A pre- and post-contact Aboriginal shell midden at Disaster Bay, New South Wales south coast

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This report describes archaeological investigation of Aboriginal shell middens at Disaster Bay on the New South Wales far south coast (Fig. 1). Small test excavations were conducted in 1989 and sorting and analysis were completed between 1990 and 1996. The research aimed to further investigate the 'mussel horizon' in NSW south coast shell middens (see below). However the sites proved to be too recent to answer the original research questions. A considerable depth of deposit at the Greenglade rockshelter appears to date after the time of European contact. This paper describes the excavations and the dating of the site and highlights possible future research directions.

Figure 1 Location map.

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Research context

The Disaster Bay excavations aimed initially to further investigate the 'mussel horizon' in south coast middens (Bowdler 1976; Sullivan 1982, 1987; Mackay and White 1987). The excavations also aimed to fill a gap in NSW far south coast midden studies which would be useful for future site management. Archaeological knowledge of the region is currently biased by the uneven geographical spread of available data. The vast majority of excavated and scientifically dated shell middens are located north of Bateman's Bay (Fig. 1). Only two well-documented sites have been excavated south of there, at Pambula Lake (Sullivan 1984) and at Merimbula Lake (Webb et al. 1986). Until the Disaster Bay excavations there were no scientifically dated shell middens between Pambula Lake and Mallacoota in southeast Victoria (Coutts et al. 1984; Weaver 1990). The research was fully endorsed by Eden Local Aboriginal Land Council and NSW National Parks and Wildlife Service, who issued a permit for the work.

Disaster Bay lies in the Ben Boyd National Park, and is largely unaffected by developments common elsewhere on the south coast. The NSW National Parks and Wildlife Service site register lists a range of Aboriginal sites for Disaster Bay, including stone tool scatters, extensive open middens around the entrance to Wonboyn Lake (e.g. NPWS Site No: 63-3-12), several smaller middens around the headlands of Disaster Bay, and a series of rockshelters located along an old sea cliff which now lies approximately 1 km from the current shoreline (Fig. 1). Several of the rockshelters contain Aboriginal rock paintings and engravings (Officer 1991, 1993) and many are filled with apparently deep shell midden deposits rich in mussel shell and fish bones. An excavation by Lourandos through midden deposits in a rockshelter on the north side of Disaster Bay (NPWS Site No: 63-3-13), conducted in the 1970s, recovered large quantities of fish bones and shell. The 0.4 m deep excavation trench did not reach the bottom of the deposit and the site was never dated (NSW NPWS Site Register).

Following field survey, two sites with potential to produce relevant evidence were selected for small-scale test excavation. These were the Greenglade rockshelter on the southern end of Disaster Bay (Site: 63-3-63; Narrabarba 1:25K 7607, 58696) and open middens at Bay Cliff at the entrance to Wonboyn Lake (Site 63-3-12; Narrabarba 1:25K 7627, 58732) (Fig. 1).

Excavations at Greenglade rockshelter (Site 63-3-63)

Excavation methods

A 1 m by 0.5 m test pit was excavated immediately outside Greenglade rockshelter in an area where midden deposits were visible on the surface (Fig. 2, Trench 1). Trench 1 was excavated in 10 cm spits and all deposit was dry sieved through a 10 mm mesh on site. Archaeological deposits extended to a depth of approximately 2 m (Fig. 3). A 1 m x 0.5 m test pit was also opened up inside the rockshelter (Trench 2). This was excavated in 5 cm spits. One bucket of deposit from each spit was wet sieved through a 1 mm mesh in a creek near the site, while the remaining deposit was wet or dry sieved through a 5 mm mesh. Trench 2A (immediately adjacent to Trench 2) was excavated in 10 cm spits and all deposit was dry sieved through

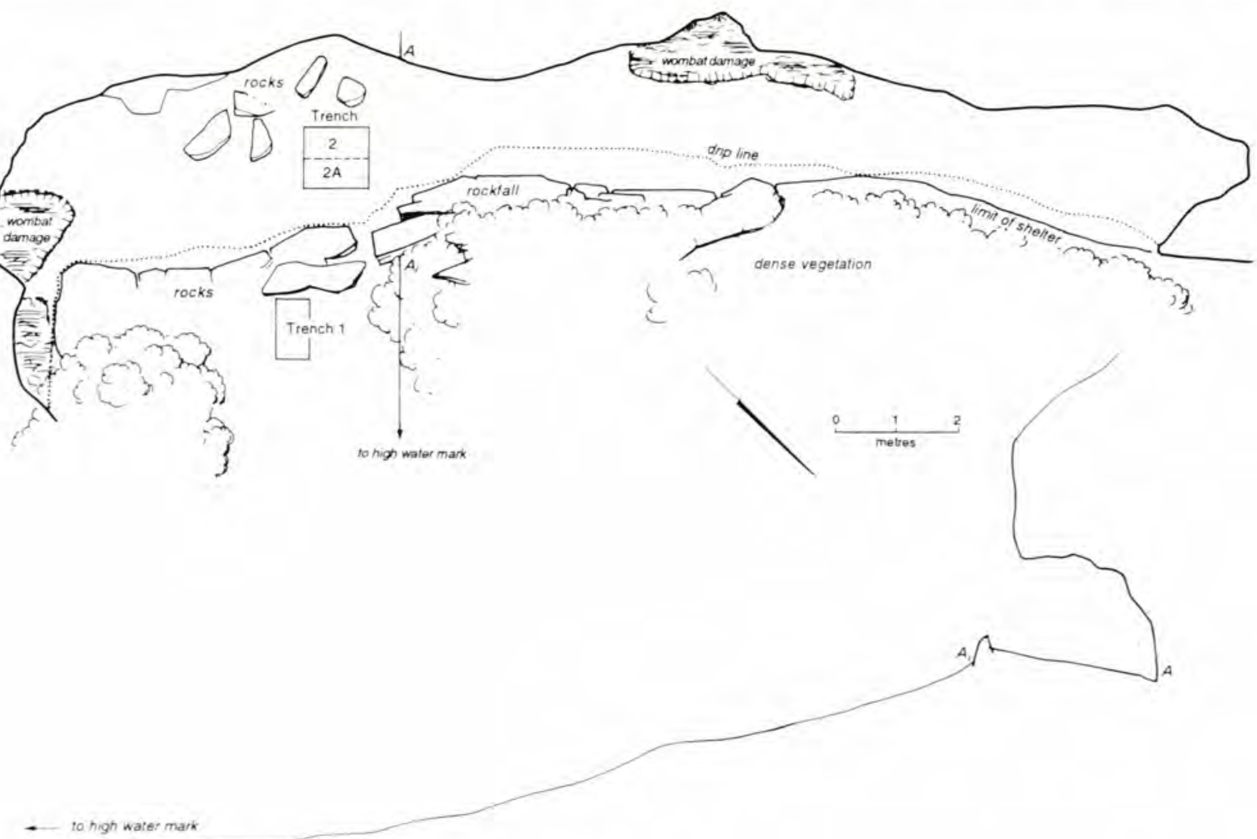

Figure 2 Floor plan and cross-section drawing of Greenglade rockshelter.

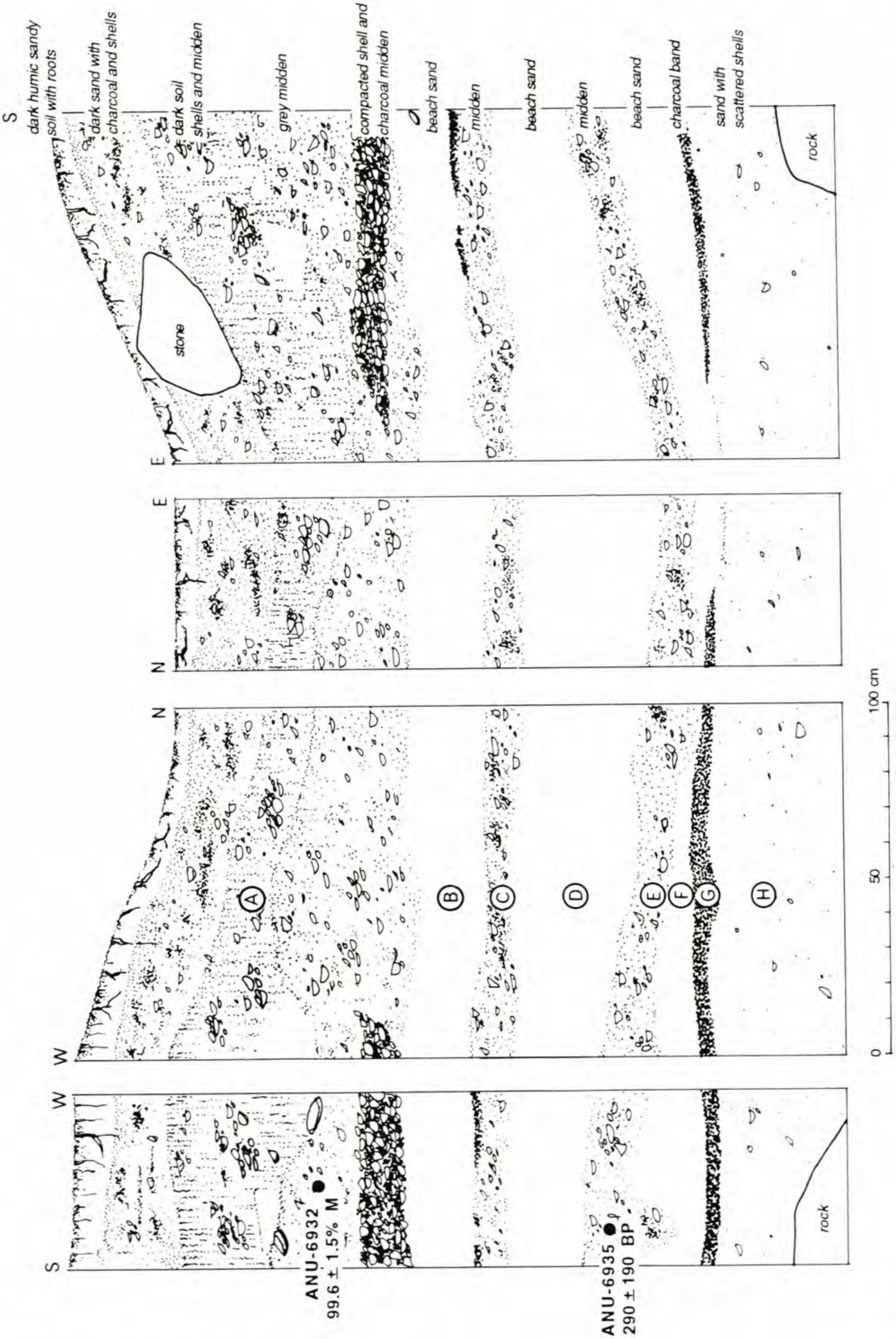

Figure 3 Cross-section through Greenglade Trench 1 showing midden stratigraphy.

a 10 mm mesh. Each 10 cm spit in Trench 2A was excavated to coincide in depth with two equivalent 5 cm spits in Trench 2. Archaeological deposits in Trench 2/2A extended down to a maximum depth of about 2.7 m (Fig. 4). When the excavation reached a depth of about 2 m shoring was constructed for safety reasons.

