environment. In the sense that increased repertoires of manufacturing methods, tools, and use of raw material reflect this capacity the Small Tool Tradition seems to herald the emergence of the first consumer society in Australia.

Given these gains in technological efficiency and a growing elaboration in tool form, the disappearance of the microlith coupled with a decline in both tool size and typological variation in the Late Phase of settlement, would appear to be a reversal of this trend and an abandonment of the basic advantages achieved in the previous stage of development. This picture may be more apparent than real however. From the advent of new manufacturing techniques, simplification in production, and increased complexity in the tool inventory itself, it is reasonable to infer that the technology was approaching mechanical limitations in design and materials. Prototypes were beginning to emerge with elements of a specialized adaptation, and the response was to both simplify the tool kit and transfer these prototypes to other materials such as bone and wood. The tool kit thus takes on the appearance of a more generalized, even devolved technology simply because major components soon become archaeologically invisible. Rather than reflecting technological collapse however, the Buandik economy appears to represent the culmination of developmental processes started sometime during the Mid-Holocene. The causes of the shifts occurring between the Early and Late Phases of settlement therefore are clear only when seen in the context of accompanying changes in subsistence organization throughout the period. With the organization of the Buandik already known, this can be accomplished by a comparison with the settlement pattern during the Early Phase. Evidence for this will be examined in the following chapter.

CHAPTER 7

CONTEMPORANEITY AND SEASONALITY IN CAMPSITE VISITATION

INTRODUCTION

It has been shown (Fig.5.6) that Plebidonax and Brachidontes middens at Canunda Rock are clustered together in a way suggesting that they are somehow related in time. The undisturbed character of the kitchen debris further suggests that the diners were only temporary visitors and made no effort to sweep aside or otherwise rearrange their camps. Since this is a common pattern in campsite spatial arrangements in the Early Occupation Phase, it is reasonable to assume that the organisation of the camps is a reflection of the organisation and operation of shellfish gatherers. Three different situations might be proposed to explain the camp arrangements. First, a single large group could have camped using several hearths while shellfish were consumed. Second, a small group might have camped on several different occasions at the site, each time constructing a new hearth. A third possibility is that individual hearths were repeatedly used by either of the two types of groups mentioned above. In each of these cases, the identity of the group and an estimate of its size would depend upon the way the camps were used. Identification of hearth groups belonging to a large number of campers may be difficult to determine, but the repeated use of a camping site is more likely to involve a similar or identical group of people. In either of these possibilities, the tool kit and other evidence may provide helpful clues. Clearly, a satisfactory description of the visitation pattern in these camps is a central issue in a reconstruction of the subsistence strategies in coastal economies during the mid-Holocene.

We can resolve this issue if we can discover whether shells from neighbouring heaps were collected at the same time. If the shells were simultaneously collected, the camps were contemporaneous. If time has elapsed between collections, either proposition two or three above is possible. To determine which case is more likely, it is necessary to realize: 1) that a mollusc shell contains a full and complex record of its life experiences; 2) that molluscs in the same community share records; and 3) that this record can be used to distinguish between animals from different times and localities. Furthermore, if a calendar can be related to a shell's record, time of death can be determined. The following discussion examines these points in detail, using Plebidonax as an example.

a) Growth Lines

Molluscs grow by depositing discrete amounts of calcium carbonate on the margins of their shells (Digby, 1968; Wilbur, 1972) under the influence of the mantle. This otherwise continuous process is interrupted by both regular and random environmental and biological events causing the organism to alter the proportion of carbonates being deposited. This behaviour leads to the formation of growth lines which are visible in the shell matrix in hand specimens and under magnification. Disturbance, or stress, produces translucent growth lines exhibiting an increase in the organic protein, conchiolin, at the expense of carbonate; whereas the more opaque increments represent more normal conditions for shell accretion. In this way, alternating growth lines record the stress/nonstress history of the mollusc.

Most of the shell's growth is periodic in nature, and tidal patterns are the principal influence. Tidal periodicities have been well documented in the clams Clinocardium (Evans, 1972) and Mercenaria (Pannella and MacClintock, 1968) and in four other marine pelecypods (Barker, 1964). At the finest level, the daily cycle of tidal submersion and exposure creates small, regular growth increments bounded by fine stress lines. Integrated with this basic pattern are two related periodicities, the more frequent consisting of the monthly maximum, or spring, and minimum, or neap, tidal exposures. These produce an expansion or compaction of the daily lines alternating fortnightly. Twice a year, spring tides create a period of maximum exposure, which produces the greatest annual tidal stress. Less important periodicities of similar frequencies derive from temperature and light changes on daily and seasonal schedules (Clark, 1974).

The application of tidal periodicity in contemporaneity studies is promising if the whole molluscan population records cyclical stresses in a clear and readable form. Using fortnightly cycles as an example, any difference in the final line counts between shells would reveal different collection times in relation to neap or spring tides. Unfortunately, studies have revealed that molluscs may inexplicably drop or add lines (Clark,1974) or may deposit such complex patterns of growth (Koike,1973) as to make direct comparisons of daily events very tenuous. In the case of Plebidonax, additional uncertainty arises from partial obliteration of the finer periodic pattern near the time of death, caused by major disturbances to the growth process. Add to this the conclusion that death during the same cycle of tidal movement does not prove contemporaneity of death during the same year, and it becomes clear that tidal periodicities have a limited use in this study.

The first priority of contemporaneity determination therefore is to distinguish individual populations in time, and this can be done with annually distinct disturbance patterns. Since molluscs are sensitive indicators of their environments, major disturbances such as storms, changes in sea temperature, salinity or food supply, and freak climatological events register in the shell growth pattern. A four year study of growth in the cockle Cardium edule from South Wales (House and Farrow,1968) for example, showed that between September 26 and October 30, 1963, strong gales were registered in all shells as marked disturbances to regular growth. A subsequent drop in winter sea temperatures correlated with pronounced ridging and a decline in growth rates. A record drop in sea temperatures during the following winter, however, failed to cause equally stressed growth in the cockle population, and the authors surmised that the animals burrowed more deeply to avoid the stress. The result of these series of events was to create a distinction between annual cycles of seasonal growth which could be used to separate the events from one year to the next even though broad similarities existed.

Similar cases involving distinctive seasonal growth disturbances have also been described. Olsen (1968) has associated sudden seasonal changes in the availability of different algal food sources with colour banding in Haliotis rufescens; Farrow (1971) has correlated minor disturbances in growth in Cerastoderma edule with extremely low air temperatures; and variability in food supply fouling and its affects on shell growth have been illustrated (Goreau,1964). In each of these studies, the environmental and biological events have caused dramatic disturbances to the periodic growth processes, creating striking translucent patterns in the record. Since these stresses do not have set frequencies, nor are they equally intense or long lasting, their imprints on the shell may be regarded as a signature of the stress history. These will be called stress signatures in this discussion, and will be used to recognise contemporaries within a population.

Different growth patterns may arise in different populations within the same geographic setting which can be used to identify each population. Fairbridge (1953) observed for example, distinct growth rates in each of five populations of the scallop *Notovola meridionalis* in the D'Entrecasteaux Channel, Tasmania, and further noted that disturbance lines correlated with the type of habitat occupied. In a similar study of two communities of *Ostrea edule*, Orton (1928) has correlated differences in growth rate and spawning behaviour with changes in differences in food availability. Two neighbouring communities of *Donax denticulatus* responded differently to available food supply in Jamaican waters (Wade, 1967), with each establishing distinctive shell colour and growth rates. This suggests that the communities or subpopulations can be distinguished on the basis of shared characteristics such as colour banding, disturbance lines, and shell morphology, but that variability exists within contemporaneous populations on a subtle level of expression. To establish whether or not these subtle distinctions arise from isolation of populations or are in fact points on a continuum, empirical studies on live populations are required, but in the cases cited above, physiographic features clearly interrupted the distribution of the populations.

b) Palaeoecology

In a general sense, growth lines can become important sources of information about past environments. Since periodicities and disturbance lines relate directly to environmental and biological conditions, variation from known cases provides evidence of changing environments. Periodic lines (Clark, 1968) and disturbance lines (Craig and Hallam, 1963; Shuster, 1951) have been used to identify individuals from the same time and place. A comparison of growth rates between modern mussel populations and Holocene collections has been used to reconstruct local and regional environments in the arctic waters of the North Hemisphere

(Andrews,1972; Feyling-Hansen, 1955). It follows then that a modern growth record in molluscs can be used to comment upon prehistoric records and conditions which may have influenced prehistoric economic activity.

VARIATION WITHIN POPULATIONS

The most significant factors altering an animal's growth pattern are related to the aging process. The older an animal gets, the more it must divert its energies to activities other than shell growth. As a result, growth rates decline in a predictable way according to age, and the growth patterns become increasingly compacted such that older classes bear stress signatures which are difficult to read.

As animals grow older, their sensitivity to the environment may also undergo dramatic change. In molluscs, the first significant change occurs at sexual maturity (Clark,1974) when blood calcium normally used to build shell is directed towards the production of gametes (Pannella,1971). With reproduction as a principal function, spawning becomes another major stress in the animal's life which renders it for the first time far more sensitive to simultaneous changes in temperatures, salinity, and food supply. From this time onward, growth rates decline sharply (Clark,1974; Pannella,1971), recovery from stress is slower, and what were formerly normal external stimuli are increasingly recorded as disturbances. In old age, the animal's response to its environment is not predictable. For these reasons, only certain age classes are useful in contemporaneity studies and these will generally be molluscs in the prime of life.

Individual growth rates may group around a mean by age class, but size is not a reliable indicator of age in older segments of the population. This is so because as the average size differences between older age classes become progressively smaller, the degree of size overlap between them increases (Valentine,1973). The only way to avoid this confusion is to resort to annual growth line counts (Orton, 1926; Craig and Hallam, 1963; Seed, 1968; Clark, 1974), or to confine the study to younger age classes.

Specimens chosen to determine either contemporaneity or seasonality should be the same age and be the most reliable indicators of events experienced by the whole population. Since precise agreement between growth patterns on separate shells is rare, it is important to set out the limitations of useful variability. Where the range of variation is unknown and where there is no quantitative way to measure the rate of growth, it is possible to compare shells on the basis of shared signatures. If such a sequence is shared, the animals are contemporaries and a difference in absolute growth rate becomes unimportant.

PLEBIDONAX ECOLOGY

The prerequisite for interpretation of archaeological shell growth patterns is a modern study of the animal in a comparable setting. The modern *Plebidonax* sample described here was collected in conjunction with a biological study of the species conducted at Goolwa Beach by Mike King of the South Australian Department of Fisheries. Although King's work has not been completed, a general picture of the cockle and its life cycle can be pieced together from observation of the animal in its habitat and from environmental data.

The distribution of *Plebidonax* between Goolwa Beach and Salt Creek is discontinuous, probably because of changes in sediment size and stability. Its habitat is the tidal zone to a depth of about one metre below tide. During submersion, it moves to the surface, and, when dislodged from the sediments by retreating tides, it will burrow quickly to maintain its position. Turbulence, which occasionally accompanies submersion, can interfere with feeding and may cause stress to be registered in place of normal growth. Within the habitat, adults seem to prefer a position near low tide, but individual daily movement across the habitat is expected (Turner and Belding, 1957) and no particular segment of the population is likely to experience unique events for long periods of time. On a daily basis however, individuals residing in the upper portion of the tide zone may respond to atmospheric conditions more than would residents of the lower littoral, and in this instance temperature is a likely cause of stress.

Seasonal contrasts in the weather pattern bear upon the inshore marine habitats. Warm weather and increased sea temperatures promote the supply of food during the warmer months of November through February, and growth is the greatest during this period. In winter, the animal is less active owing to reduced food supplies and lower water temperatures. Fierce winter storms are commonplace between June and September, when exceptionally high seas break over the beachfront, rolling the cockle around in the surf. Presumably the population escapes stranding by burrowing deeply into the sand, but a high winter mortality would be expected due to the harshness of the environment.

A mid-summer mortality at Goolwa Beach coincides with major changes in the environment. King has recorded a marked drop in salinities associated with peak discharge of the Murray River sometime between December and February. Donax populations in Jamaica respond to flooding (Wade, 1967) by withdrawing into the shell and becoming less active until salinity increases, and King has observed a similar response to freshwater dilution in Plebidonax (pers. comm.). Under these conditions, the cockle is more susceptible to stranding and may be unable to burrow to avoid either turbulence or dessication resulting from high air temperatures. At the same time however, flooding introduces nutrients into the habitat which not only stimulate growth, but may promote spawning (King pers. comm.). It would appear then that the Goolwa populations experience a combination of complex, short stresses during summer, including flooding, spawning and high sea temperatures. Although the specific effect of any one of these on Plebidonax is unknown, freshwater flooding is a major cause of mortality in molluscan populations at all latitudes (Goodbody, 1961; Thorson, 1946).

Finally, the environment around Goolwa Beach is by no means similar from one year to the next. For example, discharge of the Murray River as seen from flow data at Lock 1 was 170 megalitres between November and January 1972, and was 8100 megalitres for the same period the following year. Furthermore, the time of arrival of summer floodwaters is not constant annually.

Record high floodwaters peaked in September 1956 for example whereas more normal flow occurred in November.

In summary, Plebidonax growth is strongly influenced by winter and mid-summer stresses caused by different environmental and biological stimuli. Low temperatures and storm-related turbulence may be the primary factors affecting growth during winter, and these will have a lasting registration in the stress history of the shell. In a period of otherwise accelerating growth, the mid-summer stress is likely to be severe and attenuated. Whatever the specific causes, the record in the shell is expected to reflect these major disturbances against a background of higher frequency periodic stresses.

SAMPLING PLEBIDONAX POPULATIONS

a) The Modern Samples

The modern samples of Plebidonax used in the comparative study were collected from two localities on Goolwa Beach separated by 6.4 km, with the nearest one being 3.2 km from the mouth of the Murray River. Samples collected from Goolwa 1, were provided by King over 17 months beginning in September 1973 and by Conover for one year beginning in February 1974. These have been used to construct the master calendar against which archaeological samples are compared. Single collections were made from Goolwa 2, which is 9.6 km from the mouth, on February 2, 1975, and at Salt Creek 96 km from the mouth to the southeast on February 9, 1975. Collection in each place was confined to a small area no more than 16 square metres in the mid-littoral, although the beach was examined more widely to study the distribution of the population. The aim of the sampling was to retrieve the largest animals consistent with the archaeological populations, which were significantly larger than the modern.

Each population exhibited unique morphological characteristics, such as growth rings, ridging and coloration, not common to the others. Shells of equal lengths were not of equal weights, for example, and the flesh weight/shell length ratios were different from one population to the next, with those at Salt Creek being smallest. This distinction has also been described for scallops in different although adjacent settings

(Fairbridge,1953). Severe disturbance patterns were vaguely similar across the three collections, and the Goolwa 2 population contained a distinctive "blue" growth increment not present in the other samples. As would be expected because of their proximity, the two Goolwa populations were more alike than was either to Salt Creek.

The growth record of a single shell may be used to comment on a population involving several thousand shells if that record reflects the stress signatures seen in the majority of shells in the community. To test this hypothesis, 100 valves within the size range of 50-55 mm from the Goolwa 2 population were sorted according to shared stress signatures. Over 90% of these fell into one of two groups on the basis of distinctive growth patterns, suggesting two successive age classes. A third, smaller group of shells exhibited one or more patterns which could not be simply characterized. A Student's t test showed that the mean lengths of each of the larger groups were significantly different at the .001 level of confidence, providing acceptable evidence that stress signatures can be successfully used to identify age mates in a contemporaneous modern population. It follows then that small numbers of shells may be used to comment on the growth record of the majority and that this relationship will hold for prehistoric molluscs which have lived in a similar environment.

b) Archaeological Deposits

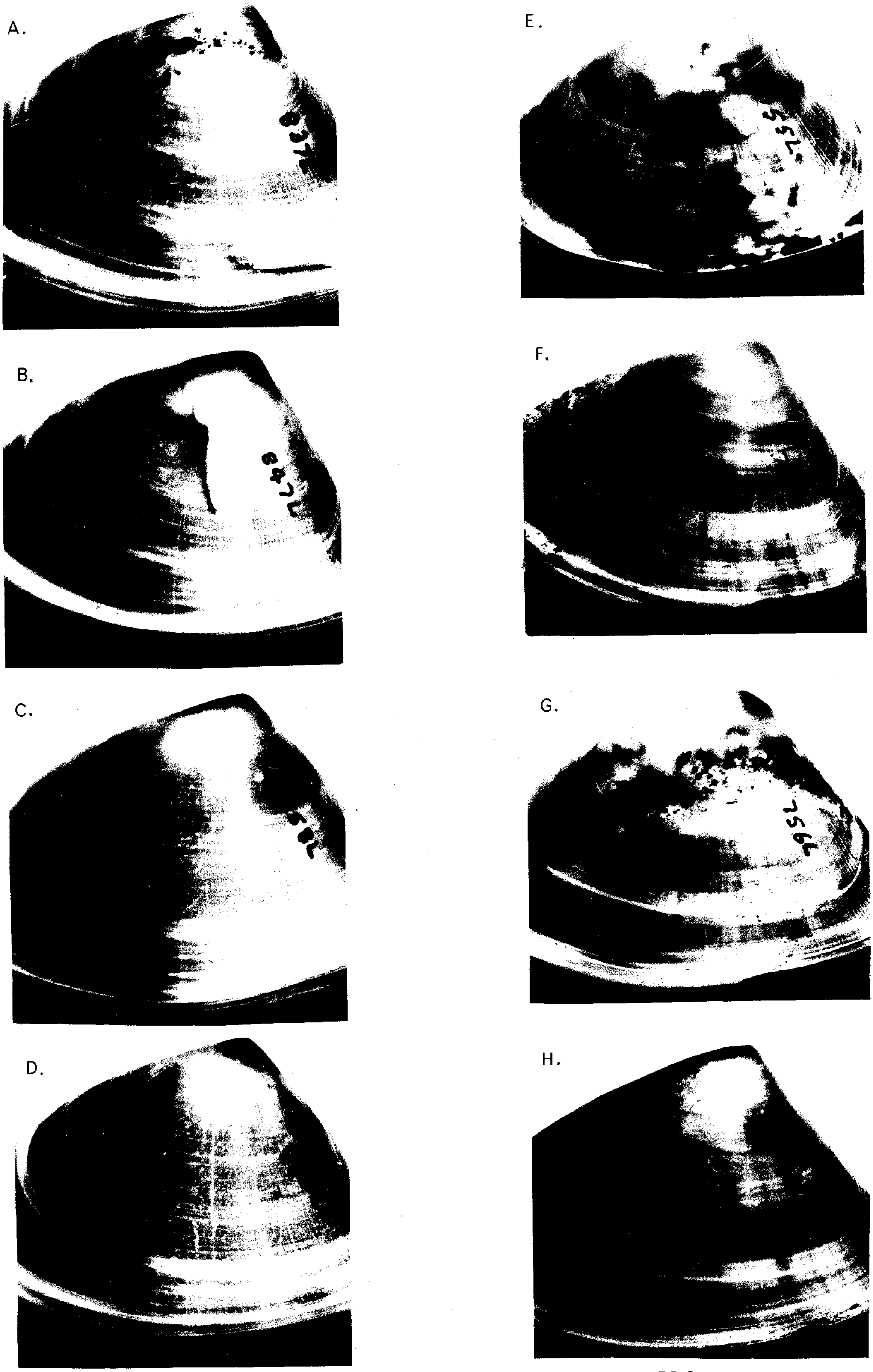
The archaeological samples were collected from discrete heaps located at Mounce and Battye Rock and at Canunda Rock. The Mounce and Battye midden, shown in Plate 5.4b, is one of two heaps of similar size and preservation, located about 3 m apart. At Canunda Rock, Site 2 (labelled FS2) is a solitary deposit and is the largest of its kind in the district. Sites 55 and 52 (Figure 5.6) are members of a group of 7 heaps in which shared growth line patterns in hand specimens suggested contemporaneous occupation. Sites 40, 45, and 39 (Figure 5.5) belong to a group of over 6 affiliated heaps, including some others which are probably unrelated. Whole shells from within each heap were collected after loose, surface shell had been removed.

A routine field sampling procedure was used to examine the extent of shared patterning in shells occurring within deposits. Whole shells were collected from separate areas of each heap, and displayed together on the ground for easy comparison. Shells from adjoining heaps were examined in a similar manner. The number of valves selected depended upon the size of the midden and the availability of whole valves, but the range varied from 10 to several hundred per heap. By far the largest proportion of shells examined in each case again fell into one of two groups on the basis of distinctive growth patterns. As with their modern counterparts at Goolwa Beach, a third group of about 10-20% could be identified on the basis of stress signatures, suggesting that at least one other age class was present as well. In hand specimens, these relationships can only be impressionistic and therefore the shells inspected at each midden were collected for further analysis.

In the laboratory, shells collected from each deposit were illuminated from behind with a strong light to emphasize stress signatures, and were photographed (Plate 7.1). Although fine growth increments can not be seen at this scale, very close similarities in signatures were apparent enough to suggest contemporaneity of collection. In the four valves from FS55 shown in Plate 7.1a-d, for example, perfect matches exist between the disturbance lines, although individual differences in translucency do occur. The only exception to this pattern is seen in shells from FS2, which exhibited two or more patterns of stress in animals of similar size. When cast against the size (length) frequency distribution of shells from discrete shell heaps, as is shown in Figure 8.2, the results of the field sampling programme provide strong evidence of collection of successive age classes in many of the middens sampled. Since stress signatures were shared in these classes, it is reasonable to conclude that a small number of animals from one age class may be used to comment on the majority in a prehistoric situation.

PLATE 7.1 Growth rings in *Plebidonax* from two shell heaps at Canunda Rock. Shells A-D are from heap FS55 and share identical stress signatures. Two stress signatures are shown in shells E-H from heap FS2 (E,F verses G,H).

PLATE 7.1



FS 55 0 50 mm FS 2

a) Shell Treatment

<u>Plebidonax</u> shell structure is comprised of three layers, and the clearest record of growth is contained in the exterior or Prismatic layer (Figure 7.1a), named after the prism-like arrangement of its crystals. To obtain a view of this internal structure, shells were embedded in resin and sections were cut along the radial, or growth axis, a-a' (Plate 7.1b) and polished to a thickness of 60-80 microns with 600 and finer mesh compounds. A 35 mm camera mounted on a Leitz biological microscope fitted for transmitted light illumination was used to photograph the prismatic layer of each section, and the resulting mosaic formed the basis of the analysis presented in these following plates. A Vickers Image Splitting Module calibrated with a micrometer stage provided accurate measurements from which the accompanying scale was made.

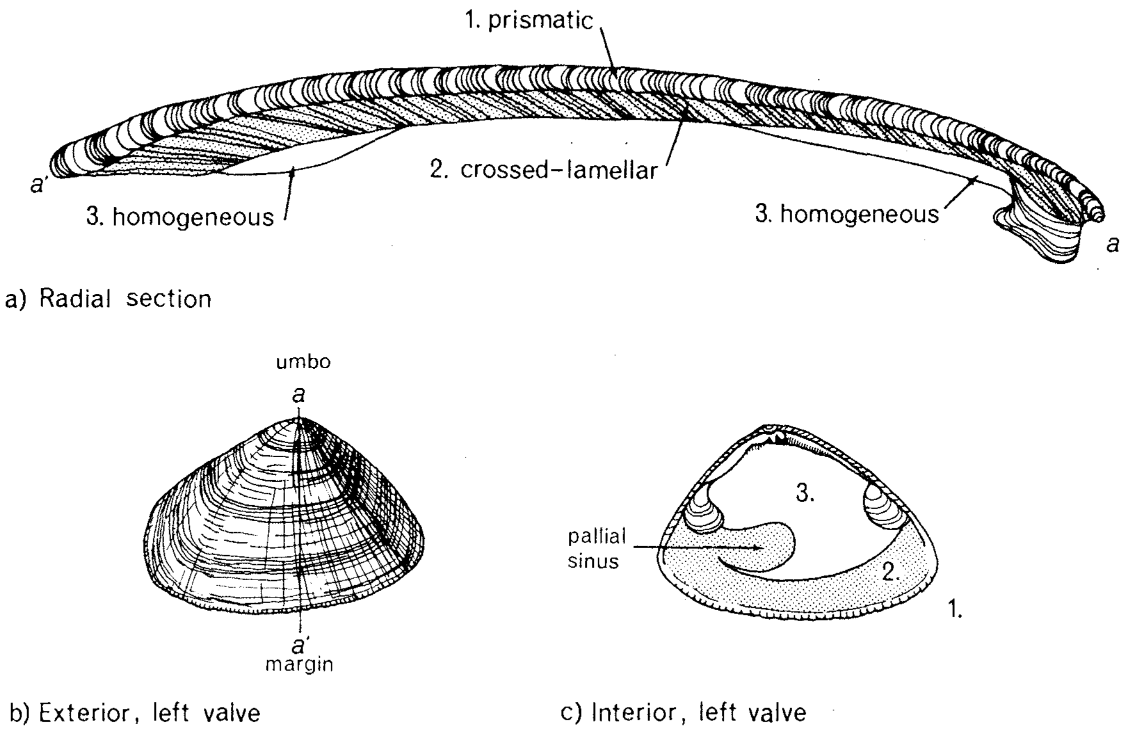


FIGURE 7.1 <u>Plebidonax</u> shell structure.

