Chapter 4: Materials and Methods

4.1 Introduction

In this chapter I present my methods for inferring changing sea-levels from the Macleay case-study sites of Clybucca 3 and Stuarts Point 1, and the materials used in the analysis of the sites. In Section 2 I present the alternate hypotheses for the formation of the Macleay floodplain and estuary, and the effects of both of these hypotheses on the marine fauna inhabiting the estuary. I then describe the marine fauna presently inhabiting the Macleay estuary and discuss habitat and behaviour of the species, as this information is used in constructing models for change over time in the Macleay. Section 4 presents my methods for re-examination of the two sites, and the materials which are available for the re-examination. I discuss the re-dating of the Stuarts Point 1 midden, and then the re-examination of the shellfish remains and the re-analysis of the vertebrate assemblages. My methods for the re-analysis of the fishbone assemblages are fully described. In Section 8 I propose a method for grouping the arbitrary spits excavated from the sites into analytical units representing time periods. All archaeological research encounters some difficulties and limitations, so I discuss some of the limiting factors which are associated with the archaeological data used in this research in Section 9. Finally I present a summary of my methods for inferring sea-level change from the Macleay sites.

4.2 Inferring Changing Sea-Levels in the Macleay Sites

The two Macleay sites chosen for this case study were selected because of their location in the landscape and because they are in close geographical proximity to one of the site of Valla used by Flood and Frankel (1989) to test their theories of sea-level instability in the Mid to Late Holocene. Clybucca 3 is located approximately 12 kilometres inland from the sea, at the point in the landscape where the foothills of the ranges start to rise. By comparison, Stuarts Point 1 is located very near the coast, separated from the ocean by the Macleay Arm and the outer barrier. By choosing these two sites I am attempting to compare marine resource availability in two different locations, as location was the main variable in identifying sea-level change identified from the literature review. From these sites, situated in different locations I will then be able to examine the possibility of changing resource use over time in the archaeological assemblages. First, I will examine the hypotheses for the development of the Macleay floodplain, and compare the outcomes of both a sea-level change in the region and infilling of the Macleay embayment by sediments.

Two hypotheses have been presented for the evolution of the Macleay floodplain –

1. That sea-levels rose sharply in the mid-Holocene to two metres higher than the present level, inundating the floodplain and forming a large, marine embayment (Mundell 2000; Baker et al. 2001),

   or,

2. That the area between the low-relief hills to the west, and the Inner Barrier sand ridges was gradually infilled with sediments carried down the Macleay River (Thom et al. 1969).

The effects of both processes on the Lower Macleay floodplain culminate in very similar outcomes after 3,500 BP as can be seen in the models presented in Table 4.1. The dating of these events are based on Mundell's (2000) model of the evolution of the Macleay floodplain presented in Figures 3.17 and 3.18, and Baker et al's (2001) hypothesis of when the sea-level rise to two metres occurred (Figure 2.8). Whilst there is some disagreement about the timing of the sea-level rise, taking both proposals into account it could be proposed to have taken place between 5,000 – 4,500 BP. In the early stages, which would have occurred in the mid-Holocene (approximately 5,000 years before present), the environmental outcome from both of the processes would be very different. The main area where the processes differ is in the turbidity and temperature of the waters in the embayment. If the sea-level was two metres higher, it would receive more of the benefits of tidal flushing of the waters of the embayment. Fresh water being introduced to the area from the Macleay River would be overwhelmed by large amount of sea water being introduced through the tides twice a day. This would moderate rising temperatures of the waters in the embayment. On the other hand, if the evolution of the Macleay floodplain was attributed only to sedimentation carried down the river from the tablelands, the result would be a slow, and gradual lessening of the amount of water in the embayment accompanied by increased turbidity and temperature of the waters due to the sediment load discharged into the embayment, and the lesser amount of water in total contained in the embayment. The major ecological difference is therefore that the conditions of the changing sea-level model favours sea grass dwellers in the earlier phase, whereas the sedimentation model does not.

As the sea-level lowered at c. 3,500 BP, the model shows how the environmental conditions between the two scenarios would become more similar. Marine habitats which had become adapted to the greater amounts of sea water would be disturbed, causing the depletion or loss of environments such as the seagrass beds. The environment around the remaining water in the Macleay would become muddier, allowing the growth of mangrove habitats, whilst the waters themselves would become more turbid, from the increased sediment load in relation to the water mass, and the shallower water would become warmer, due to the heating of a lesser amount of water, and the decreased tidal flushing. The salinity regime of the now diminished embayment would be changed as less marine water was being introduced to the area, another factor which would change the habitat for marine species. Water circulation would become more limited, perhaps creating more distinct habitats within the estuary. The effects of the lowering of sea-level, as opposed to the slow, gradual infilling of the embayment, could be catastrophic in an estuarine environment (Montgomery 1992:154).