After excavation a series of bulk soil samples and samples of charcoal and shell for radiocarbon dating were collected from each major stratigraphic layer visible in the walls of the trenches.

Stratigraphy

The site was excavated by spits (with 21 and 28 x 10 cm spits in Trench 1 and 2A respectively, and 51 x 5 cm spits in Trench 2) as this was a limited test-excavation. Small-scale stratigraphic features within the midden layers only became apparent from examining the walls of the trenches after excavation. Figures 3, 4 and 5 illustrate the stratigraphy of Trenches 1 and 2/2A and explain the letter codes used in the text for each stratigraphic unit.

Trench 1

Trench 1 cut through three main midden layers separated by layers of clean, archaeologically sterile beach sand. The upper midden layer (A) was the deepest (between 60 cm and 90 cm thick) and comprised several sub-layers which blended into each other. The uppermost 5-10 cm of deposit consisted of dark humic sandy soil heavily disturbed by roots. Beneath this was a layer of dark sand with charcoal and a few shells (15-30 cm thick). This rested on a layer of dark soil, shell and midden (15-40 cm). The lowest sub-layer of the upper midden consisted of grey midden some 20 to 40 cm thick, within which was at least one large lens of compacted shell and charcoal midden (maximum thickness approximately 15 cm).

The uppermost midden deposits overlie a band of clean light yellow sand approximately 10-20 cm thick (B). Beneath this was a 8-15 cm thick layer of midden comprising dark grey sandy soil with scattered shell and charcoal (C). This in turn overlays another layer of clean light yellow sand (between 20 and 40 cm thick) (D). Beneath this was a second lower midden layer, (E), between 10 and 25 cm thick, and very similar to the midden layer above. At the southwest end of the trench a lens of clean beach sand (F) (maximum thickness 20 cm) lay directly beneath the lower midden. Beneath this, extending across most of the trench, was a thin lens of charcoal (G) (maximum thickness 5 cm). The lowest stratigraphic level was sand with scattered shells, between 2 and 5 cm thick (H). This contained no obvious cultural material and overlays bedrock in the southern end of the trench.

Trench 2/2A

Figure 4 shows the Trench 2/2A stratigraphy. The stratigraphy of the north face of Trench 2A was drawn and recorded in detail (Fig. 5). As the other sides of the trench were partly obscured by the shoring, only the major stratigraphic breaks and layers were recorded for the other trench walls. The following detailed description of stratigraphy is therefore based on the north face of Trench 2A.

Stratigraphy in the lower part of Trench 2/2A was similar to that in Trench 1. The lowest layer was a clean yellow beach sand (A) with no cultural materials, between 25 and 35 cm thick, lying over bedrock. Within this was a thin lens of sand with charcoal flecks (B), maximum thickness 10 cm, which extended across most of the trench. The lowest midden layer (C) (10 to 20 cm thick) was a mixture of brown, black, dark grey and light grey sands containing various amounts of shell and charcoal. At least four distinct sub-layers or lenses could be discerned. Above this was a layer of clean yellow beach sand (D) about 15 cm thick. This was topped with a second band of midden (E) which ranged in thickness from 20-30 cm. This midden layer was composed of at least seven sub-layers or lenses including: compacted shell and charcoal; grey soil with ash and charcoal; black soil with charcoal; light brown sand and pink sand. Above this midden layer was another band of clean beach sand (F) about 15 cm thick. Above this was another layer of midden (G) about 25 cm thick, composed of a series of blended and indistinct sub-layers and lenses, including: brown 'clayey' soil; compacted shell; grey soil with charcoal; black soil with charcoal and shell, and compacted lenses of charcoal. The top of this band of midden was covered with a thin layer (less than 10 cm) of grey sand, which was in turn topped by and blended into a discontinuous, thin layer (maximum thickness 10 cm) of clean yellow beach sand (H). Above this layer of grey and yellow sand was a thick deposit of upper midden (I) composed of numerous sub-layers and lenses. The upper midden was at least 1.3 m deep. The top 50 cm of the upper midden consisted of very dark black-brown amorphous sandy soil with shell, charcoal and roots. This lay over a series of lenses of light brown sandy ash with small quantities of shell, about 30 cm thick. This overlays a dense deposit of highly compacted lenses, layers and dumps of shell, ash, charcoal, grey sand and black soil. This deposit was approximately 50 cm deep. The micro-stratigraphy of the lower part of the upper midden (I) was complex and difficult to record in detail.

Radiocarbon and amino acid racemisation dates

Two charcoal samples from Trench 1 and three from Trench 2/2A were submitted for radiocarbon dating to the ANU Radiocarbon Laboratory (Fig. 6, Table 1). The material submitted for dating was lumps and concentrations of charcoal removed from the walls of the trenches after excavation. The exact location of the charcoal samples is indicated by the square symbols in Figures 3, 4 and 5.

The results demonstrate that the Greenglade rockshelter deposits are too recent to address the 'mussel' question because midden accumulation commenced within the last 600 years or so. 'Modern' radiocarbon results from upper midden deposits and the discovery of flaked nineteenth century bottle glass (discussed below), strongly suggest the site was used both before and after European contact.

Radiocarbon ages were calibrated into calendar years after Stuiver and Reimer (1993). Radiocarbon dates from the last 200 years are difficult to calibrate meaningfully

Figure 4 Cross-section through Greenglade Trench 2/2A showing basic midden stratigraphy.

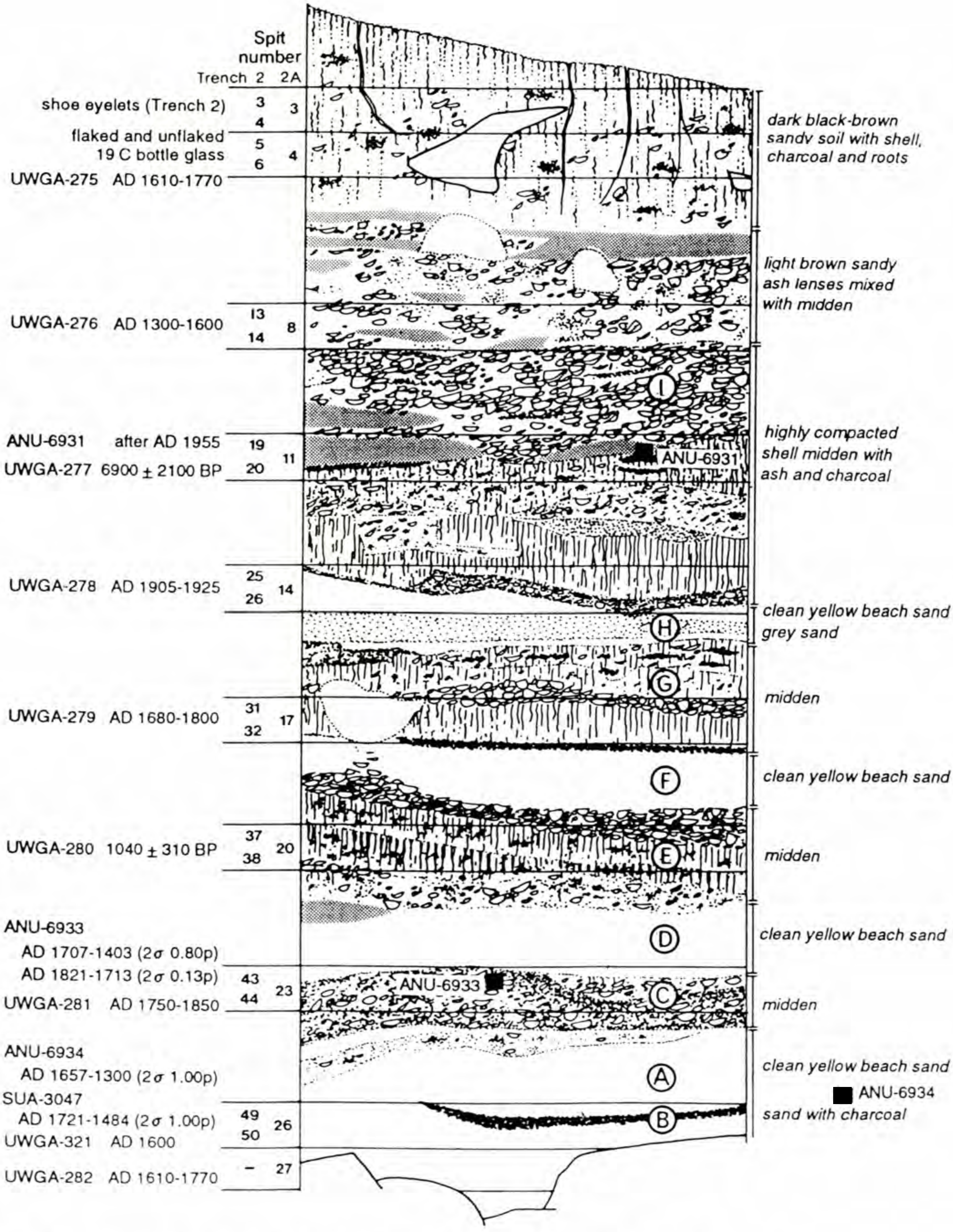

Figure 5 Stratigraphy of northeast wall of Greenglade Trench 2/2A with dating evidence and selected spits.