Most modern and many archaeological shells contain deep, opaque pigments which obscure growth patterns. To eliminate these, the shells were heated to 200°C for 15 minutes and slowly cooled to avoid thermal cracking. At the completion of this treatment each was a uniform white. Differences in translucency seen in Plate 7.1 are due either to variation in shell thickness and optical density, or to inclusion of organic material caused by moss growth on the surface.

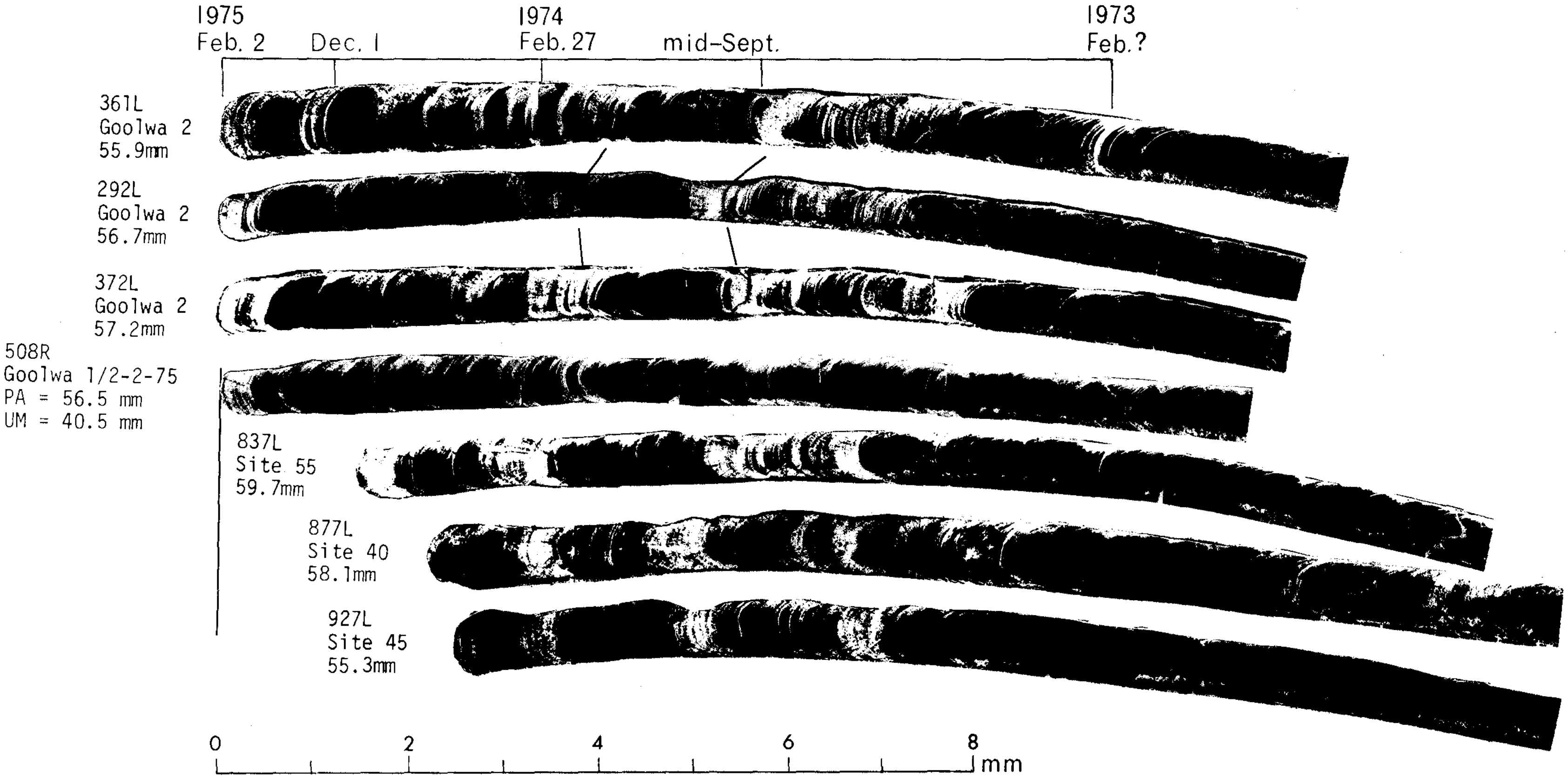
The posterior-to-anterior length (PA), radial axis length (UM), specimen number, and site number accompany each shell in the following plates. Where the axis of measurement is not identified, it is the greatest length, or PA, axis which is expressed in millimetres.

THE CALENDAR AND ITS SEASONAL IMPLICATIONS

Growth line studies are ideally suited to identifying the season of shellfish collection provided specific stress signatures can be directly related to particular periods of the year. The precise time of death is determined on the basis of a detailed documentation of daily growth increments occurring after the final stress signature. The level of confidence at which season of death can be determined then is a function of the regularity at which a particular seasonal marker is recorded from one year to the next. Unfortunately, preliminary examinations of <u>Plebidonax</u> growth rings under magnification revealed that fine growth increments could not be easily traced through periods of severe disturbance. Therefore, firm definition of elapsed time could not be achieved in this study. However, on the basis of close resemblances in disturbance patterns between the archaeological and the modern populations, it is reasonable to suggest that the signatures reflect the same seasonal phenomenon. For this reason, seasonality warrants further attention in this discussion.

The calendar has been constructed by Kathy Conover, of the Department of Prehistory (ANU), from sections of animals collected alive from Goolwa 1 over a period of 17 months between September 1973 and February 1975. Using age mates collected roughly 2 months apart, shared stress signatures were aligned. The amount of overlap occurring between shells represents the interval of time elapsed between the dates

PLATE 7.2



1975
Feb. 2
Dec. 1
1974
Feb. 27
mid-Sept.
1973
Feb.?
361L
Goolwa 2
55.9mm
292L
Goolwa 2
56.7mm
372L
Goolwa 2
57.2mm
508R
Goolwa 1/2-2-75
PA = 56.5 mm
UM = 40.5 mm
837L
Site 55
59.7mm
877L
Site 40
58.1mm
927L
Site 45
55.3mm
0
2
4
6
8
mm

of collection. Composed of specific collection dates, this calendar was transferred onto the Goolwa 2 population in which disturbance patterns were more comparable to those of the archaeological populations. Plate 7.2 shows this calendar in respect to shells from Goolwa 2 (361 292, 372) and Goolwa 1 (508), all four animals collected the same day and revealing similar sequences of disturbances. Wherever ambiguities arose in the transfer of specific collection dates from one shell to another in the master calendar, these were deleted in Plate 7.2. Common to both modern populations however, are broad winter and short mid-summer disturbance lines seen as striking translucent bands separated by opaque growth increments. While these "seasonal" signatures are broadly comparable, the alignment of individual shells in the master calendar was achieved without the aid of fine growth lines. Hence the seasonal assignment of a stress signature is approximate.

Winter disturbance is characterized by increased translucency and compaction of increments. The onset of winter is characteristically marked in the shell by increased daily stresses immediately preceding a severe early winter stress interval. The final winter episode is marked in much the same way with a dramatic disturbance associated with deep ridging to the prismatic layer. At Goolwa 2, this stress ended in mid-September. Summer disturbance is recorded in the form of intermittent translucent lines accompanied by moderate ridging. The most severe stress in either season results in interference of normal shell deposition and causes a pronounced wavy or distorted line shape, typical of severe winter stresses in particular.

As expected, annual growth increments decline with age, and the seasonal disturbance lines are more compacted and prolonged. If the first translucent bands to the right in the photograph indicate a February 1973 disturbance, radial growth for the animal during 1973 was approximately 5.6mm, while growth for the following year dropped to about 3.1mm. As a consequence of increased sensitivity to disturbance due to aging, and possibly of a different complex of stimuli during 1974, the two years of growth do not closely resemble one another. Therefore, until age mates collected from the same locality on successive years can be compared, the seasonal regularity of a particular stress signature has not been verified.

The growth pattern recorded in shell 508 at Goolwa 1, contains the sequence of disturbance lines experienced by both communities of molluscs, but expresses it in a distinctive way enabling the two populations to be distinguished. Disturbance of daily growth is more regular and less attenuated than in the neighbouring population, and ridging is not pronounced. These differences, observed in hand specimens and confirmed in section, establish the distinctive character of shellfish communities according to locality. Under magnification however, shared patterns dominate the shells from both localities.

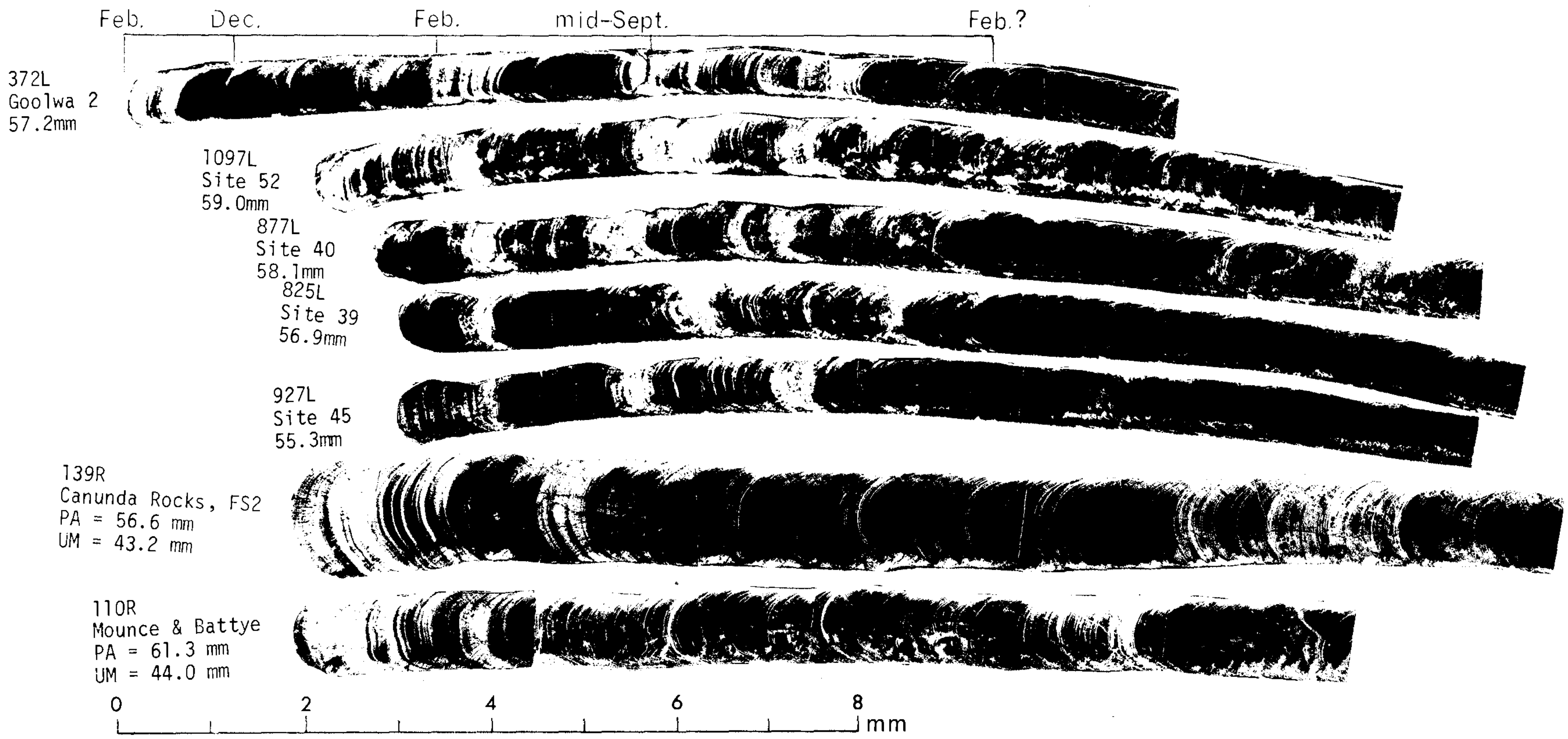
The record of disturbance in Salt Creek shells is as striking and accentuated as that from the Goolwa 2 population, and appears to share the broadly seasonal sequence seen at both other localities. The growth rate is clearly slower however, and the three specimens sectioned appear to belong to a younger age class than those chosen for the study. Further, the individuals appear to have had periods of stunted growth causing severe distortion of the shell matrix. Since these are not reliable indicators of the population's normal growth process, they are not included in this discussion.

It has been shown in this discussion that the calendar of annual growth patterns constructed from the Goolwa populations contain stress signatures which relate to broadly delineated seasonal growth patterns. That these are reflected in prehistoric populations is merely suggestive of the potential of the modern calendar to identify prehistoric shellfish collection schedules, but the fact that 4000 year old shells from the same deposit resemble one another still more closely has strong implications to this study. It is apparent from individual differences in the magnitude and duration of these signatures however, that modern Plebidonax communities respond to their environment in a complex manner. This may reflect the coincidence of biological and environmental stresses under slightly different conditions than those of the past, and only a detailed study to describe the causes and periodicity of specific signatures can resolve these ambiguities. Therefore, while any seasonal interpretation presented here must be speculative for the reasons given above, the potential of the evidence is considered strong enough to deserve further consideration in respect to the prehistoric shells.

SEASONALITY

In order to achieve comparability among shells collected from different heaps, prominent stress signatures in the sections have been aligned (Plate 7.3) with those in the calendar. Although, in the

PLATE 7.3


Feb.
Dec.
Feb.
mid-Sept.
Feb.?
372L
Goolwa 2
57.2mm
1097L
Site 52
59.0mm
877L
Site 40
58.1mm
825L
Site 39
56.9mm
927L
Site 45
55.3mm
139R
Canunda Rocks, FS2
PA = 56.6 mm
UM = 43.2 mm
110R
Mounce & Battye
PA = 61.3 mm
UM = 44.0 mm
0
2
4
6
8
mm

photograph alignment is with the final mid-summer disturbance, close matches in signatures occur over a considerable period of previous growth, including the terminal winter disturbance of the preceding year. This evidence suggests that the frequency at which stresses are being recorded is consistent between the modern and prehistoric populations, and that growth rates are generally equal for the specimens illustrated. It can be seen that the time of death clearly occurs well after this final summertime stress and in fact, despite slight individual variations in growth rates, collection takes place close to either the onset of a winter stress, as is the case in shells from sites 40 and 45, or sometime during winter itself, as is the case with shells from sites 55, 52, and 39. It is not possible to confidently determine the precise time of collection in winter with this evidence because the growth lines are too compacted for this age group and because the seasonal regularity of the stress signature has not been verified. Thus the season of death for these animals is estimated to have occurred sometime during winter, as opposed to summer, and this normally spans the six months of April to October.

Although the calendar applied to the stress signatures does not apply to animals whose growth patterns do not compare favourably with it, it is worth while considering shells from Site 2 and Mounce and Battye Rock, pictured in Plate 7.3. In each case, death has taken place during a major disturbance which appears to conform to the winter stress, although the overall growth pattern is clearly different from that defined by the modern population. The discrepancy may be explained by differences in age, growth rates, or environmental stimuli. Since shells from both ancient sites are significantly thicker and contain larger growth increments than the reference population, the archaeological shellfish were most likely growing faster and are therefore younger than comparable sized animals at Goolwa Beach. When compared to sections of younger modern individuals, these 3800 year old animals in fact approximate the pattern expected of younger, more vigorous animals whose recovery from stress is rapid. This evidence would then suggest that growing conditions for <u>Plebidonax</u> were better at Canunda Rock in antiquity than they are today at Goolwa Beach.

a) Paleoecology

The close match between stress signatures of prehistoric and modern shells suggests that the intertidal environments were the same for the two respective populations. In the Lower South East where no river outlets for surface drainage occur, it is difficult to explain the mid-summer stress in terms of peak flooding. There can be little doubt however, that runoff constitutes an important feature in the cockle's ecology and would have been so in the past.

That there was a strong summer discharge of freshwaters can be argued from the available meterological and hydrological data for the region. Today large quantities of ground water flow into the sea from the swamps via cavernous underground conduits, despite the fact that drains currently prevent large seasonal accumulations. Since the swamps continue to receive groundwater in late winter and in the spring, and in addition capture local winter rainfall, it is conceivable that prior to drainage, a back up of water lasted well into the summer. Peak discharges would, under these circumstances, occur as late spring waters entered the swamps from underground flow derived from the Victorian catchment. In light of the widespread and persistent flooding documented in pre-drainage accounts of the area, it follows that the swamps were full in summer and hence were permanent features of the landscape about 4000 years ago.

MIDDEN HEAPS AS SINGLE MEALS

Do individual heaps of shellfish represent single collection events? Heaps are meals if it can be shown that shells within the heap 1) were bedmates, and 2) died the same day. Shells from three different deposits are presented in Plate 7.4 with margins aligned.

The most compelling evidence of contemporaneous death among molluscs is seen in shells 110 and 113 from Mounce and Battye Rock. In the pair, disturbance lines related to two different periodicities match perfectly. The most pronounced match occurs between two 0.3mm wide translucent bands, 2 and 1 mm from the margin, with the final disturbance containing the distinctive wavy winter growth lines typical of winter stress observed in the Goolwa populations. A greater degree of translucency appears in shell 110 during these disturbances than in shell 113, which suggests a more sensitive personal response to environmental stimuli for this period in its life. A second set of more discrete signatures occurs 4 and 6 mm from the margin consisting of two striking lines which complete a cycle of growth suggestive of a fortnightly tidal cycle. If this is correct, the decreasing growth increments probably relate to increased exposure of the animal and reduced feeding time. What makes this disturbance so unique is that in

PLATE 7.4

110R
Mounce & Battye
PA = 61.3 mm
UM = 44.0 mm
113R
Mounce & Battye
PA = 59.9 mm
UM = 46.1 mm
138L
Canunda Rocks, FS2
PA = 56.7 mm
UM = 41.5 mm
139R
Canunda Rocks, FS2
PA = 56.6 mm
UM = 43.2 mm
926L
Site 45
56.7mm
927L
Site 45
55.3mm
922L
Site 45
56.5mm
923L
Site 45
56.7mm
0
2
4
6
8
mm

an otherwise normal growth pattern, an additional stress is imposed on the shell at the height of exposure and the sequence is not repeated in a similar fashion elsewhere in the shell. The stress then must be regarded as a unique, momentary event sufficiently strong to affect many members of the community in the same way. Whatever the actual event might have been, the fact that both animals recorded it in precisely the same phase of the period at two separate times strongly argues for contemporaneity of those events.

The two shells appear to have suffered injury at the same time and have recorded it distinctively. Located 7 mm from the margin, it appears as a thin horizontal scar in the inner one third of the prismatic layer. Shell deposition is interrupted around it as the animal attempted to mend the damage. Because the growth increment is affected by the incident, the cause is probably a random stress such as an unusual turbulence of short duration.

For such close agreement to exist between such complicated patterns of growth, the shells must be faithful recorders of their environmental stimuli and have lived together as age mates throughout their lives. That the two animals died together is shown by alignment of their disturbance lines without overlap occurring at the margin. Because these shells share stress signatures with a major, dominant age class in the midden, by implication all shells died at the same time.

A similar although less complicated growth pattern is shared in shells 139 and 138 from Site 2 (labelled FS2) at Canunda Rock. Two types of disturbance lines match, each probably caused by different stimuli. The first is a broad translucent band 3 mm from the margin which is bounded by normal growth increments on both sides. The second disturbance band consists of three episodes beginning with punctuated stress sequences between 2 and 1 mm from the margin. The pattern persists to 0.5 mm from the margin, where more normal shell deposition resumes prior to death. A single sharp line appears 0.2 mm from the margin in both shells and a precise match in growth zones continues up to the time of death. Shells bearing these signatures are seen to have been collected and eaten the same day.

Age mates with slightly different growth patterns have been recognized in Site 2 (Plate 7.1 e-h), and their presence suggests that either different shellfish populations were exploited, or that the meals were consumed at different times. Because the shells examined in this study represent only one of the patterns of disturbance, a precise determination of contemporaneity for all shellfish in the heap is not possible without comparison of shells exhibiting the other stress signatures. However, the differences observed in hand specimens are sufficiently large to suggest that at least two remote beaches were being exploited. This difference, when considered in light of internal stratification within the hearth of Site 2, argues for multiple use of the camp. The very large size of this midden, its internal strata, and the inconsistencies in shell growth rings distinguishes it from all others examined in this study.

The sections of four shells from Site 45 at Canunda Rock show two different signatures in which winter and mid-summer disturbance bands match. The amount of shell growth after the final summer disturbance indicates that collection took place at the same time of the year for each shellfish and alignment of discrete disturbance lines within the opaque segment following winter suggests further that the shells were contemporaries.

These similarities appear to be overshadowed however, by very different winter disturbance patterns. In shells 926 and 927, the winter signature is comprised of very definite initial and final disturbances associated with ridging and wide translucent shell increments. In this and subsequent growth, minor and major lines align closely as would be expected of animals in the same population. A slightly greater translucency in 926 than in 927 may indicate a personal sensitivity to stress not shared by its age mate. If similar signatures exist in shells 923 and 922 however, they are obscured by more dominant stress episodes which themselves are are not shared in the four shells. Here then, the variation in stress signatures would appear to exceed the limits expected for animals living in the same population either in time or in space. The winter disturbances are so different as to suggest that collection did not occur within the same year.

The possibility that the campsite was visited in two different years is remote since the arrangement of refuse around the hearth and the absence of evidence of reuse of the hearth are not consistent with reuse after such a long abandonment of the camp.

Prehistoric mixture of shell from another midden can not be dismissed because several heaps in the group are within 2-3 m, but inadvertent mixture is unlikely to provide sufficient numbers of shells to confuse the picture. The best explanation for these two signatures is that different populations of shellfish were exploited and consumed at the camp. Therefore, because the signatures do not appear to share definite disturbances by which to estimate elapsed time between deaths, it is not possible to say whether or not all shells were collected at precisely the same time. This ambiguity finds some resolution in a comparison of these shells with those of a neighbouring heap discussed below.

The majority of the evidence refutes the proposition that individual heaps are the refuse of repeated use of the campsite. In addition to the two sites discussed above, a comparison of shell sections from Sites 55, 52, 39, and 40 reveals that the animals within those heaps were contemporaries at the time of death. Out of the eight deposits examined, only Sites 45 and 2 could not be considered owing to ambiguities in agreement between signatures. Of these, Site 2 was recognized to contain shells with two or more different stress patterns, which when considered in light of other evidence, provides the only case of multiple or prolonged use of the same hearth. Therefore the campsites during the Early Occupation phase were visited for the duration of a single meal. It will now be necessary to consider the possibility of the contemporaneity of campsite visitation of heaps grouped together.