Time	Hypothesis One: Changing Sea-Level	Marine Fauna: Hypothesis One	Hypothesis Two: Sedimentation	Marine Fauna: Hypothesis Two
5,000 bp to 4,000 bp	The embayment is dominated by marine waters, and waters are deeper than at present in the Macleay. Seagrass beds are flourishing. The embayment receives the effect of tidal flushing, and turbidity is low. Water temperature in the marine environment is regulated by the constant tidal flushing by cooler sea-water.	Shellfish: The seagrass beds provide a habitat for freely-moving shellfish. *Anadara trapezia* are associated with seagrass beds. Oysters are abundant in areas with a rocky strata. Fish: A range of fish species are found in the sheltered embayment. Small fish find the shelter of the seagrass a suitable habitat.	A gradual decrease in the amount of water is available for a marine habitat as the embayment is being infilled by sediment carried down the river. There is a higher turbidity as more sediment is carried down the river. Water temperature increases as the waters become shallower.	Shellfish: Oysters predominate on the rocky substrata, and begin to colonise mangrove swamps. Cockles find this environment increasingly difficult. Mud inhabiting species begin to colonise. Fish: This environment favours bottom feeding fish, such as mullet, but small fish may find it a difficult environment. Oysters flourish in warmer temperatures, and may overwhelm other species of shellfish.
3,500 bp	As the sea-level dropped, marine habitats such as seagrass beds diminish, and the surrounding shoreline becomes muddier, allowing the growth of mangroves.	Shellfish: Seagrass inhabitants find this environment extremely challenging. Oysters and whelks are now able to predominate. Fish: Fish are less likely to be disrupted than shellfish as they are more mobile. They may change habitats.	Mangrove growth is ongoing as more sediments accumulate on the margins of the embayment.	Shellfish: Oysters continue to predominate as more mangroves become available. Mud inhabiting species can now proliferate.
3,500 bp to present	Sediments carried down the river accumulate relatively more rapidly, as less water is available to disseminate the sediment, building up the floodplain. The Macleay fllodplain develops, with a meandering system of river and creeks. Flooding occurs over the low-relief plain when rainfall peaks on the tablelands.	The shellfish and fish populations become increasingly more as seen in the present.	Sediments carried down the river accumulate more rapidly over time as less water is available to disseminate the sediment, building up the floodplain. The Macleay fllodplain develops, with a meandering system of river and creeks. Flooding occurs over the low-relief plain when rainfall peaks on the tablelands.	The shellfish and fish populations become increasingly more as seen in the present.

Table 4.1 The effects on the Macleay floodplain of the two hypotheses

The first to feel any catastrophic effects of a changing environment in the Macleay embayment would be the marine faunal species inhabiting the waters. Changes that could be expected due to a changing habitat are:

1. A change in species composition, perhaps even an abrupt change, with species adapted to the former conditions being lost and being replaced by new, or previously less prolific species;
2. Size ranges in taxa may also be affected. Smaller individuals may not able to tolerate the new conditions presented by a changing habitat, and some larger species may find the new estuarine conditions, with shallower waters, incompatible with their needs;
3. Not all species may find the new environmental conditions unsuitable for habitation. There may be an increase in some species which find the new habitats more to their liking.

As has already been stated fish and shellfish would be affected by a sea-level rise of two metres. For example, shellfish inhabiting shallow waters would need to move as the water level rose, disrupting habitats such as mangroves. Historical environmental change often bought on by human modification of the landscape, such as flood mitigation or the draining of swamp lands for agriculture, has affected marine faunal populations (Rhoads and Lutz 1980:3). It is very unlikely that an environmental change in prehistoric times would not have a similar effect.

4.3 Shellfish and Fish Presently Inhabiting the Lower Macleay

The ecology of shellfish and fish presently found in the Macleay estuary will be used in the analysis of the archaeological specimens to determine the habitats which would have been available to the species identified from the Clybucca 3 and Stuarts Point 1 middens. As has been shown many aspects of environmental, and therefore habitat, change will affect shellfish and fish. Environmental change will not always be detrimental to all species. Some species may thrive in the new habitat conditions, whilst others may suffer decreased populations either through death, or finding it necessary to move to another environment more attuned with their needs. By understanding the ecology of the shellfish and fish which presently inhabit the Macleay region, I will be able to apply this information to the species identified from the archaeological remains. I have assumed that it is unlikely that habitat needs and behaviour would differ in the same species identified from the sites to those same species living today (Wheeler and Jones 1989).

4.3.1 Shellfish found in the Lower Macleay

Only three species of shellfish were retrieved from the Macleay midden sites in measurable numbers, and this requires some examination of why the shellfish taxa list should be so limited. Table 4.2 lists the species of shellfish which are found in New South Wales estuaries (Robinson and Gibbs 1982). This reference was chosen as it particularly applies to estuaries in New South Wales, based upon ecological studies of estuaries. The bivalves are represented by seventeen species, and there are thirteen species of gastropods.

Taxon	Class Sub-Class	Family	Common Name	Size	Habitat	Note
Anadara Trapezia (Deshayes 1840)	Bivalvia	Arcidae	Sydney cockle; Mud ark	7-8cm long	Seagrass beds and estuarine mud flats	
Pecten fumatus (Reeve 1852)	Bivalvia	Pectinidae	Scallop	5-6cm wide	Subtidal sandflats	
Ostrea angasi (Sowerby 1871)	Bivalvia	Ostreidae	Mud oyster	15cm long	Estuaries, on muddy bottoms	
Saccostrea glomerata (Gould 1850)	Bivalvia	Ostreidae	Sydney rock oyster	8cm long	Estuarine areas where solid attachments are available eg mangroves or rocky shores. Usually intertidal or high subtidal	Previously known as *Saccostrea commerciali s, or* Crassostrea and Ostrea
Mytilus edulis planulatus (Lamarck 1819)	Bivalvia	Mytilidae	Blue mussel; Edible mussel	8-10cm long	Attached by byssus to rocks and jetty piles in estuaries. Found in clumps.	
Trichomya hirsuta (Lamarck 1819)	Bivalvia	Mytilidae	Hairy mussel	5-6cm long	Found in clumps on rocks and muddy bottoms in estuaries. Also found in seagrass beds and attached to artificial structures.	
Xenostrobus securis (Lamarck 1819)	Bivalvia	Mytilidae		3-4cm long	Low salinity parts of estuaries. Usually in clumps attached to solid substrates.	
Chama reflexa (Reeve 1846)	Bivalvia	Chamidae		3-4cm diam	Attached to rocks and other solid objects in estuaries.	
Tapes Watlingi (Iredale 1958)	Bivalvia	Veneridae	Tapestry shell	5cm long	Seagrass beds and sandflats of estuaries.	