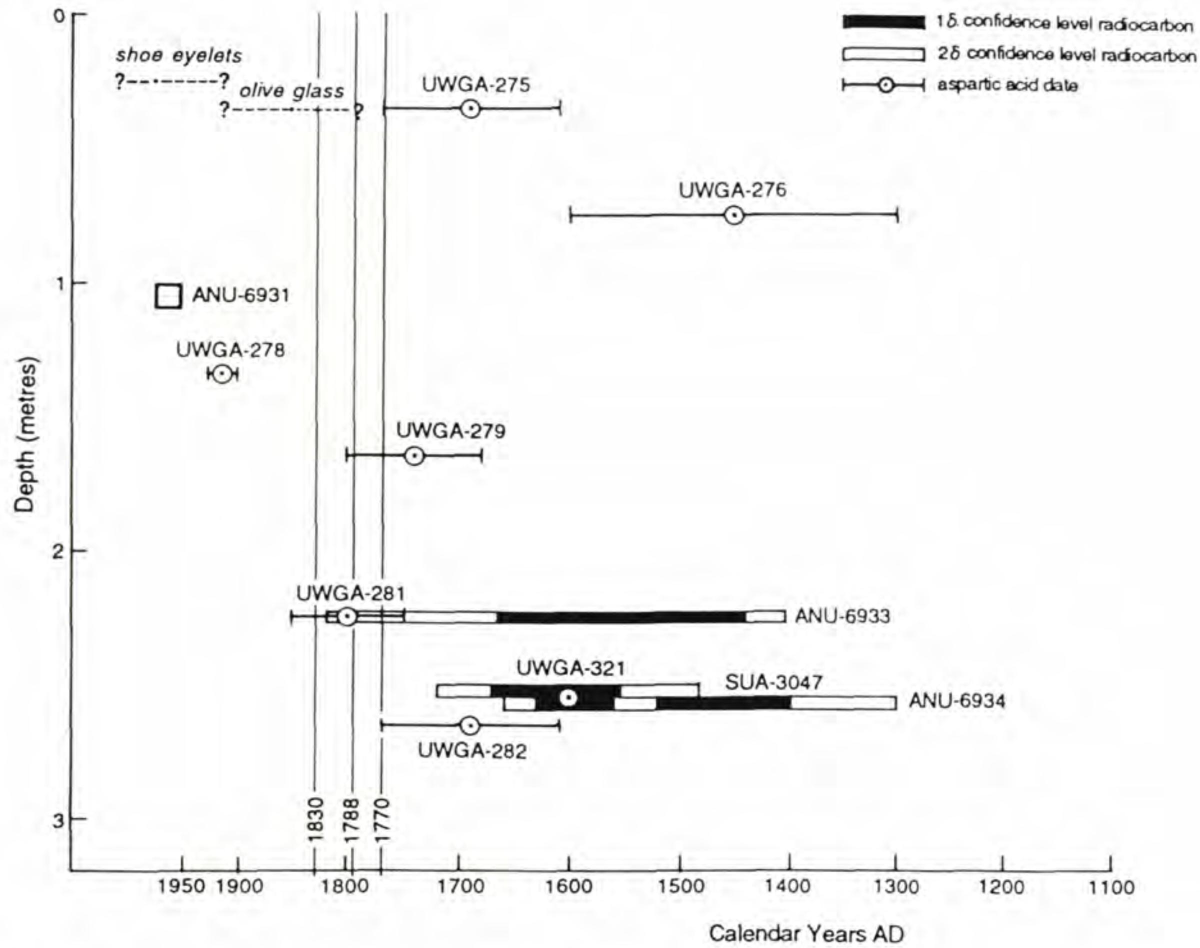

Figure 6 Depth-age graph for radiocarbon and aspartic acid dates from Greenglade rockshelter.

(Bowman 1990:38). Full details of all dates and their calibration are presented in Figures 3, 4, 5 and 6 and Table 1. The oldest conventional radiocarbon age for the site (460±110 BP ANU-6934) came from Trench 2A layer (B). A second sample from Trench 2A, from the lowest substantial midden layer (C), returned an age of 340±120 BP (ANU-6933). A third sample, from near the base of the upper midden (I), returned a modern radiocarbon age of 102.7±1.2%M (ANU-6931), calibrated as having a 95% probability of dating after AD 1955.

The two radiocarbon determinations from Trench 1 were broadly consistent with the dates for Trench 2A. The earliest date returned an age of 290±190 BP (ANU-6935). A sample towards the bottom of the thick upper midden layer (A) gave a modern radiocarbon age of 99.6±1.5 %M (ANU-6932) which calibrated as having a 95% probability of dating between 270 years cal BP (AD 1640) and AD 1955.

None of these radiocarbon ages were inverted within the stratigraphy, but they are difficult to interpret. Amino acid racemisation (AAR) dating which has the potential to date shells from the last few hundred years (Goodfriend 1992; Goodfriend et al. 1992) had obvious applications here (Murray-Wallace 1993). A pilot project was undertaken to conduct aspartic acid racemisation dating of operculae of the wavy turban shell *Turbo undulatus*. These were common in the midden, were easily identified at the species level and are well preserved, thus permitting reliable analysis. Operculae were selected from nine spits in Trench 2A chosen to sample major stratigraphic layers and where possible to correspond in depth with the existing radiocarbon dates (Fig. 5, Table 1). Details about the methods used for the AAR analyses are described elsewhere (Murray-Wallace 1993; Murray-Wallace and Colley 1997). To assist with calibration of the AAR dates an additional radiocarbon determination was made on an operculum from Spit 26. This returned an age of 690±50 years BP (SUA-3047) which calibrated to between 1484 and 1721 AD (466 to 229 yrs cal BP) at the 2 σ level (Gillespie and Polach 1979; Murray-Wallace and Colley 1997). The extent of aspartic acid racemisation was then determined in the hydrochloric acid residue from the radiocarbon sample preparation of SUA-3047 allowing direct comparison of the two dating methods. Results from the amino acid racemisation determinations were calibrated into calendar years following a method described by Murray-Wallace and Colley (1997). They are listed together with the radiocarbon dates in Table 1, and have been plotted as a depth-age graph in Figure 6.

Interpretation of dates

There is no obvious or consistent relationship between the AAR and radiocarbon dates throughout the depth of the

Spit No.	Depth of burial (m)	Artefacts	AAR laboratory code	D/L ASP (1)	Radiocarbon dates (2)	Calibrated radiocarbon dates (age yr AD)	AAR-derived age (yr AD (BP)) (3)
3	0.2-0.3	shoe eyelets					
4	0.3-0.4	olive bottle glass	UWGA-275	0.185±0.001			AD 1610-1770
8	0.7-0.8		UWGA-276	0.234±0.074			AD 1300-1600
11	1.0-1.1		UWGA-277	0.712±0.003**	102±1.2% M (ANU-6931) Charcoal and Sand	After AD 1955 (99% probability)	
14	1.3-1.4		UWGA-278	0.105			AD 1905-1925
17	1.6-1.7		UWGA-279	0.172±0.001			AD 1680-1800
20	1.9-2.0		UWGA-280	0.311**			
23	2.2-2.3		UWGA-281	0.154	340±120 yr BP (ANU-6933) Charcoal and Sand	AD 1440-1667 (1 sigma) AD 1403-1707 (2 sigma 0.80p) AD 1713-1821 (2 sigma 0.13p)	AD 1750-1850
26	2.5-2.6		UWGA-321	0.206±0.001	690±50 yr BP (SUA-3047) *Turbo undulatus*	AD 1554-1672 (1 sigma 1.00p) AD 1484-1721 (2 sigma 1.00p)	AD 1600
					460±110 yr BP (ANU-6934) Charcoal	AD 1398-1524 (1 sigma 0.70p) AD 1560-1631 (1 sigma 0.30p) AD 1300-1657 (2 sigma 1.00p)	
27	2.6-2.7		UWGA-282	0.186			AD 1610-1770

Table 1 Dating evidence from Greenglade rockshelter Trench 2. (1) Extent of amino acid racemisation (total acid hydrolysate) in operculae of the marine gastropod *Turbo undulatus*. (2) Radiocarbon dates are conventional, uncorrected ages yr BP (1 σ error term). (3) Aspartic acid racemisation-derived ages based on radiocarbon calibration sample (SUA-3047). Aspartic acid racemisation date error terms represent pooled means and include analytical precision (1 σ equivalent to 3%) and an uncertainty for the mean diagenetic temperature of 2°C. Error rounded to the nearest 10 years. ** These higher values represent significant heating events. Current mean annual temperature of Greenglade rockshelter is approximately 15°C.

deposit. As the radiocarbon and AAR methods dated different samples, inconsistencies could stem from genuine differences in the age of the materials dated, rather than indicating major divergence between results from the two methods.

Two AAR dates (UWGA-277 and UWGA-280) are completely outside the range of dates suggested for the site by the radiocarbon dates. They demonstrate an unusually high extent of racemisation which probably indicates that the shells have been heated and that the dates are too old. As discussed in detail elsewhere (Murray-Wallace and Colley 1997), the other AAR dates are thought unlikely to have been affected by heating in view of the lower extent of racemisation.

There is most consistency between all dates in the lowest part of the deposit from about 2.2 to 2.7 m. Moving up through the deposit, if AAR dates UWGA-280 and UWGA-277 are rejected, then the modern radiocarbon date ANU-6931 and the two AAR dates UWGA-278 and UWGA-279 beneath it are broadly consistent with each other and with the dates below them. Overall these results suggest that most of the material below about 1.6 m predates European contact (as defined below), with either a slight increase in age with depth, or little difference in the age. They also suggest that at least some material between 1.0 and 2.3 m is post-contact. Interpretation is complicated by AAR results UWGA-276 and UWGA-275 from near the top and midway down the upper midden. These are both older than dates immediately below them, and both predate the time of European contact. UWGA-275 came from the same spit as worked nineteenth century bottle glass (see below). AAR results from the highest and lowest part of the stratigraphy (UWGA-275 at 0.3-0.4 m and UWGA-282 at 2.6-2.7 m) returned identical dates of AD 1610-1770.

The inversion of several of the dates suggests that at least the upper layers have been subject to post-depositional disturbance. *Turbo undulatus* operculae are small and could easily be moved through the deposit by wombat burrowing or root action. Human activities in the shelter may also have caused mixing of deposits.

The consistency of the dates from the lower part of the stratigraphy may suggest slightly less mixing and disturbance. This may mean that the shelter was used less frequently or by fewer people during the earlier period of occupation. However, as the excavation represents only a small vertical sample through a broad palimpsest of horizontal layers and dumps, this interpretation is speculative.