CONTEMPORANEITY OF CAMPSITE VISITS

Do different heaps found within a group of middens belong to the same camping event or are they related to successive visitations? The level of precision with which this question can be answered depends upon the comparability or match between signatures. If the same signature appears in shells from two heaps, the shellfish were collected at the same time from the same beach. Simultaneous collections from different beaches, or different collections from the same beach will be more difficult to use in establishing contemporaneity of death.

On Plate 7.5, three shells from Site 45 are compared with three from Site 40, with mid-summer disturbance lines aligned in each. Each collection clearly occurred within the same season, but did death take place on the same day of the year? Shell 877 from Site 40 shares stress signatures with shells 926 and 927 of Site 45 throughout the previous winter and into summer. The two heaps therefore contain contemporaries from the same population, and these were growing at the same rates. Any uniform differences in shell accumulation following the mid-summer stress can not be explained by individual growth responses either in terms of the individual animal or the population. The amount of shell accumulation occurring after the mid-summer disturbance is seen to be consistently shorter for heap 45 than for those in heap 40 and since growth rates appear equal throughout the season, the difference in growth is taken as demonstration that death occurred on different days.

Death for shells in Sites 55 and 52 (Plate 7.6) occurred close together within the same season, with the greater accumulation in shell appearing in shells from heap 55. Furthermore, unlike shells previously mentioned death has taken place for each set during a major stress event associated with winter disturbance, and shells from Site 55 have recorded more of this stress than shells from 52. Since this disturbance is likely to be one the whole population is sensitive to, as with the mid-summer stress or the end-of-winter stress, it is likely that all four shells have recorded the same event at the same time. Therefore, Site 55 was constructed after Site 52 by a short period of time.

Of the 8 valves sectioned from these two deposits, those from 52 are consistently thicker and exhibit a more punctuated signature than those from heap 55. This difference is of the same magnitude existing between distant communities sampled at Goolwa Beach in 1975, leading to the conclusion that shellfishing in this instance not only took place on successive days, but on separate beaches as well. Of course, how distant it is not possible to say.

PLATE 7.5

922L
Site 45
56.5mm

927L
Site 45
55.3mm

926L
Site 45
56.7mm

877L
Site 40
58.1mm

874L
Site 40
60.0mm

876L
Site 40
56.7mm

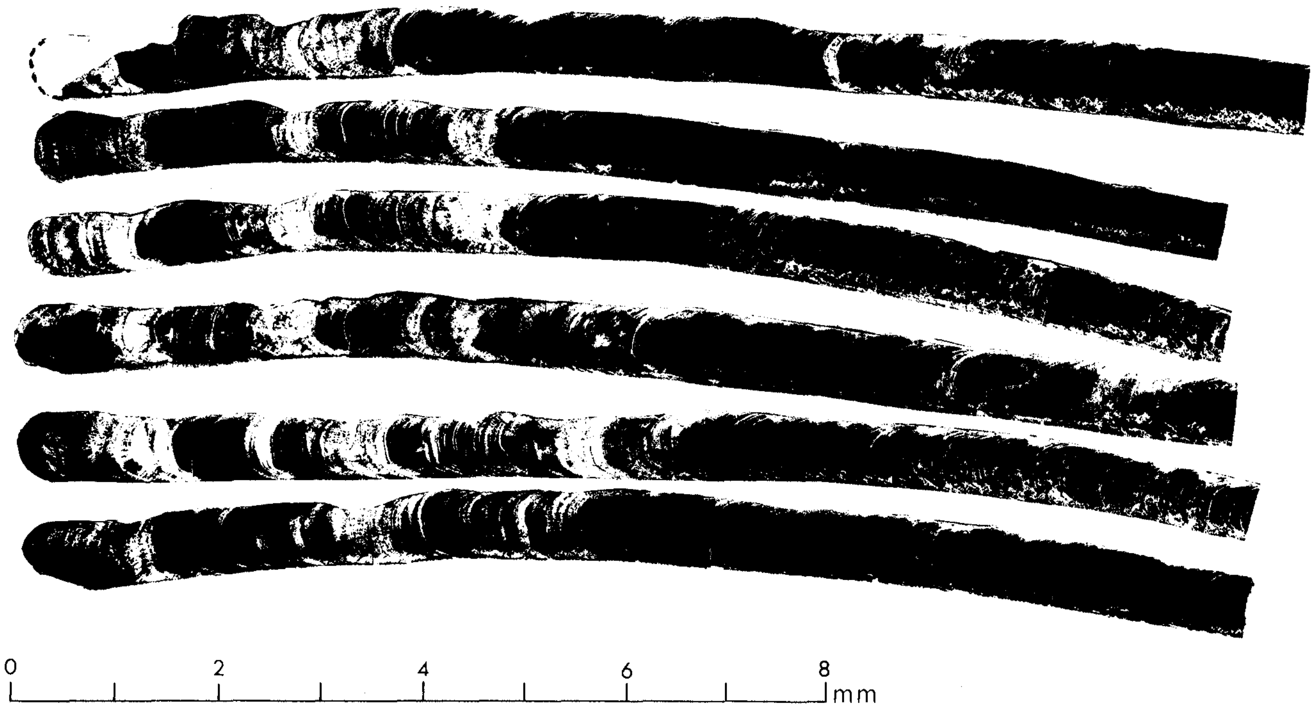
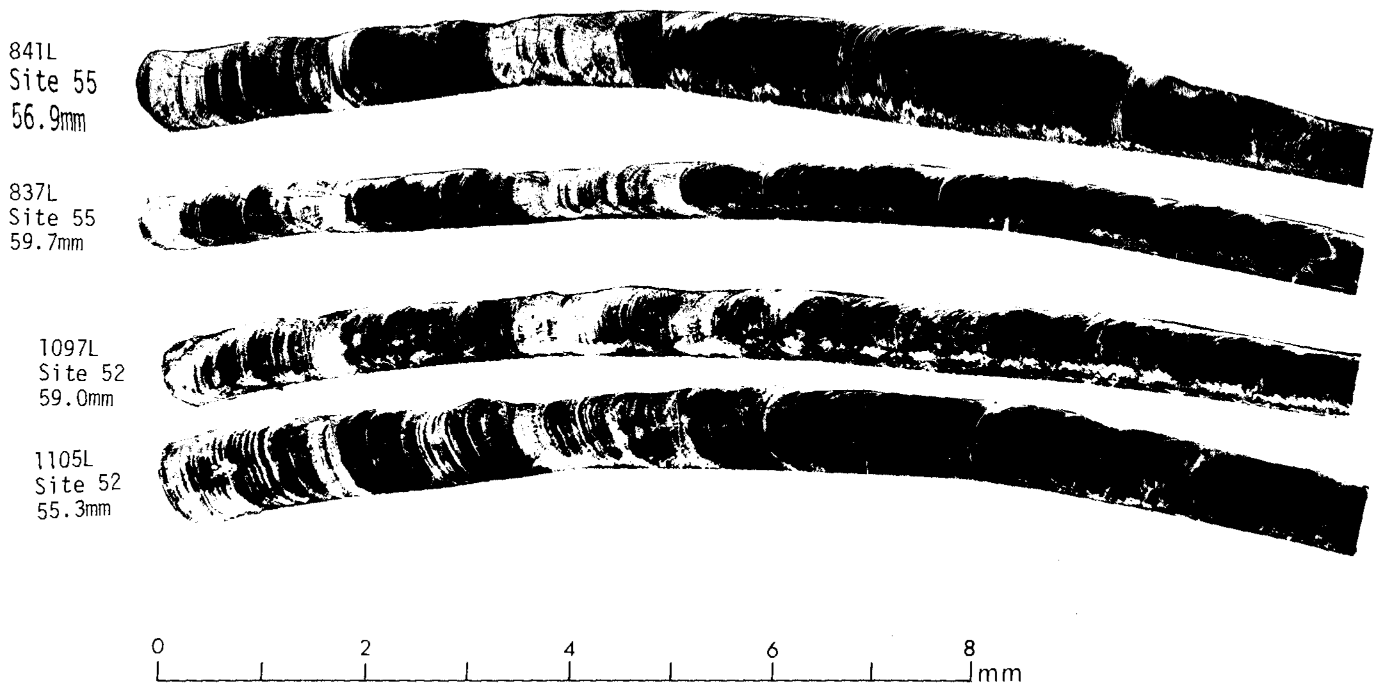


PLATE 7.6


841L
Site 55
56.9mm
837L
Site 55
59.7mm
1097L
Site 52
59.0mm
1105L
Site 52
55.3mm
0
2
4
6
8
mm

The evidence from two unrelated groups of midden heaps indicates that the meals were consumed as a result of successive visits to the site rather than at once. Up to nine individual heaps have been counted at any one complex and probably at least that many days were involved before the camp was finally abandoned. Judging from the large amount of shell growth between shells in different meals, visitation conceivably could have exceeded this time span by as much as an additional week, although admittedly such precision is uncertain. Some heaps quite clearly do not relate to the majority of heaps in the group however. In a group of ten heaps, including Sites 39 - 48 at Canunda Rock for example, the stress signatures and shell morphology of shells from Site 43, as viewed in section, contrast with shells sectioned from the other heaps in the group. Specifically, death for shells from Site 40, 45, and 39 occurred prior to a winter stress, whereas those from Site 43 definitely record a wide and pronounced winter disturbance at the time of death. The differences in this and other ways are so great as to suggest that collection did not occur close in time nor did it involve the same population of shellfish. Similar disagreements have been observed in hand specimens taken from groups during field inspections. Therefore, while the main use of the camp may have taken place over a short period of time, recurrent use may also have taken place. Who then were these groups and why would they return to such undistinguished locations in these sandhills?

DISCUSSION

This study of contemporaneity has demonstrated that individual heaps are the products of single camping events in which the shellfish were prepared and eaten. It has further been shown that the shellfishers returned to the camp several times, each time building a new fire to cook their food, and that these visitations were brief episodes during the cooler months of the year, if indeed not during winter itself.

As they reflect upon the character of the occupation, the tool kits present at these campsites suggest a recurrent interest in small scale maintenance activities against a background of brief household operations. The most common elements to occur per deposit are small woodworking tools and tools probably associated with the repair of spearing,or other hunting equipment, and other wooden implements, as are suggested by backed blades, geometric microliths, and awls. Where other implements do appear, such as aeolianite slabs, pounding stones, and larger chopper-like tools, their numbers are low and affiliation appears to be between groups of middens rather than with single meals within the group. The tools used to perform these household activities were perhaps shared between visits, whereas the maintenance activities related to hunting equipment in many instances involved the manufacture of implements each time camping commenced.

Use of a landscape by hunter-gatherers under optimal conditions may be influenced by any number of factors. Under seasonally harsh circumstances however, the place people live may be directed by pragmatic considerations of available fuel, material for erecting protective structures, and proximity to a protected setting. In the sandhills, the options for confortable life are restricted not only by the availability of firewood, but also by the difficulty in just keeping a fire lit and the body warm. Even the siting of camps during the Early Occupation phase near the coast in low grounds behind the foredune seems to suggest an attempt to acquire cover and protection against the elements. Under these conditions the huts or windbreak which might have been erected for protection would reasonably attract groups looking for a place to camp and eat their meal in reasonable comfort. If these structures remained standing (see Plate 3.2 for an example) even for a few months, the practicality of using an existing one for each visit may have dissuaded people from looking for new materials for another hut. Repeated use of the camping area during these cool wet times is best explained then as a practical attempt to conserve scarce resources and to stay warm.

Given the organization of these small groups of shellfish gatherers on the ground, it is now possible to estimate their sizes on the basis of the food remains in each meal. Given similar estimates for the Late Occupation phase, the size of the groups involved in these camps can be compared for evidence of changes. In addition, since we are dealing with a single event--namely the meal--which is likely to reflect the frequency of visitation, changes in the consumption rates of shellfish may be described by comparing the number of meals between each period of occupation. The following chapter sets out the information necessary to perform this operation and considers food collection practices as they relate to the general question of economic growth.

CHAPTER EIGHT

ECONOMIC ANALYSIS AND GROWTH OF THE MARINE ECONOMY

INTRODUCTION

The evidence for coastal adaptation that I have presented in this thesis indicates that a substantial change in the character of the coastal economy occurred between the Early and Late Phases of occupation. The major differences revolve around increased sedentism and the influence that prolonged occupation near the sea had upon the complexity of economic organization. The shift from mainly winter residency, for example, to one spanning both summer and winter months is probably correlated with the emergence of a new spectrum of sites such as ovens, woodworking centres, and other special focus activity areas. Typical of these, the clifftop shellmiddens and the Inland Camps reflect recurrent occupation which would be expected to occur as exploitation intensified. In addition, the initial stages of shellfish collection correlates with a revolutionary technological development in which the extractive capacity of the tool kit appears to be undergoing improvement, only to lose some of its prime elements - microliths - in the Late Phase. The correspondence between increased sedentism and technological elaboration suggests that systematic changes have occurred in population structure which must be examined as a possible explanation for coastal adaptation.

The task of demonstrating that prehistoric populations have increased is made difficult by the fact that several different processes influence occupation intensity, but which do not necessarily involve increases in population size. Was it the case, for instance, of a shellfish gathering group simply increasing the duration of its hunting and gathering activities at the coast, or was there in fact an actual increase in resident population, or both? We already know from the time of death studies of molluscs that people were spending more time at the coast during the Late Phase, but whether or not this involved larger groups can be determined only by establishing the size of the basic shellfish gathering party and relating it to the resident population. Once this information is known, an analysis of the change in hearthside group size and economic organization between occupation phases reveals the fundamental nature of the coastal adaptation.

The following discussion will therefore first consider the size of the group dining at individual meals by assuming that the contents of a meal reflects the size of the hearthside group. By calculating the food value represented by the seafood remains and dividing that figure by the standard daily caloric requirements for an adult, the number of people supported by that meal for one day can be estimated. Because membership of special focus exploitation groups may change at the hearthside, the composition of the hearthgroup must be considered in each occupation phase before a comparison of group size can be made between phases.

With new inshore marine habitats being formed by geomorphic processes, the marine diet is expected to be shaped by the relative availability of these resources and the ease with which they can be procured. Although the seafood menus reflect these environmental processes, the emergence of an intensive settlement pattern in the Late Phase of occupation occurs long after high biological productivity had been established in littoral communities. This evidence is consistent with drastic increases in seasonal occupancy and indicates that as a result, procurement techniques were dramatically modified in order to effectively extract resources from the littoral. The extent to which this was accomplished without seriously depleting stocks reveals the nature of the exploitation of the marine biosphere and the success of the coastal adaptation itself. Changes in food collection practices and the adaptive advantages of these will be assessed as they further illuminate the role of population restructuring in the coastal setting.

Lastly, the evidence for increased population can be sought from increases in the rate of seafood consumption. With the size of the hearthside group and its organization established from analysis, changes in the number of meals consumed will be expected to correlate with occupation intensity. Changes in the character of population density, the degree of sedentism, and economic complexity of the subsistence pattern between occupation phases will provide a basis for describing the fundamental aspects of the adaptation to the coastal margin. Possible explanations for this development can then be made on the basis of an examination of the non-coastal components of the subsistence economy and its development.

SIZE OF THE HEARTHSIDE GROUP

As a working hypothesis, the contents of the meal can be regarded as meeting the daily energy requirements of the fireside group. The energy provided by the meal can be determined by calculating the flesh weight of the seafood remains and converting these into caloric values. Because shells often survive undamaged in the archaeological record, their length can be compared with those of a modern population for which flesh weight/shell length ratios are known in order to estimate the total weight of meat in the meal. In the case of archaeological remains of the lobster, Jasus sp., the mandible is the only anatomical element to consistently survive and its length therefore becomes an index for body weight. Several qualifications and reservations must be observed in performing population estimates on the basis of caloric conversion however, and those require detailed comment.

The accuracy of energy estimates depends to a large extent on the preservation of the whole diet when not all food stuffs will necessarily survive burial. Plant foods common amongst the sandhills in the summer and autumn such as berries and fruits will leave meagre archaeological traces, and such seafoods as cartilagenous fish, stingray, octopus, and fish eggs are likely to be equally invisible shortly after abandonment of the camp. However, organic tissue such as periostracum on shells and crustacean carapace are preserved in foreshore middens as well as in the Nora Creina shelter, suggesting that conditions conducive to preservation of bone existed there, and yet bone is not present, or exists only in small amounts. It is therefore reasonable to conclude that shellmiddens in the Lower South East represent the refuse of predominately littoral exploitation and that systematic differences in their size reflect real changes in the number of people dining on seafoods around the hearth.

It must be noted in passing however, that not all refuse preserved represents food actually eaten. Heavily charred Plebidonax and mussel shells in several middens at Canunda Rock were recovered still hinged in both the hearth and the shell scatter. Considering that the rugged cardinal teeth of the cockle do not permit the valves to remesh easily after having been opened, the high incidence of hinged valves (estimated 6 per cent) in some middens indicates that a portion of the catch was prepared but not consumed. Although this practice may have been widespread, consistent evidence of this fact could not be recovered from enough deposits to permit routine corrections to be made in flesh weights.

Flesh weight also changes throughout the year in response to seasonal variation in the environment. Ambrose (1967) has cited the case of wasted conditions in cockle populations at the end of winter when the body weight had decreased as much as 50 per cent of the summer peak. Differences in local habitats may also be expected to produce significant differences in body weight. Observations based on measurement of two separate Plebidonax communities sampled on the Coorong, for example, have shown that the mean body weight of animals in the largest size class of the two populations vary by two grams, or by about 30 per cent. A closer inspection of the two habitats revealed that the variation is explained by very subtle differences in substrate conditions and food supply which nevertheless have a marked influence on the growth behaviour of the entire community. This makes the task of choosing strictly comparable communities a demanding one.

The comparability of the modern and archaeological biological communities can be evaluated in terms of time of collection and habitat. Live Plebidonax were collected from three localities on the Coorong beach, lightly steamed, and the flesh weighed on a triple beam balance after excess water was removed by blotting. Only the largest animals were deliberately collected and measured so that the sizes would coincide with the archaeological populations. Because the prehistoric cockles were consumed in late autumn and body conditions can be expected to have deteriorated by this time of the year, these probably weighed 10 per cent less than the modern samples which were collected in February. Flesh weights of the Coorong population have therefore been reduced by this value to facilitate comparability. Live weights of Brachidontes were taken from a single colony in the intertidal zone at Cape Conran, Victoria, in the month of November, within the same biogeographical province as their prehistoric counterparts. Although it is assumed that mussels were collected in late autumn in the past, and therefore they may have contained higher flesh weight values than the modern population, the seasonal variation in condition is unknown and no correction can be applied. Otherwise the techniques for measuring flesh weights of mussel are the same as that for the cockle. Table 8.1 presents the flesh weights for the cockle according to 5 mm size classes.

1mm INTERVAL	Wt. (gr.) GOOLWA 1 $\bar{X}$ (N)	Wt. (gr.) GOOLWA 2 $\bar{X}$ (N)	Mean weight in 5 mm size classes, GOOLWA 2
60.0-64.9			$\bar{X}$ = 9.49 ± .76* gr.
59.0-59.9	-	8.50*(0)	
58.0-58.9	-	8.31 (2)	
57.0-57.9	7.61 (3)	7.67 (8)	$\bar{X}$ = 7.70 ± .67 gr.
56.0-56.9	7.12 (5)	7.43 (14)	
55.0-55.9	6.79 (4)	6.82 (22)	
54.0-54.9	6.68 (7)	6.51 (21)	
53.0-53.9	6.29 (12)	6.18 (18)	
52.0-52.9	5.94 (14)	5.83 (15)	$\bar{X}$ = 5.91 ± .46 gr.
51.0-51.9	5.44 (14)	5.79 (7)	
50.0-50.9	5.17 (11)	5.28 (8)	
49.0-49.9	4.82 (8)	4.60 (6)	
48.0-48.9	4.48 (6)	4.56 (4)	
47.0-47.9	4.30 (1)	4.30 (3)	$\bar{X}$ = 4.31 ± .25 gr.
46.0-46.9	3.97 (4)	4.20 (6)	
45.0-45.9	3.77 (4)	3.97 (6)	
44.0-44.9	3.43 (5)	3.75 (2)	
43.0-43.9	3.41 (1)	3.48 (2)	
42.0-42.9	-	3.21 (3)	$\bar{X}$ = 3.24 ± .37 gr.
41.0-41.9	4.10 (1)	3.00*(0)	
40.0-40.9	-	2.80*(0)	
	N = 87	N = 147	* projected estimate

Table 8.1 Flesh weights of Plebidonax by size classes from two collection areas at Goolwa Beach in February, 1975.

The main gastropods Subninella, Dicathais, and Cellana were collected in February from the lower intertidal fringe area at Cameron Rock about 8 km southeast of Cape Buffon. As before, the animals were steamed to release the body from the shell and excess water was removed from each at the time of weighing. Length measurements of the shell were taken from the apex to the most distant point on the lip in the case of the snails, whereas the length of Cellana is the longest diameter. Figure 8.1 shows the axes of measurement for the principal molluscs used in this analysis. Table 8.2 presents the flesh weights for the gastropods and mussels sampled live in this study.

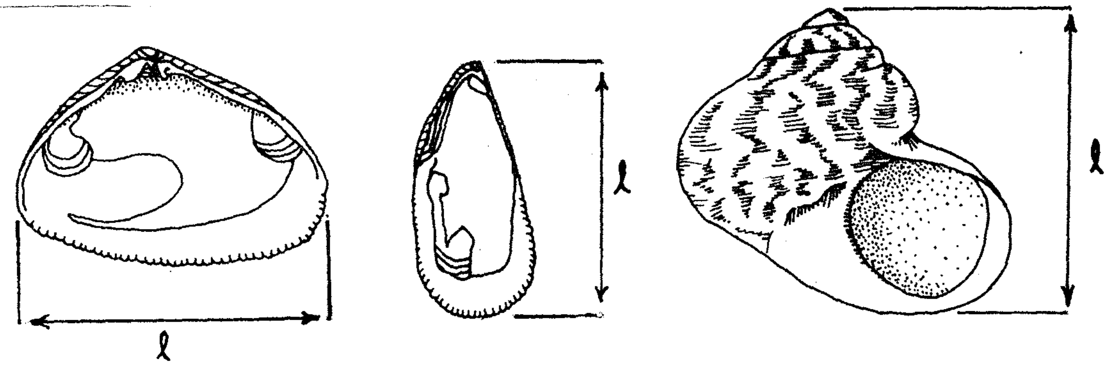


FIGURE 8.1 Axis of measurement for cockle, mussel, and snail shells used in economic analysis.

In the case of the spiny lobster, Jasus sp., the right mandibles of 18 steamed individuals from the southern New South Wales coast were measured with calipers and the entire animal weighed on an accurate electronic balance. The carapace, gills, gut, and mouth parts from two individuals were separated from the flesh and weighed as an inedible portion of the crustacean. This amount, averaging 40 per cent, was then substracted from the body weight to provide a flesh weight value for each animal measured. Seasonal flesh weight variation for lobster is unknown and therefore no correction for seasonal fluctuations were made. The flesh weight for lobsters is presented in Table 8.3.

5mm INTERVAL	Wt. (gr.) of Subninella (N)	Wt. (gr.) of Dicathais (N)	Wt. (gr.) of Cellana (N)	Wt. (gr.) of Brachidontes (N)
60.0-64.9	15.3 ± .28 (3)	12.2 ± 2.9 (4)	–	–
55.0-59.9	14.4 ± 1.7 (4)	10.0 ± .42 (2)	–	–
50.0-54.9	12.0 ± 1.0*(0)	7.3 ± 1.3 (11)	5.7 ± .97 (13)	–
45.0-49.9	10.0 ± 1.0*(0)	6.5 ± .49 (17)	3.5 ± 1.0 (5)	–
40.0-44.9	8.4 ± 1.0 (5)	4.4 ± .90 (2)	2.4 ± .61 (17)	1.00 ± .30*(0)
35.0-39.9	5.6 ± .65 (5)	–	1.9 ± 0.0 (2)	.82 ± .24 (8)
30.0-34.9	–	–	–	.70 ± .19 (16)
25.0-29.9	–	–	–	.45 ± .12 (4)
20.0-24.9	–	–	–	.18 ± .10 (4)

* projected estimate

Table 8.2 Flesh weights of common molluscs by size classes. Gastropods were collected from near Cape Buffon, South Australia, in February, 1975. Mussels were collected from Cape Conran, Victoria, in November, 1975.