Table 4.2 Shellfish of New South Wales Estuaries (Robinson and Gibbs 1982)

Taxon	Class Sub-Class	Family	Common Name	Size	Habitat	Note
Paphia undulata (Born 1780)	Bivalvia	Veneridae		4-5cm long	Muddy areas in estuaries.	
Circe scripta (Linnaeus 1758)	Bivalvia	Veneridae		5-6cm diam	Estuarine beaches and mudflats.	
Dosinia sculpta (Hanley 1845)	Bivalvia	Veneridae		3cm long	Seagrass beds.	
Glauconome plankta (Iredale 1936)	Bivalvia	Glauconomidae		2cm long	Brackish muddy areas, particularly amongst mangroves, mouths of creeks.	
Tellina (Macomona) deltoidalis	Bivalvia	Tellinidae		3-4cm long	Sandy/mud areas and seagrass beds in estuaries.	
Theora fragilis (A. Adams 1855)	Bivalvia	Semelidae		1cm long	Muddy areas in estuaries.	
Solen correctus (Iredale 1924)	Bivalvia	Solenidae	Chinaman's fingernail; Finger oyster	7-8cm long	Specimens usually burrow into estuarine mud flats and beaches	
Venatomya elliptica (A. Adams 1851)	Bivalvia	Mactridae		1cm long	Mud.	
Prothalotia comtessei (Iredale 1931)	Gastropoda Prosobranchia	Trochidae		2cm tall	Seagrass beds and estuarine beaches.	
Nerita atramentosa (Reeve 1855)	Gastropoda Prosobranchia	Neritidae		3cm high	Mangrove areas; also common rock platform species.	
Phenacolepas cinnamomea (Gould 1846)	Gastropoda Prosobranchia	Phenacolepadidae	Sugar limpet	1.5 cm long	Seagrass beds and under rocks and vegetation; usually buried in mud.	
Patelloida mimula (Iredale 1924)	Gastropoda Prosobranchia	Acmaeidae		1cm long	Sheltered areas in pools and under rocks.	

Table 4.2 Shellfish of New South Wales Estuaries (Robinson and Gibbs 1982)

Taxon	Class Sub-Class	Family	Common Name	Size	Habitat	Note
Bembicium auratum (Quoy and Gaimard 1834)	Gastropoda Prosobranchia	Littorinidae		2cm high	Sheltered parts of estuaries, particularly mangroves and seagrass beds.	
Pseudoliotia micans (A. Adams 1850)	Gastropoda Prosobranchia	Vitrinellidae		3mm tall	Seagrass beds and sandy estuarine beaches.	
Bittium lacertinum (Gould 1861)	Gastropoda Prosobranchia	Cerithiidae		2cm long	Seagrass beds and sandy estuarine beaches. Also found on the coast.	
Pyrazus ebinenus (Bruguiere 1792)	Gastropoda Prosobranchia	Potamididae	Hercules' club shell; Sydney mud-whelk	9cm long	Estuarine mud flats and mangrove areas.	
Velacumantus australis (Quoy and Gaimard 1834)	Gastropoda Prosobranchia	Potamididae		4cm long	Seagrass beds.	
Conuber sordidum (Swainson 1821)	Gastropoda Prosobranchia	Naticidae	Sand snail	5cm tall	Estuarine mud and sand flats.	
Nassarius burchardi (Dunker in Phillipi 1849)	Gastropoda Prosobranchia	Nassariidae	Dog whelk	2cm tall	Estuarine mud and sand flats; also present in seagrass beds.	*Parcanassa ellana* (Iredale 1936)
Bedeva hanleyi (Angas 1867)	Gastropoda Prosobranchia	Muricidae	Oyster drill	2cm long	Amongst oyster and mussel beds in estuaries; also often found in seagrass beds.	
Salinator solida (von Martens 1878)	Gastropoda Pulmonata	Amphibolidae		2cm tall	Saltmarsh and mangrove areas, particularly in supralittoral zone.	

Table 4.2 Shellfish of New South Wales Estuaries (Robinson and Gibbs 1982)

The king scallop (*Pecten fumatus*) is a sub-tidal species occupying waters to a depth of 80 metres. It requires a hard substrate upon which to attach when young and moves into sediments, such as sub-tidal sandflats, when approximately 6 mm in length (Edgar 1997:291). The blue mussel (*Mytilus edulis planulatus*), while occupying shallower waters from mid-tide to 5 metres (Coleman 1975:82), would probably prefer colder temperature waters than that which is currently evidenced in the Macleay estuary (Edgar 1997:286). The hairy mussel (*Trichomya hirsuta*), would appear to be well-suited to the Macleay region (Coleman 1975:28), however Coleman (1975:28) describes the species as "not as popular for human consumption as the black mussel", which is not found in the study region.

The species of Veneridae listed by Robinson and Gibbs (1982), *Circe sugillata*, could not be found in other references sources, however the authors do point out that similar species can be found on all Australian coasts. Another species of Veneridae (venus shells), *Circa scripta* (Linnaeus 1758) is listed as being found in the northern New South Wales region (Edgar 1997:304). It grows to 5 cm in diameter and occupies areas of current flow in the deeper parts of estuaries (3-15 metres), perhaps making it somewhat difficult to collect. The final bivalve listed by Robinson and Gibbs (1982) is the *Solen correctus*, or Chinaman's fingernail. Although this species occupies sheltered and moderately exposed sand areas, it can quickly burrow into the sand and thus make collection difficult (Edgar 1997:301-2). All of the Gastropods listed by Robinson and Gibbs (1982) apart from *Pyrazus ebinenus*, are small species of a length of 3cm or less.