In summary, three AAR dates and four calibrated radiocarbon dates (including those from Trench 1) date to AD 1770 or later. Two further aspartic acid dates may date as late as AD 1770. The consistency of the two lowest radiocarbon results, which are both pre- AD 1770 at the 2 σ level, suggest that the basal portion of the midden was deposited before European colonisation. However, because of likely mixing of at least the upper parts of the midden deposits, it is not possible to assign individual layers or spits in the upper part of the site to an exact time period either before or after British colonisation.

Documentary and artefactual evidence for dating

The Greenglade site raises questions about the timing of British contact in the Disaster Bay area and its likely impact on the material culture and way of life of indigenous people living there. Historical evidence can provide further information. Although Captain James Cook sailed past Disaster Bay during his voyage along the east coast of Australia in AD 1770, his expedition is not recorded as having landed anywhere in the Eden area (Pleaden 1990:4). However indigenous people in the region may have known about the British and could theoretically have had access to some items of Western material culture through trade and exchange at any time from AD 1770 onwards. Cook landed at Botany Bay in AD 1770 and left behind European goods which could have subsequently got to the far south coast along with information about his visit.

The availability of imported goods and the likelihood of encounters between indigenous people and colonists, would presumably have increased dramatically following the establishment of permanent British settlement at Sydney Cove in AD 1788. The first European officially recorded as visiting the Eden area was George Bass in AD 1798 (Pleaden 1990:18-19), although it seems unlikely that he was the first outsider encountered by local people. Thomas Raine established the first whaling station at Twofold Bay, north of Disaster Bay, in AD 1828. From the 1830s the Imlay brothers acquired large tracts of land in the area and developed infrastructure for their activities in whaling, cattle and sheep droving, and the export of livestock and whale meat. British settlement of the region increased from the 1830s when squatters moved south from the Braidwood area (McKenzie n.d.). Despite such incursions, the forests and coasts of the far south coast remained relatively untouched by colonial expansion until at least the 1860s (Byrne 1984:20).

British influence and impact in the Eden area could therefore have begun at any time after AD 1770 although the impact of British colonisation on indigenous people would presumably have been increasingly marked from AD 1788 onwards. The Greenglade rockshelter could have continued to be used by indigenous people as part of their traditional lifestyle until at least the middle of the nineteenth century and maybe later. Archaeological evidence appears to corroborate these historical accounts, although it provides few clues as to when Aboriginal people stopped camping in the rockshelter. Fragments of olive green bottle glass, some of which were flaked, suggest that the rockshelter was used by Aboriginal people into the nineteenth century. Although there are problems associated with the authentication of flaked glass artefacts (Allen and Jones 1980), in this case at least one piece of glass is bifacially worked (see below and Fig. 7[i]) and is considered to be an artefact. Three metal shoe eyelets and a single fragment of amber bottle glass recovered from the site may date from the 20th century (see below and Fig. 7[k] and [l]). Whether such items provide evidence for continued Aboriginal use of the shelter beyond the nineteenth century is highly debatable, and raises a number of theoretical and methodological issues which are not easily resolved (Colley, in prep.). The stratigraphy and scientific dating methods provide ambiguous clues to the precise age of the material evidence for Aboriginal activities in the rockshelter. While AAR results UWGA-278 dates one *Turbo undulatus* operculum to the twentieth century (calibrated to between AD 1905 and AD 1925), it is impossible to say whether this constitutes evidence for Aboriginal use of the shelter into the twentieth century.

Approach to the analysis of excavated materials

Although the deposit was wet or dry sieved on site, a very large quantity of excavated midden was removed to the laboratory. The results presented here are based on the 5 mm and 10 mm sieve fractions only. The 1 mm residue contains finely comminuted shell, bone, stone and charcoal, most of which are not readily identifiable. Samples of the 1 mm residue were examined superficially to see if they contained anything obviously unusual, but were not analysed.

The volume of matrix recovered from the midden presented a practical challenge given limited resources available and the large amount of time involved in sorting midden samples (cf. Bowdler 1983). The matrix consisted of soil mixed with broken shells (with roots and other plant remains in the upper layers), charcoal and ash, sandstone from the shelter walls, quartz, other stone, and numerous small fragments of bird, fish and mammal bone. For Trench 2, approximately 77,789 g of deposit was retained by the 5 mm sieves. This figure is based on the actual weights of bird, fish and mammal bone, quartz and other manuports sorted from the samples, and on calculated weights for the other components based on the sampling method outlined below for the analysis of shell. The relative proportions (by weight) for each component are as follows: shell 47,571 g (61%), mammal bone 399 g (0.5%), bird bone 19 g (0.02%), fish bone 1611 g (2.1%), sandstone 22,231 g (28.5%), quartz and other manuports 687 g (0.88%) and charcoal and other plant remains 5271 g (6.8%).

Analysis of the shells (and gross weight calculations for sandstone, charcoal and plant remains) is based in part on random samples selected using a sample splitter (see below). However it was impractical to base the analysis of other materials found in the midden on such random sampling. Some types of material such as worked nineteenth century bottle glass, fishhooks, bone points and crustacea fragments occur in such small quantities that they may have been missed entirely, or been grossly under-represented. While fragments of bone were more frequently distributed through the shell matrix, the proportion of identifiable bones was again very small. Any meaningful analysis and identification, especially of the fish bone, required examination of as large a sample as possible, and this involved extracting all bone fragments from the entire excavated deposit. Therefore all the 5 mm and 10 mm residue was sorted by hand to remove all bone, stone (other than sandstone) and other finds (see below).

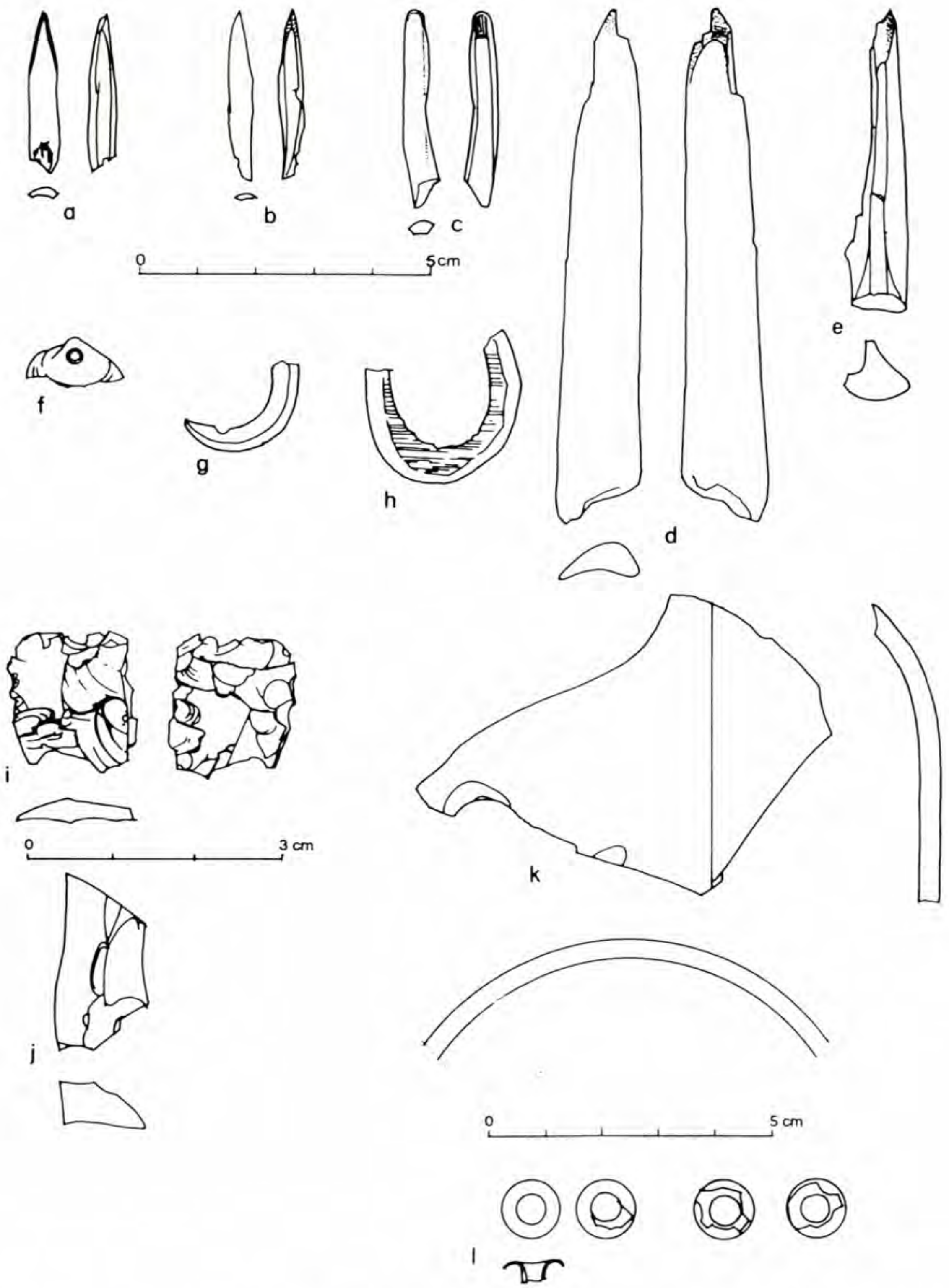

Figure 7 Artefacts from Greenglade rockshelter. Bone points (a-e); *Veneridae* shell with pierced hole (f); ground shell fishhooks (g and h); flaked olive green bottle glass (i and j); amber bottle glass (k); metal shoe eyelets (l).

Results of the analysis

Marine shell

The majority of the midden consisted of marine shell. Shells from Trench 2 were selected for detailed analysis. Shells from Trench 1 and Trench 2A were identified by students for undergraduate practical classes. The shells from these trenches are similar to those from Trench 2 in the types present, their relative abundance and their distribution within the midden.

The Trench 2 matrix was sorted to remove all stone, bone and 'other finds' (see below). The remaining material was dry sieved through a 10 mm mesh. The 10 mm residue from each spit was sorted and all shell was identified as far as possible. The smaller residue was then passed through a sample splitter to extract a one-eighth sample from which all shell was identified as far as possible. The results from the one-eighth sample were multiplied by eight and added to the results for the 10 mm sieve residue for each spit to give an estimated total for the relative representation of shell types in each spit. An attempt was made to assign every shell fragment, no matter how small, to family, genus or species, and the weight of each category was recorded.