1mm INTERVAL	Wt.(gr.) of *Jasus* sp. (N)	Percent weight of carapace, gut, gills, and mouth parts N = 2
21.0-21.9	1760 ± 164*(0)	
20.0-20.9	1520 ± 160*(0)	
19.0-19.9	1300 ± 155*(0)	
18.0-18.9	1090 ± 150*(0)	
17.0-17.9	890 ± 130 (4)	
16.0-16.9	679 ± 76 (5)	%40.0
15.0-15.9	672 ± 86 (5)	
14.0-14.9	625 ± 69 (4)	
13.0-13.9	570 ± 50*(0)	
12.0-12.9	510 ± 45*(0)	
11.0-11.9	440 ± 30*(0)	

* projected estimate

Table 8.3 Body weights of cooked, ice-free lobster from Canberra fish market according to left mandible size classes. Inedible body parts are expressed as percentage of total body weight. Measurements made in October, 1976. Projected estimates are based on assumptions discussed in text.

The live populations were divided into size classes and the mean flesh weight for each class was calculated along with a standard error. The modern population does not contain the full range of size classes found in the archaeological populations and projected estimates of these values are used to correct for this missing data according to the growth behaviour observed in marine organisms. Valentine (1973) and Wilbur and Owen (1969) have shown that increases in body length involve a nonlinear increase in body weight, as would be expected as any animal increases its size with age. However, when the age of molluscs is plotted against body weight for a given population (Medawar, 1945; Hallam, 1967), individuals in the prime of life possess a greater flesh weight to shell length ratio than do animals later in life. It is important therefore to be able to identify the age structure of the sample and to evaluate any differences in the size/age range between the modern and archaeological samples.

In the case of prehistoric cockles, the size range extends well beyond that of the modern. While the few large individuals found on the Coorong today are certainly old animals (King pers. comm.) in which the flesh weight increase has declined in relation to length gain, even the largest archaeological cockles exhibit characteristics of shell form which suggest they may still be in the prime of life. Consequently, when filling gaps in the size intervals in Table 8.1, the projected estimates are based on the shell length/flesh weight ratio of the previous intervals. This value has been increased by three per cent to reflect volumetric changes in weight gains expected for shellfish growing in the prime of life. The mean flesh weight for the largest 5 mm size class and its standard error is therefore based on trends in the means of weights calculated from 1 mm size intervals in the previous 5 mm size class. Two cockle populations from the Goolwa Beach, located on the Coorong, are presented to show variability between two neighbouring communities.

Likewise, the size range of archaeological lobster, as revealed in mandible lengths exceeds the modern sample and projected estimates of weights of the missing sizes have been calculated in Table 8.3 The body length of the live lobsters measured were in the range 25-30 cm and yet individuals exceeding 40 cm and weighing over 4 kg existed in the lower South East in the recent past (Campbell, Cleland, and Hossfeld, 1946:485). This would suggest that the modern sample represents a young adult segment of the whole community and that projected estimates of larger size classes can be made accordingly. The mean weights are therefore calculated with a 5 per cent increase over increases made in the previous size class and this adjustment applies to the standard error as well. Appendix 8.1 lists the lengths of mandibles excavated from the upper levels of Abyssinia Bay with estimates of their original body weights.

The calculation of flesh weights consumed at each meal in the archaeological record begins with the establishment of grouping of individuals into size classes consistent with the intervals of the modern populations. This information provides a size frequency distribution for the species consumed at the meal and reflects the preference for size being made by prehistoric shellfish collectors. This picture for Plebidonax is shown in Figure 8.2 along with the size distribution of a modern sample collected under similar conditions. Figure 8.3 shows the case for mussels and lobster, while Figure 8.4 illustrates the selection being made for Subninella at several sites inhabited during the

Late Phase occupation. To provide a value for the flesh weight for the size class in the prehistoric population, the number of individuals within each class is multiplied by the modern flesh weight, accompanied by its attendant error. The sum of the weights for each size class then represents the total flesh weight which that species contributes to the meal. The following examples show the manipulation of data in the cases of a cockle deposit and a multiple species meal; the flesh weights of mussel deposits are treated in the way cockle conversions were made.

Standard Formula for Computations:

$$\% \text{ of size class} \times \text{Population Size} \times \frac{\text{Mean Flesh Weight}}{\text{Size Class}} = \frac{\text{Flesh Weight}}{\text{Meat}}$$

Example a) FS 55 *Plebidonax*

24% x 2700 x 9.49 gr.* = 6149.5 gr.
61% x 2700 x 7.70 gr. = 12681.9 gr.
15% x 2700 x 5.91 gr. = 2393.5 gr.

TOTAL FLESH WEIGHT = 21,2249 $\pm$ 2750 gr.+

* projected estimate
\+ error (5% counting error, 8% variability in flesh wt.)

Example b) Meal 4

Subninella

2% x 910 x 15.3 gr. = 278 gr.
12% x 910 x 14.4 gr. = 1572 gr.
32% x 910 x 12.0*gr. = 3494 gr.
35% x 910 x 10.0*gr. = 3185 gr.
18% x 910 x 8.4 gr. = 1375 gr.

TOTAL FLESH WEIGHT = 9906 $\pm$ 1089 gr.+

* projected estimate
\+ error as above

Jasus sp. (estimates from Table 8.3)

Mandible length	Body Weight
128 mm	510 gr.
165 mm	679 gr.
171 mm	890 gr.
Frag.	?

TOTAL BODY WEIGHT 2079 gr - 40% = 1243 $\pm$ 186 gr.

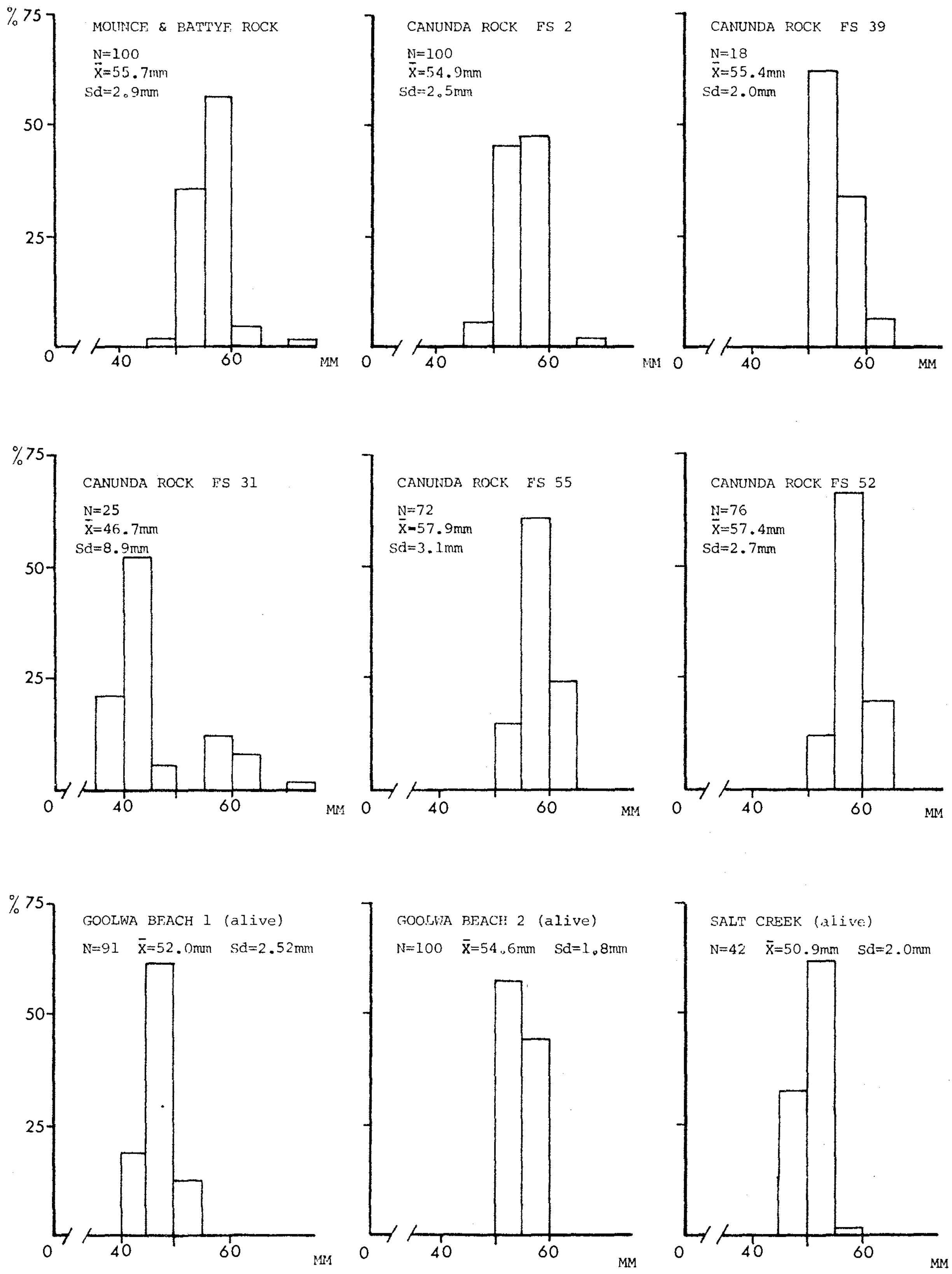


FIGURE 8.2 Size frequency distribution for Plebidonax consumed in prehistory and a modern sample collected alive in February, 1975.

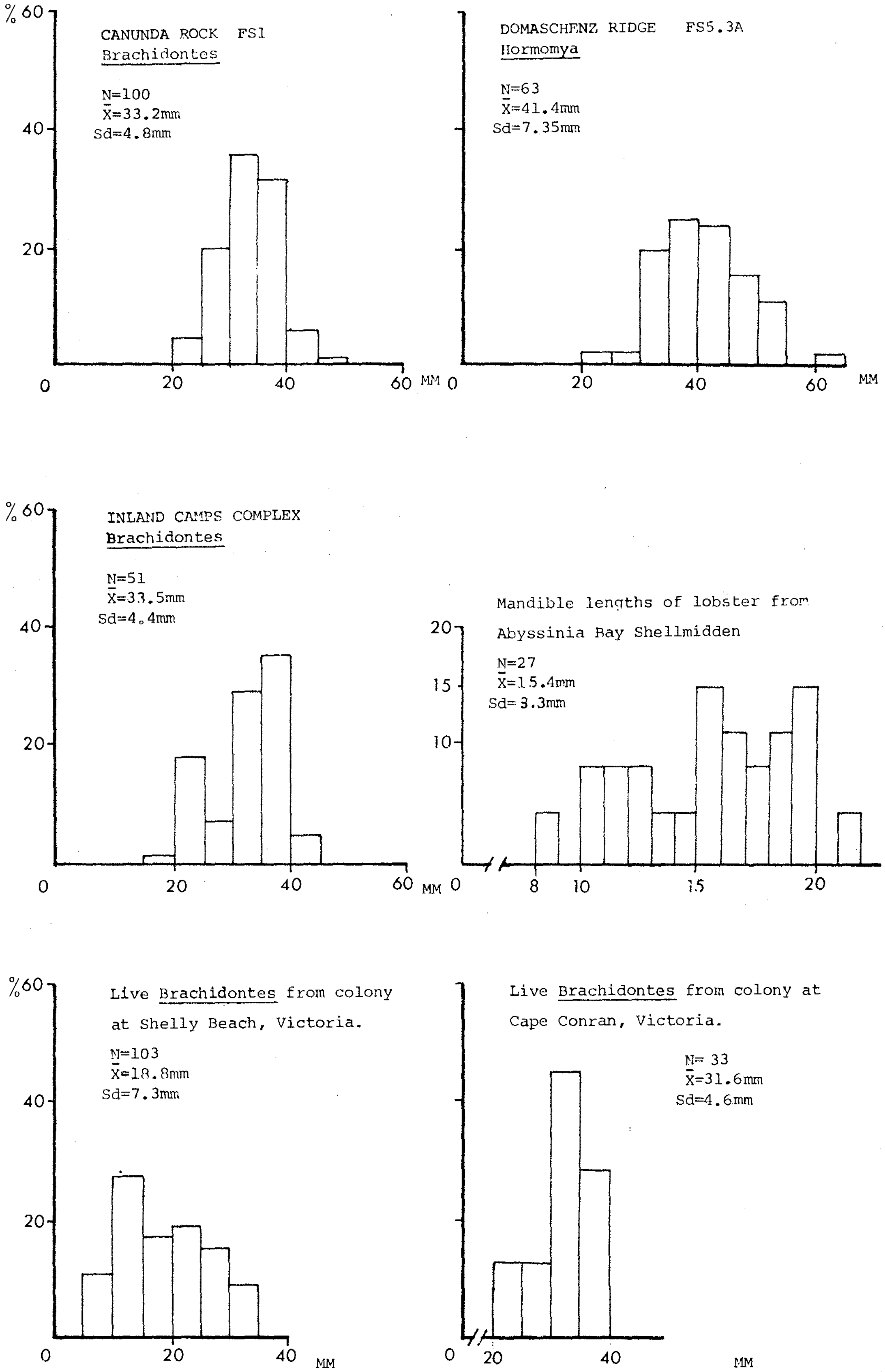


FIGURE 8.3 Size frequency distribution for mussels consumed in prehistory, and a modern sample collected live in November, 1975, from Victorian waters. Size of lobster mandibles from Abyssinia Bay shown centre right.

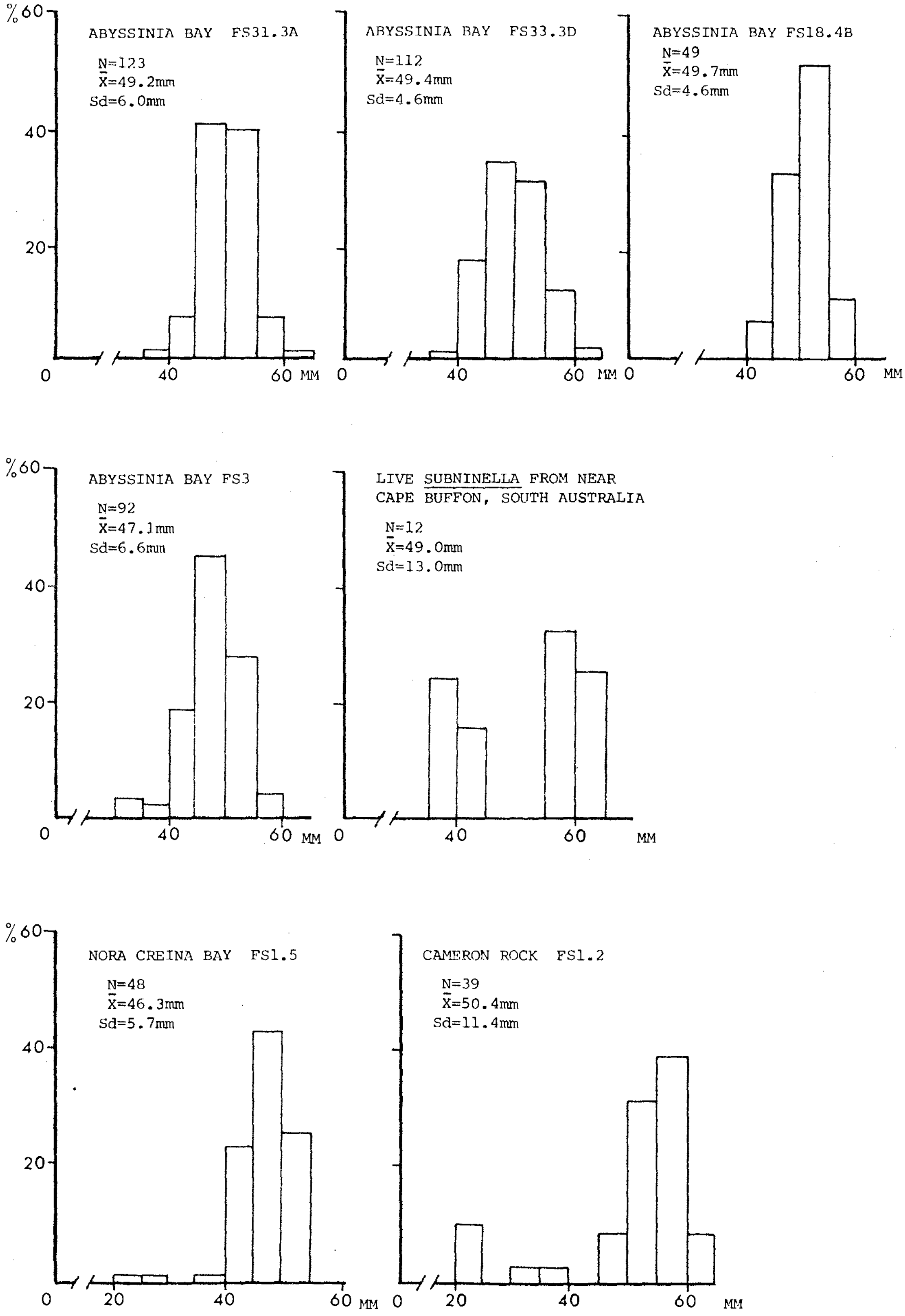


FIGURE 8.4 Size frequency distribution for Subninella from various deposits, and from modern population, collected in February, 1975.

Flesh weight of seafoods may be converted to their caloric values using published data and in applying this information to unknown species some general guidelines may be considered. Caloric values for a range of foods (Watt and Merrill, 1963; Thomas and Corden, 1970) are shown in Table 8.4 to illustrate the variation in calorie content even within similar types of animals exploited by prehistoric man. It can be seen from this information however, that shellfish with greater muscle tissue such as abalone contain larger caloric values than say, oyster. On this basis, it will be assumed that limpets contain 95 kcal/100 gr. of flesh. Plebidonax is in fact a clam and according to the tables contains 80 kcal/100 gr. It should also be noted that the values for lobster provided by Thomas and Corden probably applies to the true lobster Homarus whereas the spiny lobster, Panalirus measured by Watt and Merrill is more likely to be comparable to the spiny lobster Jasus sp. caught by the Buandik. Therefore 72 kcal/100 grams is used for lobster in this discussion. These caloric values have been used to calculate the energy quotient represented in each meal studied.

SEAFOOD TYPE	Kcal/100 gr.[1]	Kcal/100 gr.[2]
CRUSTACEAN		
Spiny Lobster (raw)	72	-
Lobster (steamed)	-	95
Crab (steamed)	93	93
MOLLUSC		
Abalone (raw)	98	-
Mussel (raw)	95	-
Scallop (raw)	81	80
Clam (raw)	80	-
Oyster (raw) Atlantic	66	68
Oyster (raw) Pacific	91	-

[1] Watt and Merrill, 1963 [2] Thomas and Corden, 1970

Table 8.4 Caloric values for the primary seafoods consumed in prehistory from published sources.

The estimated flesh weight and caloric values for the largest cockle and mussel deposits related to the Early Phase of occupation are presented in Table 8.5A and B. Table 8.6 presents the picture for the four excavated meals at Abyssinia Bay, representing clifftop shellmiddens.

Table A: Plebidonax middens

SITE	NO. COCKLE + COUNTING ERROR	FLESH WT. (Kg) + VARIATION*	CALORIC VALUES (Kcal) -10% CORRECTION
Canunda Rock FS 2	8230 ± 5%	55.25 ± 7.1	39780 ± 5100
Canunda Rock FS 48	3150 ± 7%	23.29 ± 3.4	16700 ± 2440
Canunda Rock FS 55	2700 ± 7%	21.22 ± 2.7	15200 ± 1900
Canunda Rock FS 39	2700 ± 7%	19.31 ± 2.9	13900 ± 2000
Canunda Rock FS 3	2470 ± 7%	16.58 ± 2.4	11900 ± 1700
Canunda Rock FS 52	2050 ± 7%	16.07 ± 2.4	11500 ± 1700
Mounce & Battye Rock	3220 ± 15%	17.28 ± 3.9	12400 ± 2800

Table B: Brachidontes middens

SITE	NO. MUSSEL + COUNTING ERROR	FLESH WT. (Kg) + VARIATION*	CALORIC VALUES (Kcal)
Canunda Rock FS 171	6980 ± 10%	4.58 ± 1.7	4354 ± 1650
Canunda Rock FS 174	5400 ± 7%	3.77 ± 1.3	3588 ± 1256
Canunda Rock FS 170	4030 ± 10%	2.55 ± .97	2525 ± 922
Canunda Rock FS 12	2150 ± 7%	1.75 ± .61	1663 ± 582
Canunda Rock FS 1	1690 ± 5%	1.13 ± .37	1081 ± 356

* Variation = counting error plus flesh weight deviation

Table 8.5 Calorie values for (A) the largest cockle, and (B) mussel meals associated with the Early Phase occupation. Values for the cockle have been reduced by 10% as discussed in the text, while no correction has been applied to the mussel.

SPECIES	NO. ANIMALS	FLESH WT. (gr.)	Kcal/100 gr.	Kcal
Subninella	289	3150 ± 360	80	2520 ± 250
Dicathais	6	60 ± 40	80	48 ± 9.6
Limpets	19	180 ± 50	98	176 ± 44
Poneroplax	15	300*	98*	294
Haliotis	8	800*	98*	784
Lobster	5	2020 ± 370 (N=4)	72	1454 ± 218
TOTAL KCAL FOR MEAL 1				5276 ± 896

Table 8.6 cont.,

Table 8.6 continued

SPECIES	NO. ANIMALS	FLESH WT. (gr.)	Kcal/100 gr.	Kcal
Subninella	507	5561 ± 611	80	4448 ± 444
Dicathais	7	700 ± 140	80	560 ± 112
Limpets	11	62 ± 15	98	60 ± 15
Poneroplax	12	240*	98*	235
Haliotis	3	300*	98*	294
Lobster	2	1320 ± 198	72	950 ± 142
TOTAL KCAL FOR MEAL 2				6547 ± 1112
Subninella	814	9100 ± 1001	80	7280 ± 720
Dicathais	11	110 ± 22	80	88 ± 17
Poneroplax	13	260*	98*	254
Haliotis	3	300*	98*	294
Lobster	3	1170 ± 170	72	842 ± 126
TOTAL KCAL FOR MEAL 3				8758 ± 1488
Subninella	910	9906 ± 1089	80	7924 ± 792
Dicathais	17	170 ± 34	80	136 ± 27
Limpets	40	228 ± 57	98	223 ± 55
Poneroplax	4	80*	98*	78
Haliotis	2	200*	98*	196
Lobster	4	1243 ± 186 (N=3)	72	895 ± 134
TOTAL KCAL FOR MEAL 4				9452 ± 1606

* estimate

Table 8.6 Caloric conversions of flesh weights from four meals excavated at Abyssinia Bay Shellmidden. Standard error in total Kcal is an estimated 17% of the mean.

The number of people at each meal may now be estimated on the basis of the standard daily energy requirement for adults. Several values for this requirement have been used (see Shawcross, 1967; Meehan, 1977), but most centre around 2000 kcal for an adult male, and this figure will be used here for ease of comparison. Table 8.7 then reveals the estimated minimum number of people attending the meal on the basis of the food remains preserved at the hearthside.