After eliminating those shellfish which are too small to be economically viable, those which would not find the environmental conditions of the Macleay estuary inhabitable, and those which are very difficult to collect, the remaining species listed by Robinson and Gibbs (1982) appear to be those which were retrieved from the Macleay middens. *Saccostrea glomerata* (the Sydney rock oyster) and *Anadara trapezia* (the Sydney cockle), overwhelm the remaining species retrieved by weight in the middens. There is also an appreciable amount of the mud whelk *Pyrazus ebinenus* in some of the spits excavated at Stuarts Point. I will now describe the behaviour and habitat of the oyster (*Saccostrea glomerata*), cockle (*Anadara trapezia*) and mud whelk (*Pyrazus ebinenus*).

Sydney Rock Oyster

Class: Bivalvia

Family: Ostreidae

Saccostrea glomerata (Gould 1850)

Previously known as *Saccostrea commercialis* (Iredale 1939)

The Sydney rock oyster favours a habitat of mangroves and sheltered rocky shores. Their habitats are distributed from Port Phillip Bay, Victoria to southern Queensland. Sydney rock oysters tend to dominate other shellfish at the mid intertidal level, often growing on each other and on the shells of adjoining animals. They are a common species and are commercially farmed in estuaries. Sydney rock oysters grow to a length of 80 mm. It has also been noted that oysters grow faster and larger in warmer climates. (Yonge 1960:159; Coleman 1975:31; Edgar 1997:295).

Sydney Cockle

Class: Bivalvia

Family: Arcidae

Anadara trapezia (Deshayes 1840)

Whilst the Sydney cockle's habitat is not similar to the Sydney rock oyster, its distribution is similar, and ranges from Port Phillip Bay in Victoria to southern Queensland. They prefer a sheltered situation in mud, sand and seagrasses. They reach a maximum length of 75 mm. They occur in abundance in estuaries with suitable habitats. (Coleman 1975:14; Edgar 1997:284).

Mud Whelk

Class: Gastropoda

Sub-Class: Prosobranchia

Family: Batillaridae

Pyrazus ebinenus (Brugiere 1792)
Mud whelks (Hercules club whelk) is a prolific species inhabiting sheltered mudflats and mangrove swamps in the low intertidal range in estuaries. Its distributional range is from Victoria along the eastern coast of Australia to central Queensland. The Hercules club whelk grows to 110 mm, and is the largest species of mud whelks. It is the only mud whelk with a widely flaring aperture, which may make the removal of the edible animal easier. This species may survive for some time out of water. (Coleman 1975:35; Edgar 1997:247)

4.3.2 Fish found in the Lower Macleay

The table of fish species most likely to be caught in the Macleay estuary presently (Table 4.3) is derived from those listed in *Fish Australia: The essential fishing companion* (Ross 1995), which gives detailed information of fish caught in the Macleay, both in the estuary and from the beach. This list of the most likely catch in the Macleay region is reinforced by the species listed in *Fisheries Bulletin 2: An estuarine inventory for New South Wales, Australia* (1985), and the *Interim Report on the survey of recreational fishing in New South Wales* (NSW Fisheries Dept 2002). The report on recreational fishing in New South Wales listed the most commonly caught teleost fish as flathead, bream, whiting, tailor, European carp, and luderick (2002:3). European carp can be disregarded from this research as it is a species introduced since European settlement of Australia. All of the other species which are reported as the most commonly caught fish in the present day can be found in the Macleay estuary. It is interesting that mullet (*Mugil cephalus*) is not listed amongst the most commonly caught fish, however this may be because mullet are not highly prized by recreational anglers, and usually need to be caught with a net rather than on a line. This species is however, one of the most abundant commercially caught fish in New South Wales, and also figures prominently in the oral history of Aboriginal people from the mid-north coast of New South Wales (Pierce 1978; Somerville et al 1999).

Family	Species	Common Name	Max Size Total Length (cm)	Habitat	Notes
Sparidae	*Acanthopagrus australis* (Owen 1853)	bream	66	Sheltered and moderately exposed sand, reef; 1-30m depth	Adult fish occur in abundance in estuaries and shallow coastal waters.
	Rhabdosargus sarba (Forsskal 1775)	tarwhine	80	Sheltered and moderately exposed sand, reef; 0-20m depth	Occurs on shallow coastal reefs and in estuaries, though not as abundant as bream.
	Chrysophrys auratus (Schneider 1801)	snapper	130	Reef; 1-200m depth	Reef habitat.
Platycephalidae	*Platycephalus fuscus* (Cuvier 1829)	dusky flathead	120	Sheltered sand, silt, reef; 0-25m depth	Abundant in sheltered estuaries and open bays.
	Platycephalus endrachtensis (Quoy & Gaimard 1824)	bar-tailed flathead	76	Sheltered silt, sand; 0-20m depth	Abundant in Western Aust, but less common on the east coast.
	Platycephalus richardsoni or *Neoplatycephalus richardsoni* (Castelnau 1872)	tiger flathead	65	Exposed sand, silt; 10-160m depth	Most abundant at depths below 30m, only occasionally in shallow water.
Girellidae	*Girella tricuspidata* (Quoy & Gaimard 1824)	luderick, blackfish	62	Reef; 0-20m depth	Occupies estuaries and shallow coastal reefs.
	Girella elevata (Macleay 1881)	black drummer	76	Submaximally and maximally exposed reef; 0-25m depth	Not common, inhabits caves in shallow waters with wave surge.
Carangidae	*Pseudocaranx dentex* (Bloch & Schneider 1801)	silver trevally, skipjack trevally	94	Open water, estuaries; 0-120m depth	Usually found in open waters; bottom feeder.
	Trachurus novaezelandiae (Richardson 1843)	yellowtail mackeral; horse mackeral	50	Open water, estuaries; 0-500m depth	Occurs in huge schools, small fish inshore, and large ones in deep water.
	Trachurus declivis (Jenyns 1841)	jack mackeral, horse mackeral	54	Open water; 0-500m depth	Occurs in large schools, and remains near deeep waters of continental shelf.