Thirty-three types or categories of marine shell were identified in Trench 2 (Table 2). Nomenclature follows Bennett (1992) supplemented by McPherson and Gabriel (1962). Two types of shell predominate: the common edible mussel comprising 45% by weight of all shells, and the triton, comprising approximately 21%. Three other shells are also well represented: beaked mussel (ca. 9%); wavy turban shell (ca. 8%) and chitons (ca. 8%). Cartrut shell, Sydney rock oyster, limpets and worm tubes represented between 1% and 3% of all shells. All these shells are usually found on rocky shores and rock platforms, although Sydney rock oysters can also be found in more estuarine conditions. Worm tubes are found attached to other shells, particularly the large gastropods.

A further ten types of shell represent less than 1% by weight of the sample from Trench 2. These include further rocky shore types such as the large turban shell, black periwinkle, abalone and the wavy top shell. They also include shells which are found in sheltered, estuarine conditions, such as mud ark, club mud whelk and the mud oyster. Barnacles (which are a form of Crustacea) were also represented in this category. A further 16 shells represent less than 0.1% of the sample from Trench 2 by weight. They include both rocky shore and estuarine types. Larger

Scientific name	Common name	Total weight (g)	Percentage
Mytilus edulis planulatus	common edible mussel	21,402	44.98
Cabestana spengleri	triton	9548	20.07
Austromytilus rostratus	beaked mussel	4221	8.87
Turbo undulatus	wavy turban shell	3669	7.71
Class Polyplacophora	chitons	3644	7.66
Thias orbita	cartrut shell	1409	2.96
Saccostrea cucullata	Sydney rock oyster	588	1.23
Family Vermetidae	worm shells	567	1.19
Family Patellidae	limpets	503	1.05
CRUSTACEA	rock barnacles	430	0.90
Anadara trapezia	mud ark	407	0.85
Turbo torquatus	large turban shell	209	0.43
Nerita atramentosa	black periwinkle	207	0.43
Haliotis sp.	abalone	151	0.31
Family Veneridae	Venus shell	125	0.26
Austrocochlea concamerata	wavy top shell	72	0.15
Pyrazus ebeninus	club mud whelk	66	0.13
Family Mytilidae	mussels (Not Further Ident.)	54	0.11
Ostrea agnasi	mud oyster	54	0.11
Velacumantus australis	southern mud whelk	45	<0.10
Family Littorinidae	periwinkles	42	<0.10
	gastropod (Not Further Ident.)	42	<0.10
Scutus antipodes	elephant snail	38	<0.10
Trichomya hirsuta	hairy mussel	24	<0.10
Family Pectinidae	scallops	15	<0.10
Bankivia sp.	banded kelp shell	8	<0.10
	bivalve (Not Further Ident.)	8	<0.10
Family Buccinidae	whelks	5	<0.10
Family Nassariidae	nassarius	4	<0.10
Family Cerithiidae	creepers	4	<0.10
Dicathais baileyana	Bailey's dog winkle	3	<0.10
Limpopsis tenisoni	Tenison's false dog cockle	3	<0.10
Austrocochlea constricta	ribbed top shell	2	<0.10
Bembicium sp.		1	<0.10
Family Nassidae	dog whelks	1	<0.10
Total		47,571	

Table 2 Marine shells from Greenglade rockshelter Trench 2, listed in descending order by total weight.

shellfish which are likely to have been eaten include southern mud whelk, various periwinkles, the elephant snail, scallops and the hairy mussel. While size is not an absolute indicator of whether a particular shellfish is used for food by Aboriginal people (Rowland 1994), many of the extremely small shellfish are also rare in the midden and are probably less likely to have been eaten.

Weights for each shell type identified were tabulated for each of the 51 x 5 cm spits excavated in Trench 2. It was not possible to correlate every spit unit with a discrete stratigraphic layer or lens, due to the way the site was excavated. A sample of 16 paired spits from Trench 2 was selected to examine variation in the relative proportions of shell types with depth. These spits sample the major midden layers and most correlate in depth with the spits in Trench 2A from which *Turbo undulatus* operculae were removed for amino acid racemisation dating (see above and Fig. 5, Table 1).

Table 3 lists the weight and percentage representation of the 17 most frequent types of shell for the 16 paired spits. There are no dramatic patterns in the relative distribution of shell types between the different layers sampled. In general the most abundant types of shell were found in every spit examined, while many of the less common shells were not. Common edible mussel was most frequent in the upper spits (making up between 52.1 and 40.6% of the total shell weight). However in the lower spits the relative proportion of mussels dropped markedly to between 23.3 and 13.4% of the total shell weight. In Spits 37/38 and 40/50, triton was more strongly represented than mussel (48% and 41.4% by weight respectively). In Spit 43/44 mussels made up 23.3% of shell weight, but triton and wavy turban shell were slightly more common (both at 28.3% of total shell weight). Sydney rock oyster was present in all upper spits, but missing from the two lowest paired spits, while cartrut shell was similarly missing from the lowest set of spits. The mud ark occurred only in Spits 19/20 and 25/26 and again in Spits 43/44 and 49/50 but not elsewhere. The club mud whelk only occurred in Spits 37/38 and 43/44. There was no obvious pattern in the distribution of other types of shell.

Such variations could have a number of causes and interpretation is complicated by the likelihood that at least the upper parts of the midden have been disturbed. It is tempting to interpret the under-representation of edible mussels in the lower spits in terms of differential preservation. The observed patterning could also reflect some real difference in the types of shells collected and thrown away by

Type of shell	Spit 5 and 6		Spit 13 and 14		Spit 19 and 20		Spit 25 and 26		Spit 31 and 32		Spit 37 and 38		Spit 43 and 44		Spit 49 and 50		Total No.
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Mytilus edulis planulatus	1041.8	41.0	949.3	48.0	1388.5	52.0	1696.2	46.0	1287.0	41.0	507.9	19.0	228.7	23.0	82.8	13.0	7465.70
Cabestana spengleri	454.0	18.0	324.3	16.0	625.0	24.0	1025.7	28.0	638.8	20.0	1308.9	48.0	278.0	28.0	254.0	41.0	5131.80
Austromytilus rostratus	295.0	12.0	204.6	10.0	210.4	7.9	315.4	8.6	527.7	17.0	38.9	1.4	7.2	0.7	21.7	3.5	1681.40
Turbo undulatus	233.0	9.2	181.1	9.1	99.7	3.8	164.3	4.4	111.0	3.5	204.3	7.5	103.9	11.0	125.1	20.0	1290.40
Polyplacophora	198.0	7.9	155.9	7.9	90.9	3.4	176.1	4.7	404.7	13.0	207.6	7.6	277.8	28.0	34.4	5.6	1623.30
Thias orbita	52.9	2.1	66.4	3.4	17.7	0.7	162.9	4.4	59.8	1.9	131.1	4.8	22.2	2.3	11.8	1.9	546.30
Saccostrea cucullata	42.5	1.7	4.1	0.2	45.1	1.7	12.1	0.3	23.3	0.7	188.6	6.9	10.7	1.0	0.0	0.0	338.90
Vermetidae	38.8	1.5	24.8	1.2	62.9	2.4	60.1	1.6	22.4	0.7	18.4	0.7	0.0	0.0	0.0	0.0	235.50
Patellidae	46.3	1.8	31.4	1.6	3.7	0.1	27.3	0.7	34.7	1.1	35.5	1.3	22.1	2.2	10.6	1.7	222.10
Rock barnacle	23.4	0.9	24.8	1.2	31.2	1.2	31.2	0.8	12.8	0.4	13.2	0.5	7.2	0.7	3.2	0.5	153.20
Anadara trapezia	0.0	0.0	0.0	0.0	73.9	2.8	1.4	0.0	0.0	0.0	0.0	0.0	1.9	0.2	18.6	3.0	101.83
Turbo torquatus	13.4	0.5	1.6	0.1	0.0	0.0	4.0	0.1	8.0	0.2	33.6	1.2	0.0	0.0	7.5	1.2	71.38
Nerita atramentosa	40.0	1.6	0.0	0.0	0.0	0.0	0.9	0.0	12.0	0.4	15.2	0.5	3.2	0.3	2.4	0.4	76.92
Haliotis sp.	2.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.1	7.3	0.3	0.0	0.0	38.8	6.3	57.15
Veneridae	8.0	0.3	6.1	0.3	12.8	0.5	6.4	0.2	1.6	0.1	1.6	0.1	2.4	0.2	0.0	0.0	40.50
Austrocochlea concamerata	27.2	1.1	0.0	0.0	0.0	0.0	0.0	0.0	27.2	0.8	3.2	0.1	5.6	0.6	3.2	0.5	69.50
Pyrazus ebeninus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.4	9.9	1.0	0.0	0.0	23.30
Total	2516.0	100.0	1974.4	100.0	2661.8	100.0	3684.0	100.0	3172.8	100.0	2726.8	100.0	981.0	100.0	614.0	100.0	19,129.00

Table 3 Greenglade rockshelter percentage of major shell types (by weight) from selected spits. (Key to layers and stratigraphy [also see Fig. 5]: Spits 5 and 6, 0.3-0.4 m, top of midden [i]; Spits 13 and 14, 0.7-0.8 m, top of midden [i]; Spits 19 and 20, 1.0 - 1.1 m, centre of midden [i]; Spits 25 and 26, 1.3-1.4 m, bottom of midden [i]; Spits 31 and 32, 1.6-1.7 m, midden layer [g]; Spits 37 and 38, 1.9-2.0 m, midden layer [e]; Spits 43 and 44, 2.2-2.3 m, midden layer [c]; Spits 49 and 50, 2.5-2.6 m, charcoal midden [b]).

the people who used the site. Similar comments apply to other patterns observed in the data. A particularly interesting pattern is the relative abundance of mud ark (*Anadara trapezia*) in different layers. No *Anadara trapezia* occurs in the upper 16 spits at all, but the shells are well represented in Spits 17-21 and are then found sporadically in selected lower spits (26, 27, 30, 36, 44, 45, 49, 50, 51). Today the Disaster Bay site is located at the southern end of an exposed beach immediately near to rock platforms. This is not the type of environment in which *Anadara trapezia* is found. Today very few *Anadara trapezia* occur in the more sheltered environment of nearby Wonboyn Lake, and these shells are much smaller than those found in the midden. This suggests that the vertical distribution of *Anadara trapezia* in the midden reflects local environmental change over the last few hundred years.