	Kcal (X 10^3)	Min. No. of Diners
EARLY PHASE		
Plebidonax meals		
Canunda Rock FS 2	39.87 ± 5.1	19.8 ± 2.5
FS 48	16.70 ± 2.4	8.3 ± 1.2
FS 55	15.20 ± 1.9	7.6 ± .99
FS 39	13.90 ± 2.0	6.9 ± .90
FS 3	11.90 ± 1.7	5.9 ± .85
FS 52	11.50 ± 1.7	5.7 ± .85
Mounce & Battye Rock	12.40 ± 2.8	6.2 ± 1.4
Brachidontes meals		
Canunda Rock FS 171	4.35 ± 1.6	2.1 ± .8
FS 174	3.58 ± 1.2	1.7 ± .6
FS 170	2.52 ± .92	1.2 ± .4
FS 12	1.66 ± .58	.8 ± .2
FS 1	1.08 ± 3.5	.5 ± .1
LATE PHASE		
Reeftop meals		
Meal 1	5.27 ± .89	2.6 ± .4
Meal 2	6.54 ± 1.1	3.2 ± .5
Meal 3	8.75 ± 1.4	4.4 ± .7
Meal 4	9.45 ± 1.6	4.7 ± .8

Table 8.7 Estimated minimal number of people at meals sampled from each occupation phase.

These figures show a considerable difference in hearthside group size between phases and between species. By far the largest number of people supported by these foods dined on cockles, while the lowest consumed mussels. Disregarding the size of FS 2 because internal strata suggests that the site may have been used more than once, the meals of the Early Phase appear to be in the order of twice the size as those on the clifftops and four times the size of the mussel middens. Several factors must be considered in explaining these differences. First, the more fragile, light weight mussel shells do not withstand wind transport as readily as the cockle and therefore mussel heaps may have systematically lost more shell than the others. Furthermore, the caloric values of the mussel may have been underestimated due to the disagreement between the time of year the modern and the prehistoric samples were collected. Then too, the mussel m... not have colonized the rocks in sufficiently prolific numbers to support larger numbers of Aborigines, in which case the number and size of these heaps generally reflects a real situation in the littoral for that time period. Nevertheless, the differences between the cockle and the gastropod meals cannot be explained by errors in computation or preservation, although admittedly certain fleshy foods may have been consumed on the clifftops which would not have been available in the sandy beaches 4000 years ago. For this to have been the case however, at least twice the caloric value would be required to render these two midden types equal in energy terms, and this does not seem a very plausible source for differences.

COMPOSITION OF THE GROUPS DINING AT THE MEAL

One must then consider whether or not the differences in food value represented by Early and Late Phase meals are straightforward reflection of differences in the number of diners, or instead are derived from variation in composition of the group. The working assumption employed to this point in the discussion has been that the contents of the meal satisfied a 24 hour requirement: but obviously, a meal may contribute less than a day's needs. There is in fact, other evidence to suggest that these sites were used by different types of groups in terms of composition and duration of occupation.

First, the tool kit associated with Plebidonax middens reflects mainly small-scale domestic activities, as is seen in such equipment as pounding stones and aeolianite "dishes", while equipment repair also takes place at many of these camps. The Late Phase tool kit at comparable camps, on the other hand, exhibits low functional diversity apart from two types of woodworking tools, and furthermore, tools of any description are generally uncommon around the clifftop campsites.

Likewise, there is a contrast in the amount of charcoal in the hearths of each occupation phase. Where preserved, hearths in Plebidonax middens characteristically may be up to 14 cm thick and contain intensely burned shell and flint in a heavy concentration of charcoal. The clifftop hearths by comparison, contain only traces of powdery charcoal for the most part and little evidence of intense burning of any of the kitchen refuse, except Subninella opercula.

The differences can be most easily explained by differences in duration of campsite use, which, in turn may reflect a change in group composition. Since it has been established that occupation took place during the cooler parts of the autumn, it is probable that the Plebidonax middens were overnight camps in which food was prepared at a cooking hearth which doubled as a warming fire. The occupants therefore are likely to have been members of an extended family and included individuals of both sexes and ages. While at the camp, they undertook routine tool repair and prepared and consumed the greatest portion of the daily catch.

The clifftop middens, on the other hand, appear to have been visited more briefly, probably by mainly women's groups who stopped to prepare their catch and have a meal amongst themselves. These groups would resemble those described by Tindale (1974) which carried their firewood into the sandhills to roast cockles before returning to the edge of the lagoon for the night. The middens at Abyssinia Bay represent then the discards of daytime women's camps from which a part of the day's catch may have been transported to the Inland Camps at the end of the day. If this was the case, the group dining on Plebidonax are the basic hunting-gathering unit in the area, whereas those dining on Subninella and lobster in the Late occupation phase are but a specialized fraction of the primary hunting-gathering unit. This means that the size of the population residing in the coastal margin after 1300BP may represent a substantial increase over its previous level and that both sedentism and population size have increased during the Late Holocene. This increased predation on littoral biological communities must have had a serious impact on the supply of seafoods and to examine this relationship, we can now turn to changes in food collection practices.

FOOD COLLECTION PRACTICES

The extent to which shellfish gatherers are able to intensify exploitation of marine biota depends as much upon the supply of seafoods at any one time as upon the technological adaptations to extend the range of exploitation itself. Since the watercraft was not used by the Buandik, nor is there clear evidence of fishhooks in use during the 19th century, we must assume that adjustments in collection practices were made to avoid overpredation. In order to understand this aspect of the marine adaptation, it will be necessary to realize that exploitation of littoral biota can increase only in proportion to the amount of food within reach of the human predator. The rate at which this can be done depends upon community's ability to replace numbers lost from both natural and cultural agents and the extent to which predation pressure is distributed across the habitat. Heavy loss of individuals in the prime of life, for example, will seriously influence the stability of the biological community if rapid recruitment is not assured. The mechanism of recruitment and the distribution of the species within its habitat are therefore essential issues to be considered in the reconstruction of food collection practices. The ranging behaviour of the predator can, in part, be determined with a comparison of the size frequency distribution of the animals eaten and the expected distribution of the species in the littoral. To complete this interpretation, the actual frequency of exploitation and the number of animals lost at any one time reveals the way collection practices were changed in order to intensify exploitation. Towards this end, each primary mollusc species exploited will be considered separately.

Plebidonax inhabits a zone from mid-tide to a depth of about one metre below the tide mark where they are fully accessible to human predation. Although size grading has not been observed in the modern populations in South Australia, crowding (Coe, 1955; Wade, 1968) in cockle and clam populations results in the dominance in certain areas of the habitat by larger, more vigorous individuals. Given the rapid growth rates and other evidence for optimal growth conditions in prehistoric cockle communities discussed in Chapter 7, larger individuals could have been readily located in the intertidal zone and collected. A survey of Plebidonax in the Coorong beaches today suggests that 50 or 100 large individuals require about 4-6 square metres of beach.

The size frequency distribution of the cockle in separate meals at Canunda Rock, and at Mounce and Battye Rock, as shown in Figure 8.2 indicates that a high degree of selection for large individuals occurred in almost every collection event. Mean shell length commonly ranges between 55 to 57 mm and standard deviation indicate that shellfish gatherers were able to retrieve over two thirds of their catch within a size class about 3/4 cm wide. An estimated 20% of the total number of meals inspected in the field contain two distinctive size classes, as for example FS31 (Figure 8.2), but in these cases, selection for size still remains a dominant consideration in the collection strategy. The exceeding narrow range of size variation suggests that special collecting devices may have been used or that size sorting by hand was possible owing to the distribution of the animals in the beachfront.

An experiment in shellfish collection was then performed on live communities to test a hand collection technique. Three separate populations residing in a 60 km stretch of the Coorong beach were sampled near the low tide line using a 1/4 inch (.64 mm) mesh hand sieve. As molluscs filled the sieve, only the largest were collected until a small sample had been retrieved over a 20 minute period. These were measured with calipers to the same level of precision as the archaeological sample. The results of this operation, shown in graphs at the bottom of Figure 8.2 conform well with the size distribution measured for most of the meals consumed in the sandhills 4000 years ago. It is quite possible therefore that shellfish gatherers collected their catch simply by sorting through the shellbed by hand, rejecting all smaller individuals. A photograph (Massola, 1971:114) depicting an Aboriginal man collecting cockles from the Coorong beaches illustrates the traditional use of a basket clenched in the teeth to do this. With the hands thus freed, the shells are gathered up from the sand, washed in the water, and put into the bag one by one. This collection practice is quite simple to perform and allows the catch to be made in an hour or so with precision selection for the largest animals in the sand.

Wade (1968, 1969) and others have shown from monthly sampling programmes that the age structure of molluscan communities may vary considerably throughout the year and between years. This is true due to seasonal mortality patterns, differences in the time at which recruitment occurs, and because spat falls may dramatically decline between years. It might be expected therefore that the mean size distribution and range of variation around the mean of shell collected from different years to reflect these differences. Indeed, the majority of cockle collections shown in Figure 8.2, are sufficiently different to support this conclusion since none were associated in clusters, and many in fact occur in different valleys of the hinddune. Shells in FS 55 and FS 52, however, exhibit almost identical population characteristics, suggesting that collection occurred during the same time of year on the same population. The fact that shells from both heaps possess identical stress signatures, as demonstrated in Chapter 7 proves that this is the case and further suggests that the same individual collectors were involved. The use of biological indicators in this way is the only definitive evidence by which membership to a contemporaneous biological community can be determined.

Brachidontes colonize rocks in large clusters or dominate the mid- to low tide zone in a continuous band wherever solid substrate can be found. The tiny mussel Modiolus pulex is a cohabitor of these colonies and on South Australian and Victorian (Bennett and Pope, 1953) coasts it occurs in large numbers. In addition, the bivalve (clam) Kellia australis is always associated with the Brachidontes colony, living unattached in the shelter of the byssus thread. These molluscs are then well within easy grasp of prehistoric shellfish gatherers and because of their comparatively narrow range of habitation, could easily be overexploited by repeated collections from the colony during the same year.

A close inspection of mussel heaps throughout the sandhills indicated that both Kellia and Modiolus were present in large numbers, occasionally numbering over 100 individuals. If hand sorting had occurred to remove the animals from the rock, or the catch had been prepared in some way prior to cooking, neither of the animals would be expected to be present in the midden in such large numbers. Kellia would have fallen out of the matte and neither animal is large enought to be collected for food. The presence of these cohabitors therefore suggests that the entire matte of mussel was peeled from the rock and carried as a bundle in a basket to the campfire. A fire was simply lit over the heap and the lightly steamed mussels were roasted in the vegetable matte and smoldering hearth. Because of this, the smaller individuals were inadvertently collected and were probably left behind uneaten. The presence of small individuals in the hearthside scatter collected in this manner need not mean that selection for size were not being made. It just so happens that the selection is being made at camp and not at the foreshore and this probably is due to convenience.

The size distribution of Brachidontes and Hormomya is shown in Figure 8.3 along with mean length and deviation. This figure indicates a comparatively wide range of sizes, as would be expected for removal techniques described above. Because the mussels are extinct in the Lower South East, live populations in Victorian waters were sampled. Shown in the bottom of Figure 8.3, these collections represent a clump of mussels removed from a single rock, with the largest individuals in the concentration being selected in each instance. Those from Shelly Beach, south of Melbourne are wide, short valves and the mean shell length is therefore lower than that for the Cape Conran population, which contains long, narrow valves. Cape Conran is about 150 km from the New South Wales border and Shelly Beach is near Wilson's Promontory.

The molluscs consumed during the Early occupation phase are easily collected by hand and occur in large enough quantities in the intertide zone to satisfy the daily requirements of small groups of shellfish collectors. The very large sizes of the cockle obtained in a majority of meals suggests that optimum growth conditions guaranteed more than an adequate supply. Living under unsettled sedimentary conditions and restricted quantities of suitable substrate however, the mussel colonies would not be expected to have continued exploitation at high levels of depletion.

The seafoods consumed in the Late Phase of occupation represent a variety of habitats close to the shoreline. The periwinkles and limpets are almost exclusively intertidal animals and could easily be gathered either from the reef top, or from strands of seagrass attached to the substrate. Those in the middens are all large individuals, although Austrocochlea spp. range in size and are invariably charred and broken, suggesting a special practice was followed in their preparation. Although these molluscs undoubtedly formed a minor part of the diet, their persistent appearance in the meals, as well as the effort taken to eat them indicates that the reef platforms were being systematically searched for foods. Judging by this pattern on the clifftop and rockshelter occupations, the shellfish collectors appear to have been taking everything edible regardless of size.

In the Late Phase, however, by far the greatest package of food exploited by Aborigines were the lobster and the snail Subninella, both of which were consumed at every meal prepared on the clifftops. The lobster inhabits rocky crevices from about one metre below low tide and deeper, and isolated individuals may be found in rock pools at low tide (Dakin, 1976:183; pers. obser.). Considering the large variation in size of those consumed in prehistory however (Figure 8.3), lobsters were most likely taken from below the reef by divers swimming in shallow waters.

The collection practice for Subninella, however, presents a more difficult case to reconstruct because the gastropod resides both on the reef top and below to depths of about 6 metres. As stated in Chapter 2, recruitment in the intertidal zone is slow, with the major reservoir residing below the outer limits of the reef fringe. During the first week of February, 1975, a search by two people to locate Subninella on the surface of a fully exposed reef at Cameron Rock succeeded in retrieving only six individuals as large as those consumed in prehistory. The size of each catch measured at Abyssinia Bay however ranged between 200 to 900 shellfish with large individuals consistently forming the greatest bulk of the collection at every meal. Considering that a minimum of 3.7 meals were eaten at Abyssinia Bay every year, this evidence indicates that prehistoric shellfish collectors were acquiring far greater numbers of large gastropods than would be expected from the intertidal zone. This evidence leads to the conclusion that the snail was being systematically collected by divers operating off the edge of the reef in shallow waters probably no more than 5 metres. There, the lobster and Subninella reside together amongst the seagrass in vast quantities where they could be quickly picked by hand almost simultaneously. The collection of marine foods in the Late Phase therefore could only have taken place in both the inter- and subtidal zone and this represents a substantial change in existing food collection practices.

CONSUMPTION RATES FOR SEAFOODS

The rate at which the marine economy developed may be shown in a comparison of the amount of seafoods consumed between the Early and Late Phases. To do this, the number of meals for each Phase has been computed on the basis of observed densities in a stretch of coastline long enough to span the full range of littoral habitats. In order to provide a greater degree of resolution to the growth curve, the Early Phase will be divided into two periods of shellfish exploitation to account for the possible influence changes in the littoral habitats might have had upon exploitation rates.

Containing 101 meals, the assemblage of cockle deposits at Canunda Rock represent the largest concentration of Early Phase meals observed along the 35 km of coastline between Cape Buffon and the southern end of Lake Bonney. Within the one square kilometre sample area, a thin shell scatter is estimated to represent twice the number of shells contained within the shellheaps preserved on the valley floor. The total number of original deposits was therefore 202 + 101, or 303 meals per kilometre. Cockle distribution is uneven along this shoreline, with the greatest densities coinciding with the beaches south of Canunda Rock for a distance of about 30 km. Even along this coast, certain stretches of the hinddune are nearly bare of middens of any description although the presence of a few well preserved shellheaps indicates that shellfish remains were deposited there and have not disappeared altogether. Nevertheless, I will apply the density of meals from Canunda Rock to the whole sandy beachfront, accepting that in doing so the total number of cockle meals calculated for the study area will then be an exaggeration. On the basis that 303 meals per kilometre were consumed in the past, 30 km of coastline will contain 9090 meals. During the period 5800-2900BP when cockles were eaten therefore, no more than 3.13 meals per year were consumed, and this figure represents a rate of annual visitation to the foreshore of as many days (1% per year).

The calculations for Brachidontes heaps proceed in the same way, except that the mussel is more prolific in the northern half of the shoreline where rocky conditions still prevail today. Moreover, an estimated 10% of the number of heaps of mussel found on the hinddune are found further inland, in such sites as the Inland Camps. From Chapter 5 we have seen that 44 heaps of mussel occurred at Canunda Rock and again assuming these represent one third the original number, 132 mussel heaps accumulated for each linear kilometre of coastline. Employing these calculations the total number of mussel heaps in 18 km of the coast, including the sandhill, is 2612, which for the period 2900-1300BP provides an average of 1.6 meals of mussel per year. This represents an annual visitation rate of 0.4%.

Meals containing seafoods in the Late Phase of occupation are concentrated in large amounts at the foreshore, inland along the central area of the sandhills, and are dispersed throughout the margin in small quantities wherever platform reefs predominate in the intertidal zone. Using estimates from densities obtained by excavation at Abyssinia Bay, an average of 3971 ± 45% meals of gastropods and crustaceans were consumed, as an absolute minimum in at least one large deposit. Of the 27 middens counted over that 8 km of coast, nine are believed to have been equal in size to that of Abyssinia Bay, while the remaining 18 were probably about one third as large. The total number of meals consumed on the foreshore thus, is the sum of (9 x 3971) + 1/3 (9 x 3971), or 47,532. The number of meals containing gastropods consumed at the Inland Camps and similar complexes is difficult to compute because most deposits are large enough to represent three or more meals and, in any event are partially hidden from view. At least 18 such heaps were counted in an area of 60,000 square metres, which equals about 300 heaps of gastropods per square kilometre. From observation however, several concentrations near Cape Buffon easily exceed this density and because of this, an average of 400 heaps is estimated to occur in every square kilometre. Assuming an even distribution over a 15 km stretch of sandhills at this density, the total number of heaps inland is 6000, which neither accounts for the possibility that more than one meal is contained in each deposit, nor does it consider the countless heaps of Subninella scattered elsewhere throughout the sandhills up to 5 km away from the sea. The minimal number of shellfish meals consumed during the 1200 years of the Late Phase is 53,530 ± 45%, or 44.6 meals per year. This represents 12.2% per annual visitation to the foreshore by shellfish gatherers.

Although these rates of seafood consumption must be regarded merely as rough guides to the changes in the importance of seafoods to the diet, they nevertheless serve to highlight difference too great to be due merely to errors in estimation. If anything, the exaggerated estimate of the number of cockle heaps and the conservative number of gastropod middens effectively minimizes the contrast and despite this, the consumption of marine foods has increased more than ten times during the Late Holocene. This information therefore confirms many of the trends revealed in the economic analysis. There is, for example, the temporary campsite visits during the Early Phase of occupation involving periodic returns to the camping area. Considering that the annual consumption rate of 3.1 meals of cockle is exceeded in individual clusters of middens containing up to eight heaps, it is entirely possible that visits to the foreshore did not occur every year. This picture is consistent then with the evidence for a late autumn or early winter visitation schedule to the foreshore to collect cockles and this pattern probably applies to mussel gathering as well. The groups operating in the coastal margin were likely to be families of about eight to 12 individuals organized around resources near the water's edge. The food collection strategy involved daily movements around the perimeter of the coast-lagoon shoreline with the primary focus directed towards short term, small scale hunting and gathering activities such as shellfish collecting, kangaroo hunting, and reed harvesting. Residency lasted in all probability about a week or two and seafoods provided a small fraction of the food consumed for the year as a whole.

The residency of the Late Phase occupation on the other hand is described in the ethnography to have lasted two or more months and may have involved a population of 40-60 individuals during the peak seasonal flush of foods in the sandhills. The scrub formed the central staging area for all these operations from which small groups moved daily to collect foods, gather wood, and to draw water for the day. Composed mainly of women and children, shellfish collecting groups of about 3-8 individuals might have spent several hours combing the beach and diving from the reef for lobster and shellfish. A portion of the catch was then heated over a small fire and eaten before the group returned to camp for the evening with the remainder of the seafoods. Similarly, other groups out after duck, reeds and plant food, or fish would bring them back into the habitation camps for steaming or processing. The subsistence economy of the Late Phase occupation can then be characterized as an intensive, systematic exploitation of probably every resource to be found within the coastal margin. Beginning in early summer, as is suggested by the ethnography, the population gradually increased until late February and dissipated across the Woakwine Range and into the swamps by May.

The increased occupancy of the coastal strip occurred at a time when severe disequilibrium in the coastal environment would seem to have discouraged it. Unstable sedimentary conditions prevailed at the foreshore, as shown by dune formation, are likely to have altered the structure of plant communities exploited by Aborigines on the Robe Range. In addition, at some time after 1000BP, advancing beach ridges destroyed the ecological stability of the lagoon north of Beachport and the biomass in the interdune corridor declined as a result. Nevertheless, the swamps and lakes formed by impounded waters behind the ridges would not only have increased in area, but would have become a more reliable aquatic habitat due to permanent blockage at their exits to the sea. Hence, Lake Bonney at Beachport and Lakes Fromme and Bonney south of Rivoli Bay became primary focal points of activity as has been demonstrated in the recent archaeology and described by 19th century residents (Smith, 1880). Increased diversification of resources and habitat stability can therefore be used to explain increased rates of predation and prolonged duration of residency in the sandhills. What is not apparent however, is why the residency shifted from a level of 1% annual visitation to something over 13%.

THE SWAMPS AND ECONOMIC GROWTH

If the coastal exploitation increased significantly during the Late Holocene, it is reasonable to suspect that a mirror image of this pattern occurred in swampside exploitation, whose importance to Early Holocene economies has been firmly documented in the archaeology of Wyrie Swamp. The Holocene ecology of the swamps must therefore be examined for a possible correlation. Dodson (1975a) has reconstructed the hydrology of the swamps on the basis of fossil pollen assemblages collected from five swamps located in both the volcanic highlands of Mt Burr, and in the lowest depths of the catchment of Wyrie Swamp. A strong conformity in the development of aquatic plant communities amongst these swamps has permitted Dodson (1975a:266) to construct a composite water table curve for the area in terms of relative wet phases for the past 10,000 years.

This information shows that between the period 10,200-8000BP, water gradually accumulated in the lowest depressions of the flatlands along the Woakwine Range and in the highlands. Waterstand fluctuated and conditions are described as shallow in Wyrie Swamp. The swamps rapidly increased and became permanent between 8000 and 3000BP, when conditions were wetter than today and at any other time in the past. After this period, however, the watertable fluctuated and conditions became drier, with the driest periods occurring at 2000BP and 500BP when most swamps would have become completely dry.