Table 4.3 Fish Species Presently Inhabiting the Macleay Estuary

Family	Species	Common Name	Max Size Total Length (cm)	Habitat	Notes
Scombridae	*Scomber australasicus* (Cuvier 1832	blue mackeral, slimy mackeral	50	Open water; 0-200m depth	Usually found in large schools off the southern coastline, smaller specimens may be found inshore.
Sciaenidae	*Argyrosomus holoepidotus* (Lacepede 1802)	mulloway, jewfish, river kingfish	200	Reef, sand, mud; 2-150m depth	Spawn in the surf zone and enter estuaries when about 100mm in length.
Pomatomidae	*Pomatomus saltatrix* (Linnaeus 1766)	tailor	120	Open sea, estuaries; 0-15m depth	Open water migratory species, however feeding schools enter shallow waters.
Sillaginidae	*Sillago flindersi* (McKay 1985)	school whiting	32	Sand, silt; 1-170m depth	Occupy deep water and rarely enter estuaries.
	Sillago maculata (Quoy & Gaimard 1824)	trumpeter/winter whiting	30	Sand, silt; 0-30m depth	Abundant in sheltered estuaries.
	Sillaginodes punctata (Cuvier 1829)	King George whiting	69	Sand, silt, seagrass; 0-25m depth	Juveniles are found in patches of shallow seagrass, adults occupy a bare sand habitat.
Mugilidae	*Mugil cephalus* (Linnaeus 1758)	sea mullet	79	Sheltered and moderately exposed sand, reef; 0-20m depth	Juveniles are found in estuaries - reach maturity at approx 330mm.
	Myxus elongatus (Gunther)	sand mullet	40	Estuarine	
	Mugil georgii (Ogilby)	fantail mullet, silver mullet	30	Sand, estuaries.	
Scorpididae	*Scorpis lineolata* (Kner 1865)	sweep, silver sweep	37	Reef; 1-30m depth	Commonly found in shallow waters above reefs, though juveniles are found near the entrances of estuaries.

Table 4.3 Fish Species Presently Inhabiting the Macleay Estuary

I will now describe the behaviour and habitat of the most abundant fish retrieved from the Macleay sites:

Platycephalidae (flathead)

Order: Perciforms; Sub-Order: Cottoidei

Platycephalus fuscus (Cuvier and Valenciennes, 1829)
Common names: dusky flathead, river flathead, estuary flathead, mud flathead.
Platycephalus indicus (Linnaeus)
Common names: tiger flathead, bar-tailed flathead.

Dusky or estuary flathead may be found in all states of Australia. They grow to a size of 1.2 metres, but are usually caught at around 60 cm. Flathead burrow into the sand and mud in estuary situations, and lie in wait for their prey. They eat a carnivorous diet of fish and crustaceans, and their large mouths can handle quite big fish. Flathead spawn in summer, when quite large fish may be observed close to the shore in sallow waters, and therefore many are caught in the months of January to March. Flathead are usually caught in weighted meshing nets and sometimes seine nets, though their habit of burrowing in the sand may provide a means of escape from the method of capture.
The tiger or bar-tailed flathead inhabits estuaries of waters north of Gladstone in the present day. It grows to approximately 100 cm.
(Edgar,1997:434; Kuiter, 1997:100; Roughley, 1951:136-137; Grant 1975:466; Coleman, 1980:110; Stead, 1908:111-112; Pollard, 1969:200-202.)

Sparidae (bream and tarwhine)

Order: Perciformes

Acanthopagrus australis (Owen, 1853)
Common names: yellowfin bream, bream, silver bream, black bream, sea bream, surf bream
May also be referred to in literature as *Chrysophrys australis*, black bream, (Stead, 1908:77); and *Mylio australis*, black bream, (Roughley, 1951:82).
Rhabdosargus sarba (Forsskal 1775)
Common name: tarwhine.

Bream are distributed from Townsville in North Queensland to the Gippsland Lakes in eastern Victoria. They occupy a primarily estuarine habitat, but may ascend rivers as far as brackish waters. They also inhabit the waters of surf beaches and rocky coastlines. Bream are bottom feeders eating a diet of shellfish, worms, crustaceans and small fish, such as pilchards and hardyheads. Their powerful molars allow them to crush quite dense shell, and they may do considerable damage to oyster beds. Bream are unusual in that they will allow juveniles and other species to feed close to where they are feeding. They grow comparatively slowly to attain a size of approximately 58-66 cm, and are sexually mature at 3 years of age and approximately 15-24 cm. Spawning occurs usually from May to August, but this is not a hard and fast rule as they have been known to also spawn in January/February. Spawning occurs in the surf zone, close to the mouth of the estuary, often on a flood tide and full moon. *A. australis* are primarily estuary fish, but they also like the flats round the mouth of a river, and the ends of beaches. Bream are not known to migrate and the fish return to the river or estuary which they left to spawn. These fish are caught commercially with sein, meshing and wire-netting nets. The largest catches occur near the mouth of an estuary as the fish move to the ocean to spawn. In the summer, meshing nets are used as the fish move over more shallow waters. More fish can be caught at night when they move into shallow water under cover of darkness. Berley (a weighted bait) may be used to attract fish to an area where they can be caught. Tarwhine inhabit similar habitats and have the same geographical distribution as bream. They are a smaller fish reaching a total length of approximately 30 cm. They are also carnivores, and can be separated from bream in archaeological assemblages because of one extremely large molar in the dentition. Tarwhine are not as abundant as bream, and are not a commercially significant species.