Mammal bone

Mammal fragments numbering 2170 and weighing 793 g were recovered from all trenches (Table 4). Nearly all spits produced mammal bone, most of which was not identifiable beyond noting it was mammal (rather than fish or bird). In Trenches 2 and 2A over 80% of bone by weight displayed visible signs of burning. The Trench 1 mammal bone was slightly less burned (about 50% of all fragments).

Only 5% of the mammal bone in Trench 2 could be identified beyond the level of 'mammal' (Table 4). The proportions of 'identifiable' bone in Trench 1 (21%) and Trench 2A (11%) were slightly higher, but still low. Within the 'identifiable' category most bone could not be identified to family, genus or species because it was too broken and burned. A few teeth of large macropods (wallabies or kangaroos) were present. Otherwise the bones were categorised on the basis of size and shaft thickness into large macropod, 'rat-sized' small mammal, and small marsupial (larger than rat-sized). These categories were commonly represented in most samples. Single fragments of sea mammal, lizard and wombat were also identified. A further nine fragments (including mandibles, maxillae, pelvis, humerus, phalanx) could possibly be further identified given more resources.

Bird bone

The midden contained far fewer bird bones than fish or mammal. Bird bones were recovered from each trench (1, 2 and 2A), but not from every spit. The pattern for each trench is very similar, with between 28 and 31% of bird bones classified as potentially identifiable given adequate reference collections and expertise (Table 5). Nomenclature follows Cayley (1986). The most common identified type (19 fragments in total) was *Puffinus sp.* (mutton bird or shearwater). Two fragments were identified as *Eudyptula minor* (little penguin or fairy penguin). Six more bone fragments represent an additional type or types of bird which could probably be identified with better reference collections than were available.

There was considerable variation in the proportion of burning evident on the bird bones, presumably reflecting differences in site-formation processes between trenches and spits. Only six bird bone fragments (13%) from Trench 1 were visibly burned. This compared to 19 (29%) and 11 (34%) of bird bone fragments with visible signs of burning from Trenches 2 and 2A.

All bird bones were checked carefully for signs of working or use as bone points (cf. Lampert 1966). Only two were found (see below).

Fish bone

Approximately 2300 g of fish bones were recovered. Individual fish bone fragments were not counted, but fish bones and scales were far more numerous than either mammal or bird bones. Only the fish remains from Trench 2 were analysed in detail. Fish remains from Trenches 1 and 2A were examined to see if any additional types were represented, but were not further recorded.

Skeletal elements from all parts of the body (head and jaw bones, spines and fin rays, scales and vertebrae) were all well represented. For example, 73% (by weight) of fish skeletal elements from Trench 2 were head and jaw bones or fin rays and spines, 10% were vertebrae and 17% were scales. Such figures suggest that whole fish were deposited in the midden.

Table 6 lists fragment counts of identified types of fish by skeletal element, and overall percentages, for Trench 2.

Trench	Total weight (g)	Totai number of fragments	Average fragment weight (g)	Number of identifiable fragments	Percentage Age identifiable
1	230	351	1.5	76	0.21
2	399	1463	3.7	70	0.05
2A	164	356	2.1	38	0.11
Total	793	2170		184	

Table 4 Mammal bones from Greenglade rockshelter.

Trench	Total weight (g)	Total number of fragments	Average fragment weight (g)	Number of identifiable fragments	Percentage identifiable
1	15.1	46	0.33	13	28%
2	19.1	64	0.30	20	31%
2A	14.3	32	0.40	10	31%
Total	48.5	142			

Table 5 Bird bones from Greenglade rockshelter.

Scientific name	English name	Dentary	Premaxilla	Articular	Maxilla	Otolith	Tooth	Pharyngeal	Spine	Vert. process	Total	Percent
Platycephalidae	Flathead	27	13	9	12						61	12.80
Serranidae *Epinephelus sp.*	Rock Cods		5								5	1.00
Carangidae	Trevallys	4	14		10				99		127	26.80
Carangidae *Seriola grandis*	Kingfish	12	17	6	2						37	7.80
Carangidae *Caranx nobilis*	Giant Trevally	16	6	16	7						45	9.50
Sparidae	Snapper Family	2	8	1	3					18	32	6.80
Sparidae *Chrysophrys auratus*	Snapper	5	16	1	1						23	4.80
Cheilodactylidae *Nemadactylus sp.*	Jackass, Morwong	14	6	3	1						24	5.00
Labridae	Wrasses	4	11	4	4		5	12			40	8.40
Labridae *Achoerodus gouldii*	Blue groper	1									1	0.20
Gempylidae	Barracouta	1	1		2						4	0.80
Monacanthidae	Leatherjacket	2					12		2		16	3.30
Unidentified		3				56					59	12.40
Total		91	97	40	42	56	17	12	101	18	474	99.60

Table 6 Identified fish bones (fragment numbers) from Greenglade rockshelter Trench 2.

Type of material	Trench 1				Trench 2				Trench 2A				Total			
	n	%	wt	%	n	%	wt	%	n	%	wt	%	n	%	wt	%
Quartz pebble	12	4.8	21.4	6.7	14	2.1	202.9	29.7	21	7.3	72	11.5	47	3.8	296.3	18.20
Quartz block	180	72.0	280.8	88.3	509	75.6	447.5	65.4	208	72.9	519.2	83.0	897	74.2	1247.5	76.60
Quartz flake	57	22.8	14.9	4.7	147	21.8	32.9	4.8	52	18.2	30.3	4.8	256	21.2	78.1	4.80
Chert or chalcedony flake	0	0.0	0.0	0.0	1	0.1	0.5	0.1	2	0.7	3.1	0.5	3	0.2	3.6	0.20
Silcrete flake	0	0.0	0.0	0.0	1	0.1	0.3	0.1	0	0.0	0.0	0.0	1	0.1	0.3	0.01
Other	1	0.4	0.7	0.2	1	0.1	0.2	0.1	2	0.7	0.9	0.1	4	0.3	1.8	0.10
Total	250	100.0	317.8	99.9	673	99.8	684.3	100.2	285	99.8	625.5	99.9	1208	99.8	1627.6	99.91

Table 7 Stone from Greenglade rockshelter.

Nomenclature follows Hutchins and Swainston (1986). At least twelve different types of fish were identified. The five most frequently represented types are Trevallys (Family Carangidae – not further identified) (26.8%), Flatheads (12.8%), Unidentified (12.4%), Giant Trevally (9.5%) and Wrasses (Family Labridae – not further identified) (8.4%). Three types of fish make up 1% or less of the sample – Rock Cods, Blue groper, and Barracouta. Such figures mean little in terms of the relative abundance of different types of fish which might have been caught by people using the shelter. The sample size is very small and the percentage representation of each type is largely a product of the degree to which different types of bones survive in the soil, and are easily identifiable. While estimating Minimum Number of Individuals could potentially compensate for some of these problems, MNI estimates have no necessary relation to the representation of different fish in the diet of the people who used the site. They are simply another way of describing variation in the samples, and the effort involved in estimating them was not considered worthwhile.

Crustacea

Other than barnacles (see above), 18 small fragments of crustacean claw or carapace, and a single crustacean jaw plate (cf. Bowdler 1983), were recovered from various spits in all trenches. These are from crabs or lobsters (crayfish), but have not been identified further due to lack of reference materials and the fragmentary nature of the material.

Stone

Excluding fragments of loose sandstone that had fallen from the roof and walls of the shelter, which were not retained, a total of 1208 pieces of stone (total weight 1627.6 g) was recovered (Table 7). Over 99% of the stone was quartz, ranging in colour and texture from an almost flawless transparent to a highly milky grey with considerable internal flaws. Three pieces of flaked chert or chalcedony and one silcrete flake were identified. Over 74% of the quartz consisted of fractured blocks of crystal with no evidence for working (Table 7). Many of these presumably derive from the seams of quartz crystal embedded in the sandstone roof and walls of the shelter. A small percentage of small quartz pebbles was also recovered, most of which were broken (Table 7). The remainder of the quartz consists of very small chips and flakes with some evidence for bipolar flaking (J. Kamminga, pers. comm. 1996). The relative proportions of these different categories of quartz is very similar for each trench (Table 7).

A large piece of broken dark grey quartzite with evidence of flaking, measuring approximately 450 mm by 350 mm by 350 mm, was found in Trench 2A, Spit 28. It is possibly part of a grindstone or pounder (J. Kamminga, pers. comm. 1996).

Other finds

Glass

Three pieces of flaked olive green bottle glass were recovered during laboratory sorting of the midden samples. A tiny flake was recovered from Trench 1, Spit 3 and a second piece, which appears to have been deliberately shaped by flaking on both sides (Fig. 7[i]), was found in Trench 1, Spit 4 (0.3 to 0.4 m below the surface). A third glass fragment with evidence of flaking (Fig. 7[j]) was found in Trench 2, Spit 6 (0.5 to 0.6 m below the surface). A fragment of heavily patinated olive green bottle glass with no evidence of working was recovered from Trench 2, Spit 5. The glass fragments are similar in appearance and probably derived from the same vessel. Their colour and appearance dates them to the nineteenth century (J. Lydon, pers. comm. 1996).

A broken fragment of amber bottle glass with no evidence of flaking was also recovered from Trench 1, Spit 4 (Fig. 7[k]). The colour of the glass, the shape of the bottle and the presence of a seam from a mould suggest it dates from the 20th century.

Fishhooks

Two shell fishhooks were recovered during laboratory sorting (Fig. 7[g] from Trench 2A, Spit 9; and [h] from Trench 2, Spit 5). Both display evidence of grinding as part of the manufacturing process and both are broken.

Bone points

Five worked bone points were recovered during excavation and from laboratory sorting. Figure 7[a] was from Trench 1, Spit 4. Figures 7[b] and 7[c] were both from Trench 2, Spit 33. These are made from small slivers of mammal long bone fragment [a] and bird bone [b and c] with one end ground into a sharp point. Figure 7[d] (Trench 2A, Spit 4) is made from mammal bone (probably a macropod fibula), has been ground at one end and has heavy wear and use polish. Figure 7[e] (Trench 2A, Spit 15) is made from a piece of mammal bone ground at one end, and is broken.