When placed against the growth curve for the marine economy, as shown in Figure 8.5 a correlation seems to emerge. With the swamps at their highest level 5000 years ago, consumption of seafoods

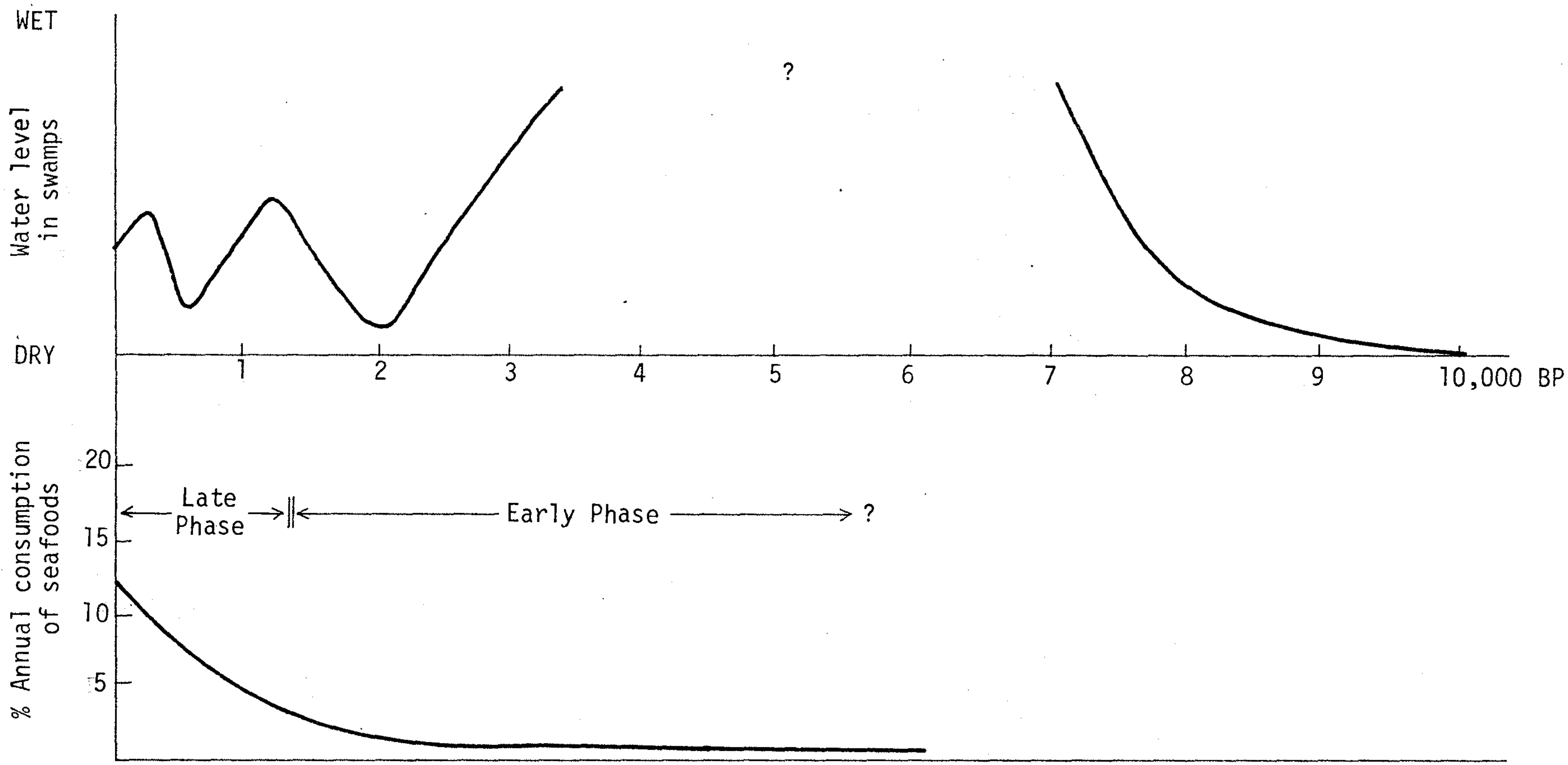


Figure 8.5 Comparison of Holocene water table with consumption rates of seafoods.
Hydrology curve after Dodson 1975a.

was at its lowest, whereas the swamps became drier and less stable, coastal residency appears to have increased accordingly. At its wettest period then, the swamps would have formed over the whole of the coastal plain for as much as 80 km inland wherever drainage was impeded by Pleistocene dunes. It is likely that Cootel Swamp at Narrowneck extended between Kingston and the southern end of Lake Bonney as a permanent lake well over 100 km long and 8-12 km wide. Under these conditions more than 10,000 square kilometres would have been under water for most of the year and the swamps could have supported a wide range of aquatic resources almost too numerous to imagine. There would have been an immense community of aquatic birds, some of which could have been permanent residents along the Woakwine Range. Others would have been migrants from the Murray River area. Then there were the small fish and possibly eel, to say nothing of the frogs, turtles, shoreline birds, and even water beetles, each of which could have provided a valuable source of protein. If eye-witness accounts from the 19th century (Angas, 1847) are a true indication, vast fields of reed beds, lillies, low scrub, sedges, and succulents may have stretched around many of the larger swamps. With these foods available across many of the shallow waterways for tens of kilometers inland, the plant foods and animal life of the comparatively narrow coastal zone would have appeared less attractive and the Early Phase occupation centred upon the swamps and the volcanic highlands.

When the swamps began to shrink after about 3000BP however, the aquatic habitats across the whole district would have changed significantly. The margins of the swamp system would have become dry in autumn or simply dried up altogether during the summer months. The waterfowl would have found food increasingly more scarce and their numbers would have therefore been reduced. Similarly, the plants and smaller animal life could not have survived in great numbers and only at the more permanent bodies of water, such as Wyrie or Cootel Swamp could these foods be found for most of the year. When severe drought struck at 2000BP therefore, the traditional way of life around the swamps could no longer be maintained and the numbers of people who had gradually built up an economic system around them were forced to seek an alternative food supply in the face of a drastically reduced biomass in the swamps. By 500BP, the transition to the coast and the emergence of a very calculated division between coastal and swampside exploitation had occurred which had effected the whole Aboriginal population.

To say that the swamps and their hydrology are the direct cause of the seaward movement of populations in the region does not fully recognize the scale of the change in the environment, however. The interpretations of climatic changes for South Australia by Dodson apply equally to western Victoria (Dodson, 1974a; Bowler, Hope, Jennings, Singh and Walker, 1976) and therefore have direct ramifications to the whole of the southern drainage of the Murray River. Embracing an area no less than 200,000 square kilometres, the ecosystems effected include the Big Desert and the Wimmera near the Murray River, as well as the river's tributary system on both sides of the basaltic divide in Victoria. When wetter conditions prevailed throughout this area during the Mid-Holocene, Aboriginal populations could have inhabited a wide range of well watered habitats and presumably occupation densities increased accordingly. With the emergence of a dry phase, however, hunter-gatherers would have been forced towards the more productive areas along the rivers and at the coast, abandoning the open, desert country in between. For the Lower South East, this meant concentrating on the swamps along the Woakwine Range and in the coastal margin itself. The result of this move then, was to drive greater numbers of people towards the coast and into shrinking habitats.

The effect this stress had upon Aboriginal populations of the region can be shown in the recent archaeology and ethnography of South Australia and Victoria. With seasonal declines occurring in effective water stand, efforts to maintain food supply at pre-stress levels may have been regulated by limitations imposed by an already high population. Hence, solutions had to take place within proscribed boundaries. This involved the construction of eel traps and large habitation mounds common in western Victoria, and the extensive fish weirs in South Australia in order to manage primary resources including crayfish, fish, eels, and possibly even certain plant foods. Perhaps Mrs Smith's Aboriginal friend captured the situation best (see Chapter 3), when she spoke longingly of her husband's lake and the sandhills and forest range which he owned and rarely left except under extraordinary circumstances. This country to him was barely a day's walk across and yet within it he had to find enough food to support himself and his kinsfolk throughout most of the year. It would appear from this type of evidence that substantial changes in land-man relationships had occurred in the Late Holocene and that possibly for the first time, human occupation in the coastal margin had made a serious impact on the local ecology.

With increased levels of sedentism and increasing human populations, the cultural response had to be drastic if people were to survive being compacted into marginal conditions of waning supply and rising demand. The ecology was being altered by increased rates of predation and burning, while greater dune mobility and infilling of the lagoons starved plant and animal communities inhabiting the coastal margin. The response then was to intensify exploitation of all available resources in the swamps and the coast. The development of the marine economy is therefore seen to have involved several factors. First, seafood collection practices intensified at the shoreline by extending the range of exploitation further to sea, albeit a few hundred metres at the most. This shift in focus to below the tide mark provided a greater yield in the daily catch and greatly expanded the menu for longer periods of the year because the biological communities were not endangered by exploitation. Hunting and gathering groups also appear to have fragmented and concentrated on single focus activities, with each distributed widely in the habitat to maintain the greatest contact with the resources.

Perhaps the most dramatic adaptation took place in the subsistence technology as they underwent revision and modification following the introduction of the composite spear and the spear-thrower. With downturns occurring in food supply and Aboriginal populations being forced to exploit a comparatively limited set of resources, the need to equalize energy flow throughout the year became stronger. This is so not only because of the seasonal flux in supply but because access to foods in times of stress were being denied by neighbours and friends alike. The pressure is there then for specific types of niches to come under systematic, intensive exploitation by adapting both organization and technology to more effectively extract energy from the environment.

The most direct way this appears to have been accomplished is the development of specialized equipment designed to obtain more aquatic foods. As a consequence, composite fishing spears, fishhooks, and an assortment of non-portable artefacts such as fish weirs and eel traps were invented both to manage and to stabilize the supply of foods. The selection was, therefore, being made for specific answers to a new problem and the only way to achieve this was to discard certain cultural traits which no longer offered enough advantages for them to be kept. The result of this was the loss of the microlithic component in favour of developments in organic counterparts which could be fashioned to the desired shapes more readily than stone. The transition, however, is more likely to have been a gradual process of selection rather than substitution with elements of a specialized tool kit emerging much earlier. The cultural adaptation in the Late Phase occupation therefore was to provide immediate, specific answers and this meant enlarging the technological possibilities in order to gain greater control of the environment.

This research has attempted to determine how and when marine economies developed in South East South Australia. It has been shown that they emerged 2000-1300 years ago as a result of substantial changes in the regional demographic structure following a major reduction in swampside resources inland. The extent to which this picture applies to more distant seaboards must be decided on the basis of further studies of economic development. The similarities between the South East and coastal margins to the east are tempting. The microlithic component at Wilson's Promontory flourished there about 3900BP (Coutts, 1970) and disappeared at 1290BP; almost exact time frames for the picture in South Australia. Likewise, the present antiquity for fishing equipment in New South Wales closely resembles the evidence for intensification in subsistence activities, and the apparent antiquity for the majority of shellmiddens is less than 2000BP. If the climatic changes forecasted by Dodson's interpretations have widespread relevance to South East Australia, the correlation between the archaeologies of the region would appear to indicate that significant cultural adaptations occurred as a result of them. If this is the case, the development of the marine economy occurred as a final stage in cultural adaptation to coastlines and the evidence for it is still preserved above the tide mark throughout mainland South East Australia.

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ABBREVIATIONS.

A.I.A.S. *Australian Institute for Aboriginal Studies.*

A.J.B. *Australian Journal of Botany.*

A.J.M.F.R. *Australian Journal of Marine and Freshwater Research.*

A.J.S. *Australian Journal of Science.*

A.P.A.O. *Archaeology and Physical Anthropology in Oceania.*

Bull. Geol. Surv. S.A.
Bulletin of the Geological Survey of South Australia.

Geol. Surv. S.A. Rep. of Investigations
Geological Survey of South Australia, Report of Investigations.

Jour. Geol. Soc. Aust.
Journal of The Geological Society of Australia.

Jour. Mar. Biol. Assoc. U.K.
Journal of The Marine Biological Association of the United Kingdom.

Jour. and Proc. Roy. Soc., N.S.W.
Journal and Proceedings of The Royal Society of New South Wales.

Jour. Roy. Aust. Hist. Soc.
Journal of the Royal Australian Historical Society.

Mem. Geol. Surv. Vic.
Memoirs of the Geological Survey of Victoria.

N.Z. Jour. Science
New Zealand Journal of Science.

Pap. Roy. Soc. Tas.
Papers of the Royal Society of Tasmania.

Proc. Roy. Soc. Vic.
Proceedings of the Royal Society of Victoria.

Rec. Aust. Mus.
Records of the Australian Museum.

Rec. S.A. Mus.
Records of the South Australian Museum.

Trans. Roy. Soc. S.A.
Transactions of the Royal Society of South Australia.

Trans. Roy. Soc. N.Z.
Transactions of the Royal Society of New Zealand.

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APPENDIX A2.1 Notes on the subfossil marine shell deposits near Lake St Clair, South Australia

Thick, stratified deposits of marine shell are exposed in numerous localities between Beachport and Robe over a distance of 30 km. The shellbed forms a continuous layer from one mouth to the other at about one metre below mean sea level. An inspection of a cross-section of habitats has revealed a sequence of molluscan assemblages typical of lagoon and protected bay settings. On the ocean side of the lagoon are a number of shallow embayments containing an abundance of large, sandy bottom clams. On the opposite side, rocky shore species are more prevalent, as would be expected under more open conditions. At the southern exit into Rivoli Bay, thick layers of sandy bottom and sessile reef dwellers occur very close to the outlet. Shells at the north mouth near Guichen Bay are not visible, but massive accumulations of oyster and scallop lie on the surface within one half a kilometre. The history of this lagoon will be reflected in these exposures.

One such exposure ($^{4}08\ ^{58}72$-F1) located on the inland side of Lake St Clair on the road to Nora Creina, and midway between the outlets, was selected for sampling. The deposit rests on a weathered calcarenite reef and is visible in section for more than 50 m along an axis roughly perpendicular to the shoreline. Samples were taken from major stratigraphic units as these were evidenced by boundary sharpness and continuity, and represent the succession within a single column. The fauna of the column are listed and a description of each sample is itemised below.

A) SANDY BOTTOM or SANDBANK MOLLUSCS:

Katelysia spp.
Equichlamys bifrons
Macomona deltoidalis
Bullaria botanica
Haminoea tenera
Gazameda iredalei
Pleuroploca australasia
Floraconus seagravei
Cominella eburnea
Niotha pyrrhus
Nevia spirata
Cymatiella sp.
Lyria mitraeformis
Phasianotrochus spp.
Phasianella spp.
Zeacumantus diemenensis
Clanculus dunkeri
Eubittium lawleyanum

B) ROCK EXPOSURE MOLLUSCS:

Hormomya erosa
Mytilus edulis planulatus
Ostrea sp.
Austrocochlea constricta zebra *A. odontis*
Thalotia conicus
Hipponyx conicus
Dentimitrella sp.
Bembicium nanum

C) CRUSTACEANS:

unidentified crab

D) ECHINODERMS:

unidentified sea urchin

E) AMPHINEURA:

unidentified chiton

F) SAMPLE DESCRIPTION:

SAMPLE 1: 2.00-1.94 m above bedrock.

Contents: Black humus matrix, with many rootlets and finely fragmented shell throughout. Whole shells present were quite small. Layer seemed disturbed throughout.

SAMPLE 2: 1.94-1.85 m above bedrock.

Contents: Mixed humus and shellsand matrix, shell fragments large, boundaries top and bottom disturbed. Two internal layers: Eubittium predominant on top, small-to-medium-sized Katelysia below (ca 10-20 mm length). Other species present in some numbers include: Mytilus edulis planulatus (fragments only), Hormomya, Cominella eburnea (more than in any other stratum), Thalotia, Zeacumantus, Dentimitrella, Gazameda, Clanculus dunkeri, and Ostrea. Species represented by only a few specimens include: Hipponyx, Haliotis sp., Bullaria, and Austrocochlea odontis.

SAMPLE 3: 1.85-1.78 m above bedrock.

Contents: Shellsand matrix, three internal layers: Eubittium and some Zeacumantus in a sandy matrix on top, a thin vague zone of Katelysia in the middle, Clanculus dunkeri with some Katelysia on bottom.

SAMPLE 9: 1.21-0.96 m above bedrock.

Contents: Four internal layers, Katelysia predominant: generally small size (ca. 17 mm length). Katelysia on top, above a layer with Zeacumantus and Eubittium, above a thick band of sand containing Katelysia. Hormomya and Macomona are present in small numbers throughout; scarce species include Clanculus dunkeri, Niotha, Haminoea tenera, Ostrea fragments, Austrocochlea constricta zebra, Cominella eburnea, and infant Gazameda.

SAMPLE 10: 0.96-0.90 m above bedrock.

Contents: Single layer, with coarse shellsand matrix, Hormomya, Zeacumantus and Eubittium, some Katelysia; Haminoea tenera, Macomona, and Austrocochlea constricta zebra.

SAMPLE 11: 0.09-0.75 m above bedrock.

Contents: Three layers; matrix throughout is fine shellsand and overall there is little whole shell. Topmost zone compact sand with some Katelysia; middle layer Eubittium (this layer is red-stained, like stratum 10 above, by some postdepositional condition); bottom layer compact sand with some Hormomya. A few Macomona present throughout.

SAMPLE 12: 0.75-0.54 m above bedrock.

Contents: Four zones of finely fragmented, badly weathered shell - also red-stained, as are Strata 10 and 11. Eubittium and Zeacumantus on top, above small Katelysia, above more Katelysia. Some Hormomya.

SAMPLE 13: 0.54-0.39 m above bedrock.

Contents: Single thick band of sand with highly fragmented shell, including some Clanculus dunkeri, Cominella eburnea, and Zeacumantus; and a little Mytilus, Katelysia, and Macomona. Layer has a white colour to it from "coating" of clayey (?) material, as do layers 14 and 15 below.

SAMPLE 14: 0.39-0.25 m above bedrock.

Contents: Thick bank of fragmented shell, bluish Clanculus dunkeri predominant. Some Gazameda, Bullaria and Macomona - all generally larger than in layers above. Occasional Hipponyx, Hormomya, Dentimitrella, Nevia, Bembicium, crab claw fragments.

SAMPLE 4: 1.78-1.69 m above bedrock.

Contents: Three internal layers: topmost sandy matrix with *Katelysia* of small (14 mm ln.) size, middle layer less sandy and small *Katelysia* still predominates, bottom layer *Eubittium* and *Zeacumantus* dominant. *Gazameda* and *Haminoea tenera* present throughout; a few fragments of *Hormomya* and a few *Clanculus dunkeri* and *Cominella eburnea* present.

SAMPLE 5: 1.69-1.66 m above bedrock.

Contents: Five internal layers: topmost a thin band of sand with some *Katelysia*, next a layer with *Eubittium* outstanding, then a mixed *Katelysia/Eubittium* predominance, fourth a layer of larger (ca. 25 mm up) *Katelysia*, and on bottom another sand layer with *Katelysia*. *Hormomya* present with most *Katelysia*; other species rare.

SAMPLE 6: 1.66-1.56 m above bedrock.

Contents: Two internal layers: *Zeacumantus* predominant in a sandy matrix on top, *Eubittium* below. Arbitrary (Horizontal) datum line runs through this stratum at 1.57 m above bedrock.

SAMPLE 7: 1.56-1.29 m above bedrock.

Contents: Seven zones, topped by a rather resistant (slightly cemented?) matrix containing *Ostrea*, *Katelysia* and *Eubittium* in thin layer; *Katelysia* in sand matrix; *Clanculus dunkeri* in sand matrix; *Katelysia* predominant; *Clanculus dunkeri* predominant; thick band of *Katelysia* on bottom; *Katelysia* small (ca.]4 mm) throughout, and some are still hinged. Also present, more or less in all layers, are *Cominella eburnea* and *Macomona*, the latter also small.

SAMPLE 8: 1.29-1.21 m above bedrock.

Contents: Six internal layers, with *Eubittium* predominant throughout - hence the layer's red-brown colour. Top layer mainly *Eubittium*; next mainly *Katelysia*; then *Eubittium*; then a thin band of sand with some *Katelysia*; followed by a thin layer of *Eubittium*; and a thin layer of of mixed *Eubittium* and *Katelysia* on bottom. Other species are scarce, but include: *Mytilus*, *Homomya*, *Clanculus dunkeri*, *Dentimitrella*, *Haminoea tenera*, *Cominella eburnea* and *Austrocochlea odontis*.

SAMPLE 15: 0.25 m - bedrock.

Contents: Thick layer with large Katelysia (35 mm) and Hormomya predominant - about half of each species still hinged, and more adults than infants are present. Also common are Clanculus dunkeri, Homalina (ca 27 mm in size), Bullaria adults, and large Gazameda. Many other species are present, although in much smaller numbers than the above: Pleuroploca, Cominella eburnea, Thalotia, Bembicium, Cymatiella, Dentimitrella, Hipponyx, Niotha, Lyria, Floraconus segravei, Phasianotrochus, Phasianella (plus opercula), Austrocochlea constricta zebra, Zeacumantus, Equichlamys, Mytilus, Haliotis fragment, sea urchin, crab claws, chiton segment. Nearly all are in very good condition and retain much of their original colours. This stratum has both larger animals and greater variety than any subsequent strata; there are generally a greater portion of adults here as well.

APPENDIX A5.1

CANUNDA ROCKS CAMPSITE SURVEY DATA

Site No.	Molluscs *	No. of Shells *in situ*/scat.	Midden Area sq. Metres	% Area Sampled	Min. No. Animals
1	*Brachid.* 1,2,4	806/2566	6.5	50.0	1690±5%
2	*Plebid.* 1,2,4	5750/10705	84.2	9.4	8230±5%
3	*Plebid.* 1,4	3063/1869	28.5	2.6	2470±7%
4	*Brachid.* 1,3,4	---	7.0	---	---
5	*Dicathais* 2,3,4	total count	3.1	100.0	50
6	Flint	---	---	---	---
7	*Brachid.* 1,4	2640/594	3.1	31.8	1620±7%
8	*Brachid.* 1	---	.4	---	---
9	*Brachid.* 1,4	91/1003	3.1	15.9	550±10%
10	*Brachid.* 1,4	1947/1211	9.2	21.9	1580±7%
11	*Brachid.* 3	---	1.8	---	---
12	*Brachid.* 4	1302/3006	19.8	2.5	2150±7%
13	*Brachid.* 3,4	---	1.7	---	---
14	*Brachid.* 3,4	---	7.0	---	---
15	*Brachid.* 3,4	---	.2	---	---
16	*Plebidonax* 3	---	3.1	---	---
17	*Brachid.* 3,4	---	1.8	---	---
18	*Brachid.* 1	3217/--	2.9	12.0	1610±7%
19	*Plebid.*	1348/--	4.9	10.0	680±7%
20	*Plebid.* 3	---	12.6	---	---
21	*Subn/Cellana* 3,4	---	3.1	---	---
22	*Plebid.* 3	---	12.6	---	---
23	*Plebid.* 3,4	---	2.0	---	---
24	*Subninella* 1,3,4	194/--	5.9	42.0	200±5%
25	*Subninella* 1,3,4	---	6.3	---	---
26	*Brachid.* 3,4	---	3.9	---	---
27	*Brachid.* 3,4	---	2.4	---	---
28	*Brachid.* 3	---	3.1	---	---
29	*Brachid.* 4	---	2.4	---	---
30	*Cellana/Subn.* 1,3,4	---	1.7	---	---
31	*Plebidonax* 3,4	---	11.8	---	---
32	*Brachid.* 1,4	475/--	1.7	33.0	420±7%
33	*Plebid.* 3,4	---	12.5	---	---
34	*Cellana/Subn.* 3,4	---	1.7	---	---
35	*Subn/Cellana*	total count	2.9	100.0	206/53
36	*Plebid.* 3,4	---	7.8	---	---
37	*Plebid.* 3	---	3.1	---	---
38	*Plebid.* 1,3,4	--/1764	6.3	4.0	880±7%
39	*Plebid.* 1,2,4	1088/4320	19.3	5.0	2700±7%
40	*Plebid.* 3,4	--/1618	7.1	8.0	810±7%
41	*Plebid.* 3,4	--/1884	9.4	3.0	940±7%
42	*Plebid.* 3	--/884	3.3	7.5	440±7%
43	*Plebid.* 1,2,4	510/512	4.7	21.0	510±7%
44	*Plebid.* 1,4	966/2124	14.1	5.3	1550±7%
45	*Plebid.* 1,2	3384/902	9.4	10.6	2140±5%
46	*Plebid.*	7144/--	9.4	5.3	3570±7%
47	*Plebid.* 1	1680/--	2.1	23.8	840±5%
48	*Plebid.* 1,2,4	1398/4896	11.7	4.2	3150±7%
49	*Plebid.* 3,4	--/3014	13.7	1.8	1510±7%
50	*Plebid.* 1,3,4	---	.7	---	---
51	*Plebid.* 3,4	---	3.1	---	---
52	*Plebid.* 1,2,4	4102/--	3.9	19.0	2050±7%