(Roughley, 1951:82-86; Stead, 1908:77-78; Pollard, 1969:104-107; Coleman, 1980:164; Grant, 2002:431-434; Edgar, 1997:451-452; Kuiter, 1997:176.)

Mugilidae (mullet)

Order: Mugiliformes; Sub-Order: Mugiloidei

Mugil cephalus (Linnaeus, 1758)
Common name: sea mullet
Also cited in literature as *Mugil dobula*, sea, river, bully, poddy, hardgut mullet (Roughley, 1951:31).

Mullet have a very wide geographic distribution from all around the coast and in brackish and freshwater rivers with an ocean outlet. The distribution is worldwide in tropical and temperate climates. Mullet spend the first year of their lives in the shallow waters within a short distance of a rivers entrance. After reaching a year of age, the migrate upstream where they spend the next two years scattered in the upper reaches of the brackish water, and are also able to occupy fresh waters. Mullet reach sexual maturity at three years and a size of 330 mm, when they move to the mouth of the river and wait for a westerly or south-westerly wind, before beginning their spawning migration. Large shoals of mullet move in a northerly direction staying close to the coast. It is believed that they spawn adjacent to the surf zone. The mullet 'runs' occur in April and May in northern New South Wales, and in June and July in southern Queensland. After the migration, the mullet enter a river to the north of where they left, to spawn. Mullet are bottom-feeders, eating the detritus of plants and diatoms. They may reach a size of 80 cm, but are usually caught at around 50 cm. Mullet are captured throughout the year, but large numbers are caught in seine nets in the rivers during their annual migrations. Mullet are a rich source of iodine.

(Roughley, 1951:31-35; Stead, 1908:40-42; Pollard, 1969:373-377; Gomon et al, 1994:662; Edgar, 1997:474; Grant, 2002:531).

Sillaginidae (whiting)

Order: Perciforms

Sillago ciliata (Cuvier, 1829)
Common names: sand whiting, bluenose whiting, summer whiting.
Sillago maculata (Quoy and Gaimard, 1824)
Common names: trumpeter whiting, winter whiting.

The whiting species *S. ciliata* and *S. maculata* are distributed all along the eastern coast of Australia. Whiting school in shallow-water habitats which include those with sand, shell, gravel or weed covered bottoms of channels, estuary mouths, and within the surf zone. The trumpeter whiting is not adverse to the partially or wholly mud-covered surface of some estuarine zones. They are carnivorous species, feeding on a diet of worms, crustaceans and molluscs. They may stir up the sandy bottoms to recover food. Sand whiting reach a length of 50 cm, but are usually caught at around half this size. They are sexually mature at 28 cm. The trumpeter whiting are the smaller species and reach a length of only 30 cm. The sand whiting spawn near the mouths of rivers in the surf zone between November and March (mostly January) in New South Wales, and between July and November (mostly September) in Queensland. The trumpeter whiting spawn between September and November and have a second spawning in February. Anglers tend to believe that trumpeter whiting can be caught most of the year, though the sand whiting are mainly caught in summer. Commercially, sand whiting are caught with hauling and meshing nets, and the trumpeter whiting with small-mesh hauling nets. (Roughley, 1951:46-48; Stead, 1908:63-65; Pollard, 1969:921-926; Coleman, 1980:140-142; Edgar, 1997:446).

Applying the ecological studies of shellfish and fish presently found in the Macleay region to the analysis of the marine faunal assemblages from the Clybucca 3 and Stuarts

Point 1 middens, should indicate if a habitat change had occurred in the estuary during the time the shell middens were being formed.

4.4 Re-Examination of Clybucca 3 and Stuarts Point I Data

The reanalysis of archaeological sites that were excavated 30 years previously can pose some difficulties. For example, very few people involved in the excavation are available for discussion of the sites' features, and it may even be difficult to locate the exact position of the excavation in the landscape. The Clybucca 3 site is no exception to these problems, as not all of the material excavated from both of the Cuttings was recorded, and radiocarbon dating determinations were made on only one of the Cuttings, Cutting I. To facilitate the re-analysis of the Clybucca 3 site I have had to incorporate material from both of the Cuttings so that a fuller picture of the events that led to these depositions can be attained. The re-analysis of Cutting II at Stuarts Point I is a little more straightforward. All information on weight of shell and faunal material is available for this cutting, along with the section and plan drawings of the excavation, and there are also the new radiocarbon dates obtained as part of the present research. In the following section of this chapter I will explain how I went about re-examining the data from the Clybucca 3 and Stuarts Point I excavations.

4.4.1 Clybucca 3

I had originally proposed to use Cutting I (IV-VI) for detailed analysis of the vertebrate marine fauna from this site for a number of reasons. Firstly, upon examination of the section drawings provided by Professor Connah (Figure 4.1), it appeared that the stratigraphy in Cutting I would provide a means of grouping the arbitrarily excavated spits into analytical units based on deposition. The stratigraphy in Cutting I is reasonably close to horizontal, whereas the stratigraphy of Cutting II dips sharply to the west, with the heavily humic soil reaching almost to the base of the excavation in the western section (Figure 4.1). Cutting I had also been radiocarbon dated after its excavation (Connah 1975). Even though it would have been preferable to re-date the Clybucca site, funding did not allow for this.