Other finds

Three metal shoe eyelets (Fig. 7[l]) were recovered during laboratory sorting of Trench 2, Spit 3.

A fragment of venus shell (Family Veneridae) with a hole though it was recovered from Trench 2, Spit 13 (Fig. 7[f]). Examination under a low-power binocular microscope revealed the hole to be conical in shape, very regular and placed near to the apex of the shell. These features suggest that someone deliberately drilled the hole through the shell, rather than it being due to the radula of a boring gastropod (J. Kamminga, pers. comm. 1996).

Excavations at Bay Cliff (Site 63-3-12)

A 0.5 x 1 m test excavation at Bay Cliff aimed to date and sample a midden located in a different environment to the Greenglade rockshelter (Fig. 1). Although midden was eroding from the foredunes of Wonboyn Lake for several hundred metres, little midden was visible on the thickly vegetated dune surface. Augering revealed midden deposits at least 0.7 m thick beneath an overlying cap of blown beach sand and vegetation extending at least 12 m back from the shore.

The trench was excavated in 10 cm spits and all excavated deposit was dry sieved through a 5 mm mesh on site. 0.7 m of midden overlay clean beach sand. Figure 8 shows the stratigraphy.

A radiocarbon date on charcoal excavated about 55 cm below the surface returned an age of 330±110 BP (ANU-6930). At a 1 σ level this date calibrates as having a 100% probability of falling within the range 510 to 290 years cal BP (AD 1440-1660). At a 2 σ level the date has an 81% probability of falling in the range 540 to 240 years cal BP (AD 1410-1710).

Analysis of excavated material

The 36,103 g of excavated deposit comprised: charcoal and plant remains 498.6 g (1.3%); mammal bone 3.3 g (<0.1%); bird bone 8.4 g (<0.1%); fish bone 8.6 g (<0.1%); stone (sandstone, quartz and other) 547.8 g (1.5%) and shell 35,026 g (99.0%). The vast majority of Bay Cliff deposit was shell, in contrast to Greenglade where shell was relatively less predominant, presumably reflecting different site-formation processes.

Shell

Table 8 lists the gross weight and percentage of the 33 types of shell identified. Edible mussel predominated (66.5% of the total weight) followed by mud ark (7.1%) and triton (6.8%). Six types of shell comprised between 3.5% and 1.9% of the sample (Sydney rock oyster, mud oyster, cartrut shell, barnacles, wavy turban shell and chitons). Fourteen shells represented less than 1% by weight, and a further 13 shells each made up less than 0.1% of the sample.

The shells in the Bay Cliff midden come from both rocky shore and more sheltered estuarine conditions. From casual observation, most of the *Anadara* shells were larger than those which occur in Wonboyn Lake today. The greatest lengths (measured on the long axis) of a sample of 100 left and right valves of *Anadara* were measured. The minimum greatest length was 34.3 mm, the maximum was 82.6 mm, and the average was 44.09 mm. There was no evidence that any of the *Anadara* shells were used as scrapers, as reported elsewhere (McDonald 1992:101).

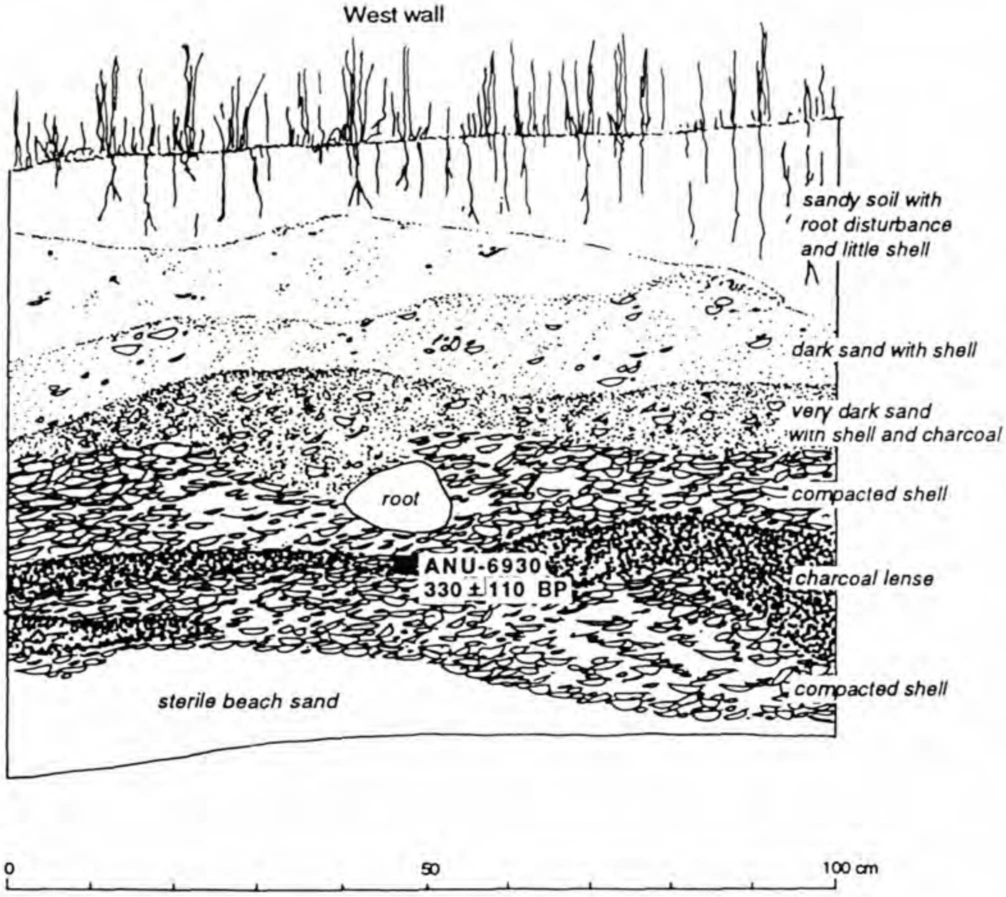

Figure 8 Stratigraphy of west wall of Bay Cliff, Trench 1.

the sites meant that the project could not answer the original research questions, but suggested that Greenglade rockshelter was used by Aboriginal people both before and for a considerable time following British colonisation, despite the very low density of imported European items in the midden.

Establishing a chronology for the Greenglade rockshelter was complicated by problems involved in calibrating recent radiocarbon ages into calendar years. A pilot project was therefore undertaken to date shells from the site using aspartic acid racemisation, which has not previously been applied to recent archaeological sites in Australia. AAR combined with radiocarbon and artefactual evidence dated the deposits variously from around 600 years ago until the 20th century, but suggested that at least the upper parts of the midden had been disturbed and mixed. Despite these problems the site provides material evidence for continuing use of the rockshelter, and for hunting, fishing, shellfish collecting as well as the use of traditional tools and flaked bottle glass, by Aboriginal people both before and after British colonisation.

AAR has obvious potential for dating Australian archaeological sites from the last 200 years or so for which documentary evidence is either imprecise or unavailable. At Greenglade rockshelter the amino acid dates were calibrated into calendar years by comparison with radiocarbon determinations (Murray-Wallace and Colley 1997). Sampling considerations and error margins inherent in the radiocarbon dating process introduced uncertainty into the interpretation of the results. An obvious next step to refine the technique further is to calibrate AAR dates using shells derived from archaeological contexts securely dated by documentary sources.

For a variety of reasons the Disaster Bay project was limited in scope, and the conclusions that can be drawn from such small-scale excavations are limited. Nevertheless, the project has provided further documentation of an Aboriginal shell midden in an area of the NSW south coast where few previous detailed studies have been conducted. Greenglade rockshelter, which spans the period of 'contact' between indigenous people and colonial settlers, crosses the boundary between Australian prehistory and Historical Archaeology and raises a number of challenging theoretical

Bone

Very little bone was recovered from the midden. Eight pieces of mammal bone (total weight 3.3 g) were recovered from four spits. All the bone was highly fragmented and not identifiable. Six bird bones (total weight 8.4 g) were recovered from three spits only. None of these could be identified. Approximately 60 fragments of fish bone (total weight 8.6 g) were recovered. Skeletal elements included scales, vertebrae, head bones and spines, suggesting the presence of whole fish. Only a dentary and a premaxilla of snapper (*Chrysophrys auratus*) were identifiable.

Stone

Stone weighing 547.8 g was recovered (Table 9). Unmodified sandstone predominated, followed by quartzose sandstone, quartz and quartz pebbles. Clay and ironstone were also represented in small quantities. The quartz was opaque and consisted mostly of blocks similar to those from the Greenglade rockshelter. A small proportion of the quartz was flaked. The quartzose sandstone was unweathered and seems likely to be local in origin (J. Kamminga, pers. comm. 1996).

Discussion and conclusions

The Disaster Bay excavations were initially designed to answer questions about Australian prehistory in which explanation was primarily conceived in terms of human-environmental interaction and ethnographic analogy. Such considerations influenced the whole way in which the project was approached and implemented. The recent dates for

Scientific name	Common name	Total weight (g)	Percentage
Mytilus edulis planulatus	common edible mussel	23,287.8	66.5
Anadara trapezia	mud ark	2476.0	7.1
Cabestana spengleri	triton	2395.4	6.8
Saccostrea cucullata	Sydney rock oyster	1224.9	3.5
Ostrea agnasi	mud oyster	1174.6	3.3
Thias orbita	cartrut shell	1069.5	3.0
CRUSTACEA	barnacles	721.3	2.0
Turbo undulatus	wavy turban shell	670.6	1.9
Class Polyplacophora	chitons	575.4	1.6
Family Vermetidae	worm shells	233.0	0.6
Trichomya hirsuta	hairy mussel	158.4	0.4
Family Patellidae	limpets	152.6	0.4
Nerita atramentosa	black periwinkle	140.5	0.4
Austrocochlea constricta	ribbed top shell	124.0	0.3
Austromytilus rostratus	beaked mussel	87.3	0.2
Velacumantus australis	southern mud whelk	68.1	0.2
Haliotis sp.	abalone	48.5	0.1
	gastropod NFI	43.5	0.1
Family Buccinidae	whelks	42.7	0.1
Bankivia sp.	banded kelp shell	41.3	0.1
Pyrazus ebeninus	club mud whelk	38.3	0.1
	unidentified shells	38.1	0.1
Family Veneridae	Venus shells	28.5	<0.1
Family Littorinidae	periwinkles	22.4	<0.1
Limopsis tenisoni	Tenison's false dog cockle	10.5	<0.1
Bembicium sp.		9.1	<0.1
Austrocochlea concamerata	wavy top shell	7.6	<0.1
Family Nassariidae	nassarius	6.4	<0.1
Family Cerithiidae	creepers	3.5	<0.1
Dicathais baileyana	Bailey's dog winkle	2.7	<0.1
Family Nassidae	dog whelks	2.2	<0.1
Family Mytilidae	mussels NFI	1.6	<0.1
Family Cypraeidae	cowries	1.6	<0.1
Family Pectinidae	scallops	1.4	<0.1
Family Capulidae	slipper limpets	1.3	<0.1
Total		34,910.6	