Site No.	Molluscs *	No. of Shells *in situ*/scat.	Midden Area sq. Metres	% Area Sampled	Min. No. Animals
53	*Plebid.* 1,4	706/350	1.5	17.0	530±7%
54	*Plebid.* 1,3,4	---	1.1	---	----
55	*Plebid.* 1,2,4	1094/4084	7.0	14.0	2590±5%
56	*Plebid.* 1,4	4688/--	12.5	4.0	2340±5%
57	*Plebid.* 1	2835/--	7.0	9.0	1420±5%
58	*Plebid.* 3,4	---	4.9	---	----
59	*Brachid.* 1,4	4948/517	8.2	9.0	2730±5%
60	*Brachid.* 1,4	---	1.1	---	----
61	*Subn/Cellana* 1,4	---	1.6	---	----
62	*Brachid.* 1,3,4	---	4.7	---	----
63	*Cellana/Brach.* 3	total count	.4	100.0	60/35
64	*Cellana* 3,4	total count	.5	100.0	75
65	*Brachid.* 3,4	---	3.7	---	----
66	*Plebid.* 3,4	---	4.7	---	----
67	*Plebid.* 3	---	3.1	---	----
68	*Plebid.* 1,3,4	---	2.3	---	----
69	*Plebid.* 1,3	---	1.5	---	----
70	*Plebid.* 1,3,4	---	4.9	---	----
71	*Plebid.* 3	---	3.1	---	----
72	*Plebid.* 3,4	---	3.1	---	----
73	*Plebid.* 3,4	---	2.3	---	----
74	*Subninella* 3	---	3.1	---	----
75	*Plebid.* 3,4	---	---	---	----
76	*Haliot/Subn.* 3	---	1.5	---	----
77	*Plebid.*	---	2.0	---	----
78	*Plebid.* 3,4	---	6.3	---	----
79	*Plebid.* 1,4	2250/--	10.0	7.5	1125±20%
80	*Plebid.* 3,4	---	---	---	----
81	*Brachid.* 1	1288/--	3.1	24.0	644±7%
82	*Cellana* 3,4	---	1.0	---	----
83	*Brach/Pleb.* 3	---	.5	---	----
84	*Plebid.* 3	--/198	3.1	16.0	100±7%
85	*Plebid.* 3,4	--/148	3.1	16.0	70±10%
86	*Brachid.* 3,4	--/302	6.3	12.0	150±10%
87	*Cell/Sub/Brach.* 3	--/110	1.1	45.0	110
88	*Cell/Sub/Brach.* 3	--/110	1.1	45.0	110
89	*Plebid.* 3,4	--/2122	7.8	6.0	1060±7%
90	*Plebid.* 3,4	1092/--	7.8	10.0	550±7%
91	*Brachid.* 1,4	100/--	2.0	12.0	50±7%
92	*Plebid.* 3	---	9.3	---	----
93	*Plebid.* 1,3,4	--/166	2.3	21.0	80±7%
94	*Plebid.* 1	3494/--	6.2	4.0	1750±7%
95	*Plebid.* 4	714/--	2.1	23.0	360±7%
96	*Plebid.* 4	754/-	2.3	21.0	380±7%
97	*Brachid.* 3,4	--/1178	3.1	16.0	590±7%
98	*Plebid.* 4	1470/--	4.9	10.0	740±10%
99	*Plebid.* 3,4	--/1638	11.7	6.0	820±7%
100	*Plebid.* 3	--/936	3.9	13.0	470±7%
101	*Plebid.* 1,4	4212/--	11.7	6.0	2110±5%
102	*Plebid.* 1,4	1034/--	4.7	16.0	520±5%
103	*Plebid.* 1,4	1092/--	3.9	13.0	550±5%
104	*Plebid.* 3	--/710	7.1	3.5	360±5%
105	*Plebid.* 3,4	--/558	3.1	8.0	280±5%

Site No.	Molluscs	*	No. of Shells *in situ*/scat.	Midden Area sq. Metres	% Area Sampled	Min. No. Animals
106	*Plebid.*	3,4	--/132	1.1	23.0	70±5%
107	*Plebid.*	3,4	--/132	1.1	23.0	70±5%
108	*Plebid.*	3,4	--/204	1.7	28.0	100±5%
109	*Plebid.*	3,4	--/252	1.5	31.0	130±5%
110	*Plebid/Subn.*	1,3	----	---	---	40/30
111	*Pleb/Subn.*	1,3	total count	---	---	40/30
112	*Plebid.*	3	--/568	7.1	3.5	280±7%
113	*Plebid.*	3	--/138	2.3	10.0	70±7%
114	*Plebid.*	3,4	--/120	.8	31.0	60±7%
115	*Brachid.*	3,4	--/600	3.1	8.0	300±10%
116	*Sub/Cell/Pleb/Brach* mixed			---	---	----
117	*Brachid.*	1,4	4312/--	19.6	3.0	2160±7%
118	*Subn/Halio/*Chi ton	3	----	3.1	16.0	60/6/5
119	*Cellana/Subn.*	3	--/170	3.1	8.0	85/85
120	*Cellana/Subn.*	3	--/220	3.1	8.0	110/110
121	*Brachid.*	3,4	---	50.2	---	1000±20%
122	*Subninella*	1,3	--/284	7.1	3.5	280±7%
123	*Plebid.*	1,4	80/1130	11.7	6.4	600±10%
124	*Plebid.*	1,4	32/296	3.9	12.8	160±7%
125	*Subninella*	1,3,4	---	7.1	---	200±20%
126	*Subninella*	1,3,4	---	7.1	---	200±20%
127	*Subninella*	1,3,4	---	7.1	---	200±20%
128	*Subninella*	1,3,4	---	7.1	---	200±20%
129	*Subninella*	1,3,4	---	7.1	---	200±20%
130	*Plebid.*	3,4	---	9.4	---	150±20%
131	*Plebid.*	3,4	---	9.4	---	150±20%
132	*Plebid.*	1,4	936/--	3.9	12.8	150±20%
133	*Plebid.*	1,3,4	--/5652	15.7	3.0	2830±7%
134	*Plebid.*	1,4	5254/--	12.5	6.0	2630±7%
135	*Plebid.*	3,4	--/1704	7.1	3.5	850±10%
136	*Plebid.*	3,4	--/1704	7.1	3.5	850±10%
137	*Plebid.*	3,4	--/1704	7.1	3.5	850±10%
138	*Plebid.*	3	--/1382	3.1	16.1	690±7%
139	*Subninella*	3	--/750	12.5	2.0	750±7%
140	*Plebid.*	1,3,4	--/2520	9.4	5.3	1260±7%
141	*Plebid.*	3	--/2808	11.7	2.1	1400±5%
142	*Plebid/Subn.*	3	----	28.6	---	600/80±20%
143	*Thais/Cellana*	4	--/200	7.1	---	200±20%
144	*Plebid.*	1,4	352/--	1.6	15.6	180±5%
145	*Plebid.*	3,4	--/198	1.7	14.7	100±7%
146	*Hormomya*	3	--/520	3.8	---	260±7%
147	*Subninella*	3	--/470	4.6	---	470±10%
148	*Brachid.*	3	----	14.5	---	----
149	*Plebid.*	3,4	--/558	3.1	8.0	280±10%
150	*Plebid.*	3,4	--/558	3.1	8.0	280±10%
151	*Plebid.*	1,3,4	--/558	3.1	8.0	280±10%
152	*Plebid.*	1,3,4	--/558	3.1	8.0	280±10%
153	*Plebid.*	3,4	--/558	3.1	8.0	280±10%
154	*Brachid.*	1,4	712/--	1.6	31.2	360±10%
155	*Plebid.*	3	--/570	1.5	33.3	290±10%
156	*Plebid.*	3,4	----	---	---	----
157	*Brachid.*	1,3,4	----	---	---	----
158	*Plebid.*	3	----	---	---	----
159	*Plebid.*	3,4	----	1.0	---	170±20%

Site No.	Molluscs	*	No. of Shells *in situ*/scat.	Midden Area sq. Metres	% Area Sampled	Min. No. Animals
160	*Plebid.*	3,4	---	1.0	---	170±20%
161	*Plebid.*	3,4	---	1.0	---	170±20%
162	*Plebid.*	3,4	---	1.0	---	170±20%
163	*Plebid.*	3,4	---	1.0	---	170±20%
164	*Plebid.*	4	---	1.0	---	170±20%
165	*Brachid.*	1,4	1536/384	7.1	7.0	960±7%
166	*Brachid.*	1,4	1008/413	7.1	7.0	710±7%
167	*Brachid.*	1,4	864/354	7.1	7.0	610±7%
168	*Brachid.*	1	1176/--	1.2	33.3	590±7%
169	*Brachid.*	3	--/2624	3.2	1.8	1310±10%
170	*Brachid.*	1	3822/4239	19.6	2.5	4030±10%
171	*Brachid.*	1,4	6080/7872	19.6	3.8	6980±10%
172	*Brach/Cellana*	1,4	1408/--	9.4	5.3	720/140
173	*Subninella*	1,3	---	14.6	---	---
174	*Brachid.*	1,4	10792/-	7.1	7.0	5400±7%
175	*Brachid.*	1	6580/--	4.7	10.6	3290±7%
176	*Brachid.*	1,3	---	.4	---	---
177	*Brachid.*	1,4	1888/--	1.6	31.2	940±7%
178	*Plebid.*	1,4	734/--	2.7	9.2	370±7%
179	*Plebid.*	1,3,4	---	1.4	---	---
180	*Plebid.*	1,3,4	272/738	4.9	5.1	500±10%
181	*Brachid.*	4	380/814	4.7	10.6	600±10%
182	*Dicathais*	1	244/--	4.7	10.0	240±7%

* Observations

1=Charring of Shell
2=Excavated
3=Scattered or Disturbed Deposit
4=Stone Artefacts Associated

Molluscan species list

Clam
Plebidonax deltoides

Mussel
Brachidontes rostrata
Hormomya erosa

Gastropod
Subninella undulata
Cellana tramoserica
Dicathais textilosa
Haliotis cf. ruber

Chiton
Poneroplax albida

APPENDIX A5.2

CHARCOAL/SHELL DATING PROGRAMME FOR SOUTH AUSTRALIA

Precision in dating individual occupations in shellmiddens depends upon a positive association between the hearth charcoal and the shellfish cooked in the hearth. This crucial relationship may not be well preserved in the harsh depositional environment near coastlines. There, for example, charcoal can find its way into older deposits or be selectively removed and reworked (Hughes and Sullivan, 1974). Given these possibilities of disturbance, the shellfish often survive as the only archaeological indicator of occupation from which a date may be obtained. The objective of this dating project has been to investigate the suitability for dating of shellfish commonly consumed in the Lower South East of South Australia. The basis for a positive association between charcoal and shellfish rests in the fact that cooking hearths and their refuse are well preserved as discrete depositional units in which post-depositional disturbance is minimal.

The reliability of marine molluscs for providing "true" radiocarbon ages is unclear owing to the uncertainty of the C^{14} equilibrium reached between oceanic and atmospheric environments (Olson, 1963; Rafter, 1968; Rafter and O'Brien, 1972; Taylor and Berger, 1967). This uncertainty is particularly acute in estuarine and lagoon systems where circulation is greatly impeded and concentrations of carbonates in solution may occur. In addition, postmortem contamination of the shell carbonates by recrystalization provides another source of possible dating error (Gillespie and Polach, 1976). Measurements on the radioactivity of pre-1950 shell from the northern hemisphere indicate an average age for "modern" shell ranging from 410 to 740 years according to latitude (Mangerud and Gilliksen, 1975). More recent research from South East Australia provides a correction value of 450±35 years as determined from dating of pre-1950 marine molluscs collected from several localities at southern latitudes, including Tasmania (Gillespie and Polach, 1976). Techniques are improving for the evaluation of post-depositional contamination, making it possible to avoid some suspect samples. Therefore the documentation of the reliability of marine shells for dating is showing encouraging results.

It is reasonable to suspect that C^{14} disequilibrium in shell may vary according to habitats. This may be so due to changing contributions from offshore and terrestrial nutrients, including carbonates in solution and other fossil detritus ingested during periods of high turbidity and surface runoff. Since it has been established that at least certain molluscs incorporate carbonates directly from oceanic waters independent of metabolic processes (Wilbur, 1960), more ancient carbonates would have an effect upon the apparent radiocarbon age. Changing oceanographic features, such as submarine topography and current flow, may induce different inputs of more ancient deep waters inshore through time, which would differentially influence the radioactivity measured. For these reason, corrections in apparent C^{14} ages may more precisely correlate with particular marine habitats rather than with oceanic averages. A detailed description of these habitats is provided here to document the correlations in so far as knowledge exists.

(a) Sampling stragegy

The most common shellfish in the diet of the South East are *Subninella undulata*, *Brachidontes rostratus*, *Plebidonax deltoides*, and *Hormomya erosa*. Except for *Subninella*, the three remaining shellfish are deposited in small, monospecific heaps, each clearly distinguished one from another. With a central hearth surrounded by undisturbed food refuse, it is reasonable to assume that these heaps represent single meals in which the molluscs died together. Where middens containing *Subninella* and other reef gastropods accumulated during a series of occupations, meals are stratigraphically separated and can be isolated by careful excavation.

Shells in the hearth and below the midden surface were collected for dating. Only charcoal found in association with a clearly defined hearth was collected for dating and to further assure association, only shell of the species found charred in the hearth was collected. In this way, every effort was made to guarantee association between shell and charcoal. Where disagreement in ages exists therefore, it may reflect use of ancient wood for cooking, but is more likely to be caused by unequal distribution of ^{14}C in nature with respect to the sea or post-depositional contamination.

(b) Measurements

The dates for the pairs appear below arranged by species and site. A dental drill was used to remove external shell layers, and the remaining internal material was examined for evidence of recrystalization (XRF). None was detected by the radiocarbon laboratory (J. Head, pers. comm.).

APPENDIX A5.2 (Cont.)

CHARCOAL		*Subninella undulata*		Shell Minus Charcoal ± error *	Site
ANU-1238	350±70BP	ANU-1243	1190±110BP	840±130	Abyssinia Bay
ANU-1171	1030±80BP	ANU-1242	1550±80BP	520±113	Abyssinia Bay
ANU-1244	650±90BP	ANU-1240	1250±90BP	600±127	Nora Creina Shelter
ANU-1245	1160±70BP	ANU-1241	1670±70BP	510±99	Cameron Rock
				596±58 **	
CHARCOAL		*Brachidontes rostratus*			
ANU-1231	2990±70BP	ANU-1232	3250±90BP	260±114	Canunda Rock
ANU-1487	2590±75BP	ANU-1488	2830±120BP	240±141	Inland Camps
				252±89 **	
CHARCOAL		*Plebidonax deltoides*			
ANU-1233	3800±90BP	ANU-1234	4140±80BP	340±120	Canunda Rock
ANU-1545	3870±80BP	ANU-1483	4560±85BP	690±116	Mounce and Battye Rock
				521±83 **	
CHARCOAL		*Hormomya erosa*			
ANU-1246	3150±80BP	ANU-1484	4420±150BP	1270±170	Boomaroo Park Midden
ANU-1169	1590±70BP	ANU-1239	2990±90BP	1400±114	Domaschenz Ridge
				1360±95 **	

* ($A-B \pm \sqrt{a^2 + b^2}$) after Polach and Golson, 1972)
** (pooled mean after Polach, 1969)

TABLE A5.2 Results of Radiocarbon dates from Paired Shell and Charcoal samples

(c) Habitat Descriptions

Subninella undulata, (Common Warrener or Wavy Turbo), inhabits exposed marine reefs and rock pools at and below mid-tide. Adult snails are mobile herbivores favoring sublittoral platforms at depth, although upward seasonal migration is expected. Small numbers of young inhabit sunlit rock pools which are periodically stranded by the tide, thereby experiencing rapid temperature and salinity changes within a particular setting. Southern temperate distribution of the species is indicated, presumably limited by sea temperatures (Underwood, 1974). Species is common in South Australia (Cotton, 1959).

Brachidontes rostratus, (Beaked Mussel), inhabits fully exposed marine reefs and rocky foreshores at mid-tide, where, as a sessile herbivore, it feeds only during submersion. The animal has a low tolerance to fresh-water, requires a stable substrate for attachment, and probably is stressed by sediments in suspension. The mussel is almost locally extinct and was previously known as Austromytilus rostratus (Cotton, 1961), but the term Brachidontes is preferred (Macpherson and Gabriel, 1962).

Plebidonax deltoides, (Goolwa Cockle), inhabits fully exposed sandy surf beaches at low water mark, where as a filter feeder, it is locally mobile under the influence of longshore currents. It displays a low tolerance to saline dilution although world wide evidence indicates a strong affinity for seasonally punctuated freshwater flooding via river or lagoon systems. Both food intake and reproductive behaviour are affected by terrestrial runoff. Uninterrupted exposure to diluted sea water may prove fatal, but prolonged, intermittent brackish conditions in the habitat have been described in South Australia (King, pers. comm.) and elsewhere (Wade, 1968). Despite vigorous interaction with the oceanic environment, this animal's C^{14} is constantly derived from terrestrial reservoirs of unknown equilibrium during periods of greatest growth. Species is locally extinct, but is widespread in warmer South Australian waters.

Hormomya erosa, (Rough Beaked Mussel), inhabits sheltered bay and lagoon settings at mid-tide on rocks and reefs, which it colonizes in number. It favors calm waters where circulation with open tidal conditions may be impeded and therefore would tolerate brackish conditions. In Tasmania, the animal is affiliated with esturarine settings close to open ocean localities. This locally extinct mollusc has been described by Cotton (1961) for South Australia, and by Macpherson and Gabriel (1967) for Victoria.

(d) Conclusions

It can be seen from the above information that the first three molluscs do not share the same habitat. Brachidontes and Subninella may be neighbors on the same rocky foreshore (Bennett and Pope, 1952; Womersley and Edmonds, 1958:236), but the former is strictly intertidal while the latter is chiefly subtidal. Plebidonax on the other hand inhabits a sandy environment into which free carbonates are introduced from seasonal floodwaters, and these may in turn bathe inshore communities. In South Australia, these carbonates are derived from ancient shell sands deposited on the coastal plain by aeolian and beach-forming processes (Sprigg, 1952; Blackburn et al, 1965). Therefore despite the fact that these three species reside in an open oceanic environment and so are ideal candidates for dating, an adjustment of their apparent radiocarbon ages by a single correction value is inappropriate for the aims of this project. The following list summarizes these conclusions.

1) As predicted from oceanic/atmospheric C^{14} disequilibria, all shell ages are older than those from associated charcoal.
2) As expected, a great discrepancy exists between the ages of molluscs inhabiting closed aquatic systems and ages of associated charcoal.
   Therefore Hormomya is an unsuitable candidate for correction according to current best estimates (Gillespie and Polach, 1976)
3) The averages of the pooled mean error of the three remaining molluscs, Plebidonax, Brachidontes, and Subninella, agree with correction values proposed by Gillespie and Polach, i.e. 450±35 years. (596+252+521) divided by 3 equals 456 years.
4) Brachidontes may be the more reliable indicator of age once correction factors become available from additional dating.
5) That despite 3) above, and although further measurements are required from this shoreline, these results suggest that correction of apparent C^{14} ages of marine molluscs may more precisely correlate with particular marine habitats rather than with oceanic averages.

APPENDIX A5.3

LIST OF REFUSE FROM ABYSSINIA BAY MIDDEN BY LEVEL

	FS30.1	FS.31.1	FS32.1	FS33.1	FS34.1	TOTAL
Subninella undulata	143	216	47	198	159	763
Subninella opercula	150	200	89	160	61	660
Dicathais textilosa	2	5	1	8	2	18
Patelloida alticostata	0	14	4	2	1	21
Patellanax peroni	0	0	0	1	1	2
Cellana tramoserica	0	1	0	0	0	1
Haliotis ruber	2	4	4	2	0	12
Austrocochlea constricta	0	3	4	5	0	12
A. adelaidae	4	2	0	2	0	8
A. concamerata	3	0	0	1	0	4
A. odontis	0	0	0	0	2	2
Poneroplax albida	5	11	4	15	5	40
Jasus mouth parts	1	3	2	1	1	8
Crab parts	0	0	0	0	1	1
Flint (wt. in grams)	50gr.	310gr.	225gr.	451gr.	288gr.	1324gr.

	FS30.2	FS31.2	FS32.2	FS33.2	FS34.2	TOTAL
Subninella undulata	350	285	85	571	421	1712
Subninella opercula	281	321	169	559	238	1568
Dicathais textilosa	0	4	0	8	0	12
Patelloida alticostata	0	0	1	4	0	5
Patellanax peroni	0	2	1	3	0	6
Haliotis ruber	0	0	0	2	3	5
Austrocochlea constricta	2	0	0	6	0	8
A. adelaidae	10	2	0	0	1	13
A. concamerata	1	0	0	0	1	2
A. odontis	0	0	0	0	1	1
Melanerita melanotragus	0	0	0	0	1	1
Austrosipho waitei	0	1	1	0	0	2
Pleuroplax australasia	0	1	0	0	0	1
Poneroplax albida	16	17	12	67	5	117
Jasus mouth parts	1	0	1	2	1	5
Crab parts	0	0	0	3	0	3
Flint (wt. in grams)	420gr.	91gr.	100gr.	655gr.	543gr.	1809gr.

	FS30.3	FS31.3	FS32.3	FS33.3	FS34.3	TOTAL
Subninella undulata	915	982	517	1202	984	4600
Subninella opercula	1220	747	258	1375	864	4464
Dicathais textilosa	14	6	1	10	2	33
Patelloida alticostata	35	0	0	0	0	35
Patellanax peroni	0	0	0	1	0	1
Cellana tramoserica	25	1	0	0	1	27
Haliotis ruber	4	2	1	2		9
Austrocochlea constricta	40	1	0	5	0	46
A. adelaidae	0	1	0	7	1	9
A. concamerata	28	3	0	4	0	35
A. odontis	15	1	3	6	0	25
Melanerita melanotragus	0	0	0	2	0	2
Austrosipho waitei	1	1	1	0	0	3
Poneroplax albida	3	2	2	43	4	53
Jasus	0	1	2	6	3	12
Crab parts	0	0	0	2	0	2
Flint (wt. in grams)	1458gr.	1161gr.	500gr.	525gr.	3023gr.	6667gr.

APPENDIX A5.3 (Cont.)

	FS3	FS15.4-18.4	FS19.1	FS20.1	FS25.3	FS28.3
Subninella undulata	938	886				
Subninella opercula	1046	910	265	174	201	130
Dicathais textilosa	5	17				
Patelloida alticostata	52	31				
Patellanax peroni	6					
Cellana tramoserica	1	9				
Haliotis ruber	1	2				
Austrocochlea constricta	4	1				
A. adelaidae	22	4				
A. concamerata	9	19				
A. odontis	5	3				
Cominella lineolata	2					
Pleuroploca australasia	4	1				
Poneroplax albida	18					
Jasus mouth parts	1	4				
Crab parts						
Flint	200gr.	3490gr.				