However, the analysis of Cutting I alone posed a number of problems. Table 4.4 illustrates the archaeological resources available for re-examination or reanalysis from the Clybucca 3 (1972) excavation.

Table 4.4 Clybucca 3 – Data Available For Re-Analysis

Data	Cutting I	Column Sample	Cutting II
Stratigraphy	Section Drawing	Section Drawing	Section Drawing
Shell Species	Not Recorded	Analysed	Analysed
Weight of Shell	Not Recorded	Recorded	Recorded
Radiocarbon Dates	Dates Published	Not Dated	Not Dated
Weight of Deposit Excavated	Not Recorded	Recorded	Not Recorded
Fishbone Assemblage	Re-analysed	Not Available	Re-analysed
Other Bone Assemblage	Re-analysed	Not Available	Re-analysed
Stone Artefacts	Weight	Weight	Weight

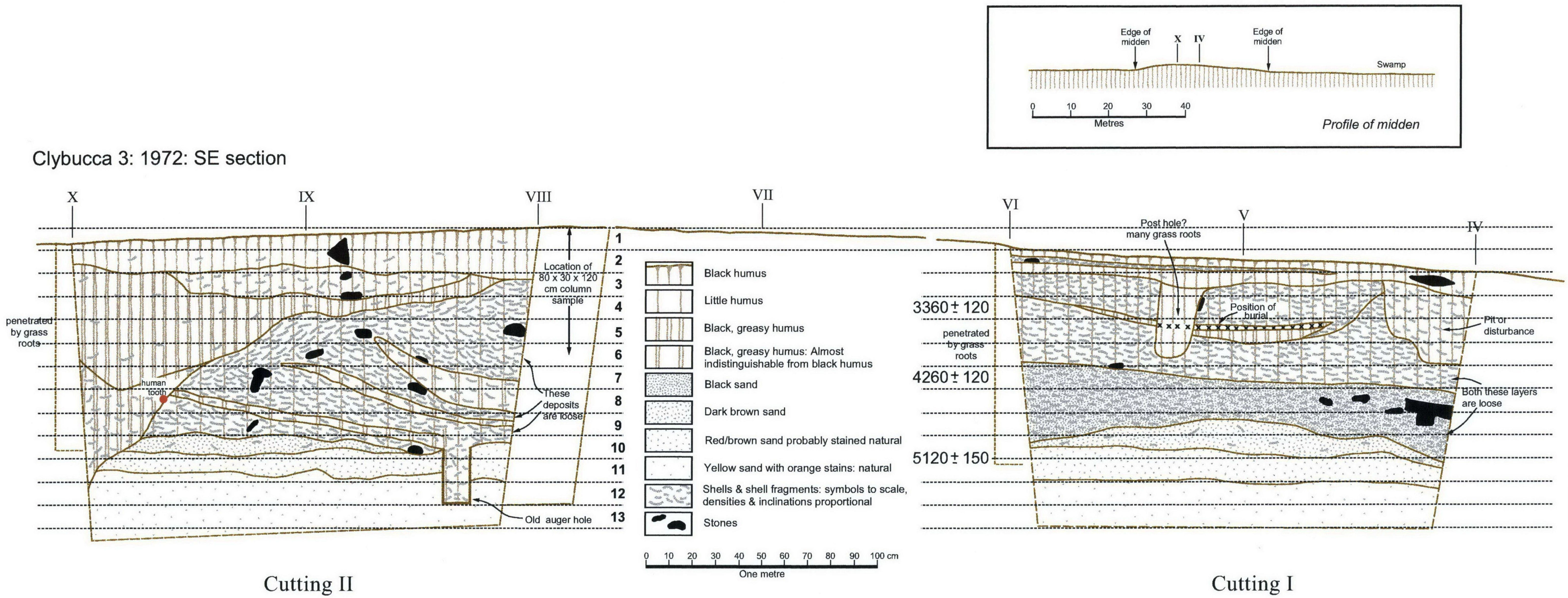

Figure 4.1 Section Drawing Clybucca 3 (after Connah, 1972)

Two cuttings were excavated at Clybucca 3 in 1972, along with a column sample taken from the eastern wall of Cutting II. No record of the shell species recovered or the weights of the shell excavated were kept from Cutting I. Also, the weight of the total deposit excavated was not recorded. Therefore, to be able to research change over time in the marine faunal assemblages it was necessary to take into account all of the archaeological resources available from both of the cuttings at Clybucca.

In Chapter 5 I fully describe the data from the Clybucca 3 excavation which were available for re-examination or reanalysis. I used photocopies of the original field notes provided by Professor Connah in describing the excavated material from each spit of both Cutting I and II. I detail the shellfish remains retrieved from Cutting II alone - as these are not available from Cutting I - and present a spit by spit analysis of the fish remains recovered from Cutting I and Cutting II. I then present the details of the terrestrial (or non-fish) fauna recovered from Cuttings I and II, followed by a discussion of the dating of the site. Finally, I offer a brief summary and my interpretation of the archaeological deposits recovered from Cuttings I and II of the Clybucca 3 site.

4.4.2 Stuarts Point 1

Cutting II of the 1975 excavations at Stuarts Point was chosen for my detailed analysis of the marine fauna recovered from this site. Figure 4.2 shows the two cuttings excavated into the centre of the midden. Connah’s section drawings appear to show that the stratigraphy was reasonably horizontal, whereas the Cutting I stratigraphy appeared to have been intruded upon by a large tree root, and there was less definition of the stratigraphic layers (Figure 4.2). This figure is scanned from a photocopy of Connah's section drawing of the south wall of the completed excavation.