Table 8 Marine shells from Bay Cliff midden listed in descending order by total weight.

and methodological questions which are explored in detail elsewhere (Colley and Bickford 1996; Colley in prep.). The archaeology of pre-colonial Australia has traditionally been the province of Australian prehistory, while Historical Archaeology has usually concerned itself with the archaeology of colonial settlement. A number of Aboriginal middens have been excavated in the Sydney region and along the NSW south coast over the last 20 years or so. Several sites provide evidence for Aboriginal use after British colonisation e.g. Ball's Head (Bowdler 1971); Captain Cook's Landing Place, Kurnell (Megaw 1969); Durras North (Lampert 1966) and Pambula Lake (Sullivan 1984). In most cases this aspect of the site is not well-described as it did not form a major focus of the research which was primarily concerned with 'prehistory'. Sites such as these and the Greenglade rockshelter raise interesting questions about how Australian archaeologists conceptualise what they do, and what might be appropriate methodologies for studying the process of Aboriginal-settler contact in south-eastern Australia using archaeological, documentary and oral evidence. Such work also may have implications for Aboriginal people seeking to make native title claims under the *Native Title Act* where it is necessary to demonstrate continuity of use and association both prior to and following British settlement (Cane 1992; Colley 1992).

Acknowledgements

Fieldwork was funded by the Department of Prehistory, Research School of Pacific Studies, The Australian National University. Laboratory analysis was assisted by a University of Sydney Special Project (1990). Most of the work was done with the help of volunteers and students from The Australian National University and the University of Sydney, including shell analysis undertaken as part of Sydney University undergraduate practical work classes. Most of the report was completed while I was a Sabbatical Fellow at the Humanities Research Centre, The Australian National University between February and June 1996.

So many people have been involved in the project that it is impossible to list them all here. I would like to thank everyone for all the time and help they gave me.

Individuals who deserve special mention include: Val Attenbrow, Michael Barry, Anne Bickford, David Crewe, Gary Dunnett, Sue Feary, Noel Fisk and family, Trish Fletcher, Prue Gaffey, Jack Golson, Chris Griffiths, Johan Kamminga, Luci-Anne Kreller, Stacey Lee, Jane Lydon,

Spit	Quartz wt (g)	Quartz pebbles wt (g)	Sandstone wt (g)	Quartzose sandstone wt (g)	Clay? wt (g)	Iron stone wt (g)	Total
1	0.0	7.8	15.0	27.8	0.6	0.5	51.7
2	1.8	2.1	3.0	87.2	0.0	0.0	94.1
3	5.9	0.0	4.4	0.0	0.0	0.0	10.3
4	37.5	0.0	92.3	4.9	0.0	0.0	134.7
5	9.4	3.8	154.8	16.8	0.0	0.0	184.8
6	8.3	0.5	22.6	0.0	3.3	0.0	34.7
7	25.2	0.0	2.8	0.0	9.5	0.0	37.5
Total	88.1	14.2	294.9	136.7	13.4	0.5	547.8

Table 9 Stone from Bay Cliff midden.

Letricia Martin, Bernard Mufumba, Kerry Nathan, Ian Nicholson, Richard Nipperess, Kelvin Officer, Tessa Rath, George Susino, Neil Stevens, Jo Thompson and David Wardlaw. I would particularly like to thank Colin Murray-Wallace for carrying out the amino acid racemisation dating, calibrating my radiocarbon dates and providing useful comments on the text. I would also like to thank Winifred Mumford for completing the illustrations to her usually high professional standard. Finally, I would like to express my thanks to Ben Cruse and other members of Eden Aboriginal Land Council for giving me permission to conduct this research into Aboriginal places in their area and for being helpful and supportive throughout the project.

References

Allen, J. and Jones, R. 1980 Oyster Cove: Archaeological traces of the last Tasmanians and notes on the criteria for the authentication of flaked glass artefacts. *Papers and Proceedings of the Royal Society of Tasmania* 114:225-33.

Bennett, I. 1992 *Australian Seashores*. Sydney: Angus and Robertson.

Bowdler, S. 1976 Hook, line and dilly bag: An interpretation of an Australian coastal shell midden. *Mankind* 10:248-58.

Bowdler, S. 1983 Sieving seashells: Midden analysis in Australian archaeology. In G. Connah (ed.) *Australian Field Archaeology. A Guide to Techniques*, pp.135-44. Canberra: Australian Institute of Aboriginal Studies.

Bowman, S. 1990 *Radiocarbon Dating*. London: British Museum Publications.

Byrne, D. 1984 *The Mountains Call Me Back. A History of the Aborigines and the Forests of the Far South Coast of NSW.* Sydney: NSW Ministry of Aboriginal Affairs.

Cane, S. 1992 Aboriginal fishing on the south coast of New South Wales. Unpublished report to Blake, Dawson and Waldron and the New South Wales Aboriginal Land Council.

Cayley, N.W. 1986 *What Bird is That?* Sydney: Angus and Robertson.

Colley, S. 1992 Archaeological evidence for abalone fishing by Aboriginal people on the NSW south coast. Unpublished report to Blake, Dawson and Waldron Solicitors on behalf of the New South Wales Aboriginal Land Council.

Colley, S. in prep. Archaeology and Aboriginal-settler contact in coastal New South Wales. In R. Torrence and A. Clarke (eds) *Negotiating Difference: Re-interpretations of Intercultural Encounters in Oceania*. London: Routledge.

Colley, S. and Bickford, A. 1996 'Real' Aboriginals and 'real' archaeology: Aboriginal places and Australian historical archaeology. *World Archaeological Bulletin* 7:5-21.

Colley, S. and Spennemann, D. 1989 Fire in a pit: The effects of burning on faunal remains. *Archaeozoologia* 3:51-65.

Coutts, P.J.F., Aplin, K. and Taylor, N. 1984 Archaeological excavations at Captain's Point, Mallacoota. In P.J.F. Coutts (ed.) *Coastal Archaeology in South-eastern Victoria. Records of the Victorian Archaeological Survey* 14:1-184.

Gillespie, R. and Polach, H.A. 1979 The suitability of marine shells for radiocarbon dating of Australian prehistory. In R. Berger and H. Suess (eds) *Proceedings of the Ninth International Conference on Radiocarbon Dating*, pp.404-21. University of California Press.

Goodfriend, G.A. 1992 Rapid racemization of aspartic acid in mollusc shells and potential for dating over recent centuries. *Nature* 357:399-401.

Goodfriend, G.A., Hare, P.E. and Druffel, E.R.M. 1992 Aspartic acid racemization and protein diagenesis in corals over the last 350 years. *Geochimica et Cosmochimica Acta* 56:3847-50.

Hutchins, B. and Swainston, R. 1986 *Sea Fishes of Southern Australia*. Perth: Swainston Publishing.

Mackay, R. and White, J.P. 1987 Musselling in on the NSW coast. *Archaeology in Oceania* 22:107-11.

McDonald, J. 1992 *The Archaeology of the Angophora Reserve Rock Shelter*. Sydney: New South Wales National Parks and Wildlife Service. *Environmental Heritage Monograph Series*, 1.

McKenzie, J.A.S. n.d. *The Twofold Bay Story*. Eden Killer Whale Museum and Historical Society, 94 Imlay Street, Eden, NSW 2551.

McPherson, J.H. and Gabriel, C.J. 1962 *Marine Molluscs of Victoria*. Melbourne: Melbourne University Press.

Murray-Wallace, C.V. 1993 A review of the application of the amino acid racemisation reaction to archaeological dating. *The Artefact* 18:19-26.

Murray-Wallace, C.V. and Colley, S.M. 1997 Towards a chronology for the contact period in Australian archaeology – an application of amino acid racemisation and radiocarbon dating. *Archaeology in Oceania* 32(2):163-69.

Officer, K. 1991 *Boanyoowurragh Murrowan (Living Pictures): The Pictorial Record of the Aboriginal Rock Art of South-eastern New South Wales*. Canberra: Report to the Australian Institute of Aboriginal and Torres Strait Islander Studies and Department of Prehistory and Anthropology, The Australian National University.

Officer, K. 1993 Style and graphic. An archaeological model for the analysis of rock art. Unpublished Ph.D. thesis, Department of Prehistory and Anthropology, The Australian National University, Canberra.

Pleaden, R.F. 1990 *Coastal Explorers*. Milton, NSW: Milton/Ulladulla and District Historical Society.

Rowland, M. 1994 Size isn't everything. Shell mounds, middens and natural deposits. *Australian Archaeology* 39: 118-23.

Sullivan, M.E. 1982 Aboriginal shell middens in the coastal landscape of New South Wales. Unpublished Ph.D. thesis, Department of Prehistory and Anthropology, The Australian National University, Canberra.

Sullivan, M.E. 1984 A shell midden excavation at Pambula Lake on the far south coast of New South Wales. *Archaeology in Oceania* 19:1-15.

Sullivan, M.E. 1987 The recent prehistoric exploitation of edible mussel in Aboriginal shell middens on southern New South Wales. *Archaeology in Oceania* 22:97-106.

Stuiver, M. and Reimer, P.J. 1993 Extended ^{14}C data base and revised calib 3.0 ^{14}C age calibration program. *Radiocarbon* 35:215-30.

Weaver, F. 1990 Goanna Bay excavation, Top Lake, Mallacoota Inlet, north east Victoria. *Artefact* 13:28-39.

Webb, E., Cane, S., Aiken, G. and Lance, A. 1986 An excavation and analysis of two Aboriginal shell middens near Merimbula, New South Wales. Unpublished report to Sinclair Knight and Partners Pty Ltd. The Australian National University Archaeological Consultancies, ANUTECH Pty Ltd, Canberra, ACT 0200.