LIST OF NUMBER OF SHELLS FOR EACH EXCAVATION LEVEL AT DOMASCHENZ RIDGE MIDDEN

Grids 1 & 2

Molluscs	FS1.1	FS1.2	FS.1.3	FS2.1	FS2.2	FS.2.3	FS.2.4	FS2.5
Subninella undulata	4	13	0	2	3	17	1	0
Subninella opercula	3	23	0	1	5	38	1	0
Dicathais textilosa	1	0	0	0	1	2	0	0
Hipponyx conicus	3	0	0	0	0	27	3	0
Zeacum. diemenensis	0	6	0	0	3	36	0	0
Hormomya erosa	1	19	1	5	15	270	4	7
Katelysia spp.	0	72	1	10	5	243	8	14
Ostrea angasi	0	9	0	2	1	15	0	0
Mytilus planulatus	0	3	0	0	0	6	1	1
Dentimitrella spp.	0	0	0	0	0	3	0	0
Equichlamys bifrons	0	2	0	0	0	0	0	0

Grids 3 & 4

Molluscs	FS3.1	FS3.2	FS3.3	FS3.4	FS3.5	FS4.2	FS4.3
Subninella undulata	2	3	6	5	0	2	11
Subninella opercula	0	3	31	4	0	10	8
Dicathais textilosa	0	0	0	0	0	0	0
Hipponyx conicus	1	0	0	5	0	0	2
Zeacum. diemenensis	0	0	26	2	1	0	2
Hormomya erosa	0	15	65	40	12	0	152
Katelysia spp.	13	6	297	29	8	2	31
Ostrea angasi	2	1	4	2	0	0	5
Mytilus planulatus	1	0	6	4	0	0	3
Equichlamys bifrons	0	0	1	0	0	0	0
Fulvia tenuicostata	0	0	1	0	0	0	0
Isoclanculus dunkeri	0	0	0	0	0	0	1

Grids 5 & 6

Molluscs	FS5.2	FS5.3	FS5.3A	FS5.4	FS6.2	FS6.3	FS6.3A	FS6.4
Subninella undulata	3	11	15	0	13	7	11	3
Subninella opercula	7	10	14	0	10	25	14	1
Hipponyx conicus	0	5	46	0	2	9	8	0
Zeacum. diemenensis	2	2	111	0	0	20	29	2
Hormomya erosa	12	66	234	5	17	163	351	40
Katelysia spp.	9	35	97	5	27	25	93	19
Ostrea angasi	2	8	4	1	6	3	4	1
Mytilus planulatus	0	2	6	1	1	5	3	5
Equichlamys bifrons	0	1	0	0	0	0	0	1
Dentimitrella spp.	0	0	12	0	0	0	3	0
Isoclanculus dunkeri	0	0	6	0	0	0	0	0

Grids 7 & 8

Molluscs	FS7.1	FS7.2	FS8.1-3
Subninella undulata	6	7	traces
Subninella opercula	1	1	only
Hormomya erosa	1	4	
Katelysia spp.	2	4	
Ostrea angasi	0	1	
Mytilus planulatus	0	4	
Equichlamys bifrons	0	1	

APPENDIX A5.5

TABLE OF ESTIMATES OF MINIMUM NUMBER OF ANIMALS AT NORA CREINA SHELTER BY GRID LEVEL

Test Pit 1972

Molluscs	FS1.2	FS1.3	FS1.4	FS1.5	FS1.6	FS1.7	FS1.8
Subninella undulata	134	268	97	147	111	108	64
Subninella opercula	101	476	460	104	85	59	46
Dicathais textilosa	2	6	3	20	7	0	1
Patelloida alticostata	50	200	6	194	28	2	0
Patellanax peroni	1	19	1	47	5	4	3
Patellanax squamifera	4	0	0	4	0	0	0
Hipponyx conicus	7	72	74	87	26	11	10
Cellana tramoserica	2	0	0	6	0	0	0
Haliotis ruber	1	1	0	3	0	0	0
Austrocochlea odontis	0	63	16	15	2	3	5
A. concamerata	0	1	1	3	3	0	0
A. adelaidae	3	9	0	4	0	1	3
A. constricta	0	3	0	4	0	0	0
Melanerita melanotragus	0	0	2	4	3	0	0
Cominella lineolata	0	2	1	5	1	0	0
Austrosipho waitei	0	1	0	4	0	0	0
Pleuroploca australasia	3	0	1	7	1	0	0
Zeacumantus diemenensis	2	4	0	3	0	0	1
Poneroplax albida	2	11	3	17	8	2	2
Brachidontes rostratus	0	0	1	2	0	0	0
Hormomya erosa	1	4	1	3	0	1	1
Katelysia spp.	3	13	3	2	3	8	10
Ostrea angasi	1	1	0	2	0	1	0

Vertebrates

FS 1.2: humerus, small rodent; canine, seal; ulna, seal; mandible frag. Trichosurus vulpecula; humerus, macropid.

FS 1.7: humerus, Macropus; lower incisor, small marsupial; 109 fish vertebrae and numerous spine fragements and scales; 3 fish mandibles (not mullet).

FS 1.8: numerous fish vertebrae, spines, unidentifiable; mandible, Tiliqua rugosa; mandible, Amphibolurus sp. (cf. muricatus).

Grid 2

Molluscs	FS2.1	FS2.2	FS2.2A	FS2.3	FS2.3B	FS2.4	FS2.4B	FS2.5	FS.2.6B
Subninella Undulata	7	6	3	25	12	6	6	22	216
Subninella opercula	6	6	5	25	24	5	0	12	293
Dicathais textilosa	0	0	0	1	3	0	0	0	8
Patell. alticostata	3	5	2	5	8	2	0	3	3
Patellanax peroni	0	1	0	1	0	1	0	0	3
Hipponyx conicus	1	0	6	7	8	0	0	2	88
Cell. tramoserica	0	0	0	0	0	0	0	0	0
Haliotis ruber	1	0	0	0	0	0	0	1	1
Austro. odontis	3	7	1	11	17	2	0	4	0
A. concamerata	1	0	0	0	0	0	0	1	0
A. adelaidae	1	1	0	3	1	2	0	2	0
A. constricta	1	1	1	5	11	3	0	3	0
Melan. melanotragus	1	3	0	0	1	0	0	1	0
Poneroplax albida	1	3	1	3	2	0	0	1	14
Katelysia spp.	2	1	1	0	0	0	0	0	0

	FS2.7	FS2.8B	FS2.8	FS2.9B	FS2.10	FS.2.11	FS2.12	FS2.13
Subninella undulata	73	15	9	59	54	62	75	--
Subninella opercula	36	14	11	35	29	22	44	14
Dicathais textilosa	2	1	0	0	1	0	1	0
Patell. alticostata	5	11	2	4	11	18	7	2
Hipponyx conicus	0	0	0	7	9	7	12	5
Haliotis ruber	1	0	1	0	0	0	1	0
Austro. adontis	2	1	0	0	6	13	12	3
Austro. concamerata	1	2	0	0	0	1	1	0
A. adelaidae	1	6	0	00	7	0	2	0
A. constricta	0	8	0	0	2	1	27	8
Melan. melanotrangus	2	1	0	0	0	0	0	0
Zeacuman. diemenensis	0	0	0	0	1	0	2	0
Poneroplax albida	2	5	0	2	5	1	4	1
Katelysia spp.	0	0	0	1	0	0	0	1

FS2.13; fragment, sea urchin

Vertebrates

FS2.3B: maxilla fragment, Rattus lutreolus
FS2.5: scapula, seal
FS2.6B: right mandible, Pseudocheirus peregrinus; canine, human; metatarsal Macropus.
FS2.8: vertebra, fish
FS2.8B: one fish scale
FS2.9B: vertebral fragments, fish; one skull fragment, fish (not mullet)
FS2.10: four parasphenoid bones, equal small size, Mugil foresteri; two interoperculur bones, fish; four reptilian bones, unidentiable.
FS2.12: one parasphenoid fragment, Mugil cf. foresteri; 5 fish scales; one interopercular, Mugil cf. foresteri; one interopercular fragment, fish.
FS2.13 seven complete parasphenoid bones (six are small), Mugil foresteri; six interopercular bones, fish; one skull fragment, fish (not mullet); six scales, fish.

APPENDIX A5.5 (Cont.)

Grid 3

Molluscs	FS3.1	FS3.2	FS3.3	FS3.3A	FS3.4	FS3.4A	FS3.5	FS3.6	FS3.7A
Subninella undulata	9	12	25	39	109	14	47	63	28
Subninella opercula	9	--	8	--	20	13	--	--	1
Dicathias textilosa	0	0	0	2	2	0	0	1	0
Patell. alticostata	1	3	8	6	13	3	0	0	1
Hipponyx conicus	0	0	6	0	3	4	0	0	1
Haliotis ruber	0	0	1	1	0	0	0	0	0
Austro. odontis	0	0	6	0	19	5	0	0	0
A. concamerata	0	0	0	0	0	1	0	0	3
A. adelaidae	0	0	0	1	0	0	0	1	3
A. constricta	0	0	3	0	1	0	0	0	0
Pleuro australasia	0	0	0	2	1	0	0	0	0
Austrosipho waitei	0	0	1	0	1	0	0	0	0
Zeacum. diemenensis	0	0	0	0	1	1	0	0	1
Poneroplax albida	1	0	0	0	2	1	0	0	1
Hormomya erosa	0	0	0	0	1	1	0	0	1
Katelysia spp.	1	0	5	0	0	2	0	0	3

Crustacean

FS3.1 Jasus, mandible
FS3.3 Jasus, mandible; crab claw

Invertebrates

FS3.6: one interopercular, Mugil cf. foresteri; one large skull, fish (not mullet); numerous fish postcranial fragments.

FS3.7A: numerous fish postcranial fragments.

FS3.7: pelvis fragment, small rodent.

Grid 4

Molluscs	FS4.1	FS4.2	FS4.3	FS4.4	FS4.5	FS4.6	FS4.7	FS4.8
Subninella undulata	21	104	50	48	24	39	48	23
Subninella opercula	41	67	58	57	46	44	26	24
Dicathais textilosa	1	1	3	1	1	1	0	0
Patelloida alticostata	9	8	27	17	16	7	8	7
Hipponyx conicus	12	16	15	0	17	30	4	1
Cellana tramoserica	2	1	0	0	0	0	0	0
Haliotis ruber	1	1	1	0	0	1	0	0
Austro. constricta	2	2	4	1	1	0	2	5
A. adelaidae	1	1	2	5	1	0	0	5
A. concamerata	1	1	3	4	1	0	1	0
A. odontis	3	15	21	6	5	0	0	4
Melan. melanotragus	0	1	0	0	0	0	0	0
Austrosipho waitei	0	2	0	0	0	0	0	0
Pleurop. australasia	1	2	0	0	0	0	0	0
Zeacum. diemenensis	2	0	0	0	1	4	0	0
Poneroplax albida	1	5	0	2	2	4	2	1
Hormomya erosa	3	0	0	4	2	1	1	1
Katelysia spp.	15	13	14	3	5	18	85	11
Ostrea angasi	0	1	0	0	0	0	1	0

Grid 4 (Cont.)	FS4.8A	FS4.9A	FS4.10	FS4.10A	FS4.11A	FS4.12
Subninella undulata	55	41	10	27	29	17
Subninella opercula	35	79	18	48	24	11
Dicathais textilosa	4	0	0	0	1	0
Patelloida alticostata	4	8	0	4	0	1
Hipponyx conicus	0	13	3	4	0	0
Cellana tramoserica	0	0	0	1	0	0
Haliotis ruber	0	0	0	1	0	0
Austroc. constricta	10	3	0	7	0	0
A. adelaidae	8	0	1	11	0	2
A. concamerata	0	2	0	0	3	0
A. odontis	4	3	2	1	0	5
Melan. melanotragus	2	0	0	0	1	0
Austrosipho waitei	0	1	0	0	0	1
Pleurop. australasia	0	0	0	2	0	0
Zeacum. diemenensis	8	2	1	4	0	0
Poneroplax albida	3	3	1	1	1	1
Hormomya erosa	1	2	0	1	4	0
Katelysia spp.	0	8	2	79	48	0
Ostrea angasi	0	1	0	1	0	0
Gazameda iredalei	1	0	0	0	0	0
Brachidontes rostratus	0	3	0	0	0	0

Jasus mandibles: FS4.2 (2); FS4.5 (2)
Sea urchin frags: FS4.10A

Vertebrates

FS4.7: Premolar, macropod
FS4.9A: Vertebral elements, fish
FS4.10: scales, vertebral elements, fish
FS4.11A: scales, vertebral elements, fish; large fish vertebra (not mullet).
FS4.12: scales and vertebral elements, fish; mandible frag., Dasyurus cf. viverrinus.

Grid 5

Molluscs	FS5.1	FS5.2	FS5.3	FS5.4	FS5.4A	FS5.5	FS5.6	FS5.7A
Subninella undulata	16	31	55	17	5	43	7	18
Subninella opercula	26	61	67	25	8	76	20	18
Dicthais textilosa	2	0	0	0	1	0	1	4
Patelloida alticostata	11	18	14	5	5	0	2	3
Patellanax peroni	1	1	1	0	6	0	0	0
Hipponyx conicus	0	29	15	9	2	31	4	2
Haliotis ruber	0	0	0	0	0	1	0	1
Austro. constricta	1	10	6	4	1	1	0	0
A. adelaidae	1	6	2	2	1	1	0	4
A. concamerata	1	3	2	0	0	3	1	3
A. odontis	6	17	17	6	1	9	3	3
Melan. melanotragus	5	0	2	1	0	0	0	0
Austrosipho waitei	1	1	0	0	0	0	0	0
Pleuop. australasia	1	0	0	0	0	1	0	0
Zeacum. diemenensis	0	0	0	1	0	1	2	0
Poneroplax albida	2	4	12	1	1	0	3	2
Hormomya erosa	0	0	1	0	0	0	0	0
Katelysia spp.	0	1	6	2	0	1	0	1
Ostrea angasi	0	0	0	0	0	0	0	0

Molluscs	FS5.8A	FS5.9
Subninella undulata	6	4
Subninella opercula	6	1
Patelloida alticostata	3	2
Hipponyx conicus	8	0
Poneroplax albida	1	1
Hormomya erosa	1	0
Katelysia spp.	0	1

Jasus mandible: FS5.3

Vertebrates

FS5.2: Maxilla fragment, Rattus.

FS5.3: Pelvic fragment, small marsupial.

FS5.5: Left mandible, Rattus fuscipes; long bone fragments, Rattus; right maxilla fragment, Mastacomys fuscus.

FS5.6: Left mandible fragment, Rattus; humerus, rodent.

FS5.6A: Vertebral elements and incisor, Rattus.

FS5.7A: Right mandible fragment, Rattus; vertebra, reptile (snake).

FS5.8A: Right mandible and incisor, Rattus fuscipes; fragments of unidentifable fish vertebra.

FS5.9: One fish scale and numerous fish vertebra.

APPENDIX A5.5 (Cont.)

Grid 6

Molluscs	FS6.1	FS6.2	FS6.3	FS6.4	FS6.5
Subninella undulata	8	11	6	3	2
Subninella opercula	3	3	-	0	0
Dicathais textilosa	0	0	1	0	0
Patelloida alticostata	5	3	0	0	0
Austrocochlea constricta	0	11	0	0	0
A. odontis	3	1	0	0	0
Poneroplax albida	1	1	0	1	0
Katelysia spp.	1	1	0	0	0

APPENDIX A5.6

TABLE OF NORA CREINA BAY SHELTER IMPLEMENTS *

FS 1

2.1	Small scraper
2.2	Utilized flint flake
2.3	Scraper, multiple edges
2.4	Scraper, convex edge
2.5	Scraper
2.6	Scraper, multiple edges
3.1	Small scraper
5.1	Large flake
5A.1	Cylinderical aeolian stone
7.1	Aeolian cylinder
7A.1	Small, convex scraper
7A.2	Scraper
8.1	Scraper
8A.1	Flake
9.1	Scraper, concave
9.2	Utilized flake
9.3	Small, concave scraper

FS 2

3B.1	5 Flakes
6B.1	3 Flakes
7.1	Charred flint
9.1	Charred flint
9B.1	2 chips
9B.2	Travertine slab
9B.3	*Haliotis* shell scoop
10.1	Flake
11.1	Flint nodule
11.2	Travertine slab with parallel markings
12.1	Bone awl
12.2	Core/scraper

FS 3

3.1	Flake
3A.1	Flake
4.1	Flake
6.1	Flake

FS 4

1.1	11 chips, 3 charred
2.2	Scraper, multiple edge
2.3	Small, convex scraper
3.1	*Mytilus* implement
4.1	Aeolian slab
5.1	Flake
8.1	3 chips
8A.1	Aeolian slab with pecking
8A.3	Small, scraper
8A.2	2 flakes
9A.1	Travertine cylinder
11A.1	8 chips
11A.2	Chip

FS 5

1.1	5 chips
2.3	Travertine slab with end abrasion
5.1	2 flakes
6.1	Core-scraper
9.1	Flake

* Note: Not all stone chips are identified.

APPENDIX A6.1

LITHIC INVENTORY FOR CANUNDA ROCK MIDDENS

FS 1 — *Brachidontes* midden

	Zone 1	4 geometric microliths, 2 flake scrapers; 60 flakes.
	Zone 2	1 steep edge scraper; 3 core faces; 20 flakes;
	Slump 1	1 geometric microlith; 1 rejuvenation flake; 7 blakes; 10 flakes.
	Slump 2	4 geometric microliths; 1 flake awl; 70 flakes;

FS 2 — *Plebidonax* midden

	Zone 1	1 backed blade; 4 small flake scrapers; 18 blades; 8 cores; 117 flakes; 2 large flake scraper.
	Slump 1	1 backed blade; 8 small scrapers; 2 choppers; 14 primary nodules; 47 primary flakes.

FS 7 — *Brachidontes* middens

	Zone 1	6 backed blades; 5 geometric microliths; 1 flake awl; 2 flake cores; 11 flake scrapers; 4 primary nodules; 101 flakes.

FS 10 — *Brachidontes* midden

	Zone 1	6 backed blades; 1 geometric microlith; 1 fabricator; 3 flake scrapers; 3 primary nodules; 39 flakes.

FS 10 — *Brachidontes* midden

	Zone 1	1 backed blade; 3 cores; 2 flake scrapers; 1 flake.

FS 35 — *Dicathais* midden

	Zone 1	2 simple flake scrapers; 3 flakes.

FS 55 — *Plebidonax* midden

	Zone 1	1 rejuvenation flake; 3 simple flake scrapers; 3 flakes; 1 primary nodule.

APPENDIX A6.1 (Cont.)

FS 50	*Plebidonax* midden	
Zone 1		4 rejuvenation flakes; 1 geometric microlith; 14 primary flakes; 1 aeolianite slab; 1 small core.

APPENDIX A6.2

LITHIC INVENTORY FOR ABYSSINIA BAY MIDDEN

FS	30.1A	1 flake
	30.1B	5 chips
	30.1C	1 nodule 2 flakes
	30.1D	8 chips
	30.2A + 3A	1 nodule 1 simple scraper 3 flakes
	30.2A	1 flake
	30.2B	1 nodule
	30.2B.2	2 nodules
	30.2C	35 chips
	30.2D	8 chips 4 nodules
	30.2D.1	1 flake
	30.3A.1	1 scraper
	30.3A	1 nodule 2 flakes
	30.3B	1 nodule 6 flakes 12 chips
	30.3C.1	1 scraper
	30.3C.2	1 scraper
	30.3C	3 nodules 15 chips
	30.3D	7 nodules 4 flakes
FS	31.1A	3 nodules 1 flake
	31.1B	1 flake 5 chips
	31.1C.1	1 retouched flake
	31.1C	4 flakes 4 chips
	31.1D	15 chips
	31.2A	3 flakes
	31.2B	1 charred flake 8 chips
	31.2C	8 chips
	31.2D.1	Ochre
	31.2D	3 nodules 20 chips
FS	31.3A.1	1 scraper
	31.3A	3 flakes 4 chips
	31.3B	1 nodule fragment 2 flakes 5 chips
	31.3C.1	1 scraper
	31.3C.2	1 scraper
	31.3C.4	1 scraper
	31.3C.5	1 scraper
	31.3C.6	1 scraper
	31.3C	1 nodule
		10 aeolianite nodules 8 flakes 15 chips
	31.3D.1	1 scraper
	31.3D	29 chips
	32.1A	1 flake
	32.1A.1	1 core scraper
	32.1B.1	1 scraper
	32.1B	1 charred nodule 3 chips
FS	33.1A	1 Nodule 5 flakes
	33.1B.1	1 scraper
	33.1B	27 flakes
	33.1C	1 nodule 3 large flakes 5 chips
	33.1D	2 nodules 3 flakes 2 chips
	33.2A	2 flakes 15 chips
	33.2B	2 large nodule flakes
	33.2C	3 nodules 30 chips
	33.2D.1	1 scraper
	33.2D	2 nodules 30 chips
	33.3A	1 nodule 1 flake 15 chips

APPENDIX A6.2 (Cont.)

FS	33.3A.1	1 scraper
	33.3A.2	1 scraper
	33.3A.3	1 scraper
	33.3B	1 nodule
		7 flakes
		2 chips
		1 aeolianite
	33.3C	5 flakes
	33.3C.1	1 scraper
	33.3D	4 nodules
		2 aeolianite slabs
		5 flakes
		30 chips
FS	34.1A	5 flakes
	34.1B	2 nodules
	34.1C	2 nodules
	34.2A	5 flakes
		8 chips
	34.2B	1 flake
		10 chips
	34.2C	2 flakes
	34.2D	2 flakes
		15 chips
	34.3A	6 nodules
		3 aeolianite slabs
		8 flakes
	34.3A.1	1 scraper
	34.3A.2	1 scraper
	34.3B	2 nodules
		1 flake
		35 chips
		5 aeolianite pieces
	34.3C	4 nodules
		4 flakes
		5 aeolianite pieces
		10 chips
	34.3D	2 nodules
		1 travestine cylinder
		15 chips
	34.3D.1	1 scraper

APPENDIX A6.3

LITHIC INVENTORY FOR DOMASCHENZ RIDGE MIDDEN

(FS1-1973)

FS 1.1.1	1 backed blade frag.
misc.	6 chips
1.1.2	1 red-stained flake 4 flakes 31 chips
FS 2.1.0	4 chips
2.2.	3 flakes 13 chips
2.3.2	1 scraper
2.3.3	1 scraper
2.3.4	1 scraper
2.3.5	1 scraper/core
2.3.6	1 backed blade
2.3.7	1 rejuvenation scraper frag.
2.3.8	1 graver
2.3.9	1 aeolianite "awl"
2.3.	4 flakes 30 chips
2.5.1	1 flint chip
FS 3.1.0	12 chips
3.2.1	10 chips
3.3.1	1 backed blade
3.3.2	1 backed blade
3.3.3	5 flakes 15 chips
3.4.	1 flake 5 chips
3.5.1	1 backed blade
3.5.2	1 flake
FS 4.2.1	1 scraper
4.2.2	1 scraper
4.2.3	12 chips
4.3.1	1 backed blade
4.3.2	1 flake
4.3.	4 flakes 23 chips
FS 5.2.	3 flakes 10 chips
5.3.1	1 core
5.3.2	6 chips
5.3A.2	1 scraper
5.3A.3	1 scraper
5.3A.4	1 blade core?
5.3A.5	1 backed blade
5.sA.6	1 scraper
FS 6.2.0	1 flake 15 chips
6.3.1	1 scraper
6.3.2	1 scraper
6.3.3	1 scraper
6.3.4	1 aeolianite cylinder frag. 15 chips
6.3A.2	1 core/scraper
6.3A.3	1 scraper
6.3A.4	1 scraper
6.3A.5	1 backed blade frag.?
6.3A.6	1 scraper
6.3A.7	1 geometric microlith
6.3A.8	1 scraper
6.3A.9	1 flake 30 chips
6.4.1	1 flake
FS 7.1.0	1 flake 11 chips
7.2.1	1 scraper
7.2	2 flakes 10 chips
FS 8.1.1	1 flake 6 chips
8.2.1	3 chips
8.3.1	1 chip

APPENDIX A6.3 (cont.)

(Test Trench 1972)

TT 2.0.1	1 scraper
2.0.2	1 scraper
2.0.3	1 scraper frag.
2.0.4	1 scraper
2.0.5	1 scraper rejuvenation frag.
2.0.6	1 scraper
2.0.7	1 core
2.0.8	1 core
2.0.9	1 geometric microlith/graver
2.0.10	1 geometric microlith/end scraper
2.0.11	1 backed blade 13 flakes 29 chips several unworked blades

APPENDIX A8.1

TABLE OF LOBSTER MANDIBLE LENGTHS FROM ABYSSINIA BAY AND THEIR CORRESPONDING BODY WEIGHTS

EXCAV. UNIT	MANDIBLE LENGTH (mm)	ESTIMATED BODY WT. (gr.)	EXCAV. UNIT	MANDIBLE LENGTH (mm)	ESTIMATED BODY WT. (gr.)
FS30.1B	15.2	672 ± 86	FS33.1C	18.5	1090 ± 150
FS30.3C	19.4	1300 ± 155		14.5	625 ± 69
	18.8	1090 ± 150		13.0	570 ± 50
FS30.3D	Frag.	-	FS33.2C	15.8	672 ± 86
FS31.3C	Frag.	-	FS33.2D	>18.0	>1090 ± 150
FS31.1	11.0	440 ± 30	FS33.3D	11.7	440 ± 30
	17.2	890 ± 150		10.1	360 ± 30
FS18.4	12.8	510 ± 45	FS34.3A	16.1	679 ± 76
	15.3	672 ± 86		Frag.	-
	17.1	890 ± 130	FS34.2D	19.3	1300 ± 155
	Frag.	-	FS34.3D	19.1	1300 ± 155
FS32.1A	21.0	1760 ± 164		13.8	570 ± 50
	16.5	679 ± 76			
FS32.2B	15.1	672 ± 86			
FS32.3A	10.5	360 ± 30			
	16.5	679 ± 76			
	18.1	1090 ± 150			
	8.7	-			
	Frag.	-			
FS32.3B	12.8	510 ± 45			

N = 27
$\bar{X}$ = 15.4 mm
Sd = 3.3 mm