The details of the excavation which appear in Chapter 6 are taken verbatim from photocopies of Connah's 'trench book', a spit-by-spit description of the excavation as it proceeded including plan drawings. I also quote extensively from Connah's 'day book', in adding further details to augment the descriptions of the excavated material from the 'trench book'. All excavated material was sieved through 1/2 inch over 1/4 inch mesh (approximately 10 mm and 5 mm).

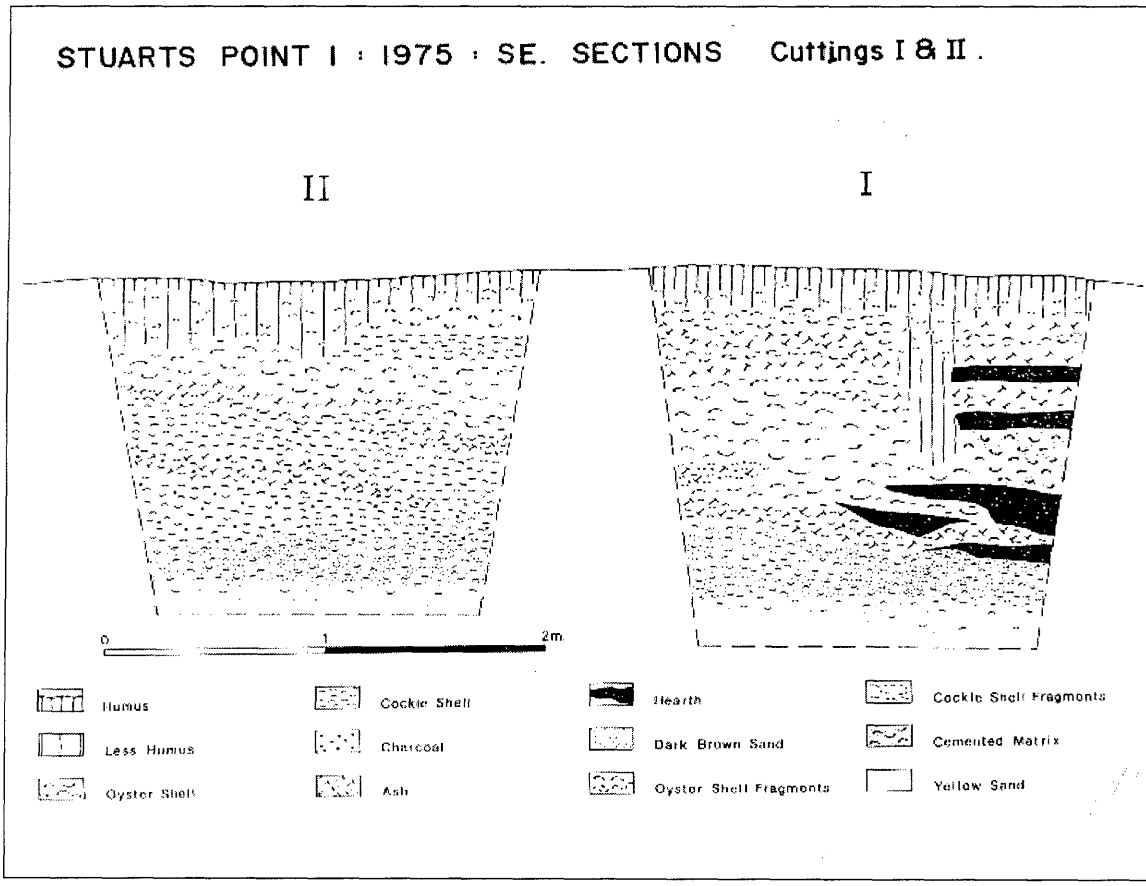

Figure 4.2 Generalised section drawing of Cuttings I and II Stuarts Point 1, 1975 (Drawn by D. Hobbs)

My methods for presentation and interpretation of the Stuarts Point 1 site follow the same structure as described for the Clybucca 3 site.

4.5 Re-Dating of the Stuarts Point 1 Site

The funds available did not allow for the re-dating of the Clybucca 3 site, so I chose to use what resources were available to me re-date the Stuarts Point 1 site because of the controversy generated over the basal date obtained by Connah in 1975 of c. 9,000 BP. Shell samples from Cutting II were selected from the material stored in the University of New England's archaeological store and sent to Waikato Radiocarbon Laboratories for dating. Samples were taken from Spit 3, Layer 1, and from Spits 5, 9, 10 and 13 of Layer 2. The shell sample obtained from Spit 3, Layer 1, was the species *Saccostrea glomerata*, while the samples obtained from the other four spits all comprised the species *Anadara trapezia*. There was not enough *Anadara trapezia* able to be located from the upper layers of the assemblage to provide a reliable dating sample. All of the samples sent to the Waikato Laboratory were well-preserved specimens, exhibiting minimal damage. The results and the implications of the re-dating of the Stuarts Point 1 site are presented in Chapter 6.

4.6 Re-Examination of Shellfish Remains

The shellfish remains from both the Clybucca 3 and Stuarts Point I sites had been analysed by Callaghan (1980). As a lot of the shellfish remains could not be located in the U.N.E. archaeological store, my re-analysis used the weights and identifications of the shell from Callaghan's study as well as the information gained from Connah's excavation notes. I also incorporated information drawn from research into the behaviour and habitat of shellfish presently inhabiting the Macleay estuary, to infer the likely environmental conditions prevailing during the time when the shell middens were being formed (see Section 4.2). The shellfish remains were examined, as with the other archaeological remains, to identify any change in the relative measures of richness and abundance in the assemblages over time. I looked especially for any changes in shellfish species that would indicate changing environmental conditions.

Determining relative calorific value of food obtained from shellfish based on the weight of shellfish remains from archaeological sites, and indeed the weight of meat obtained from vertebral fauna, is not straightforward (Wing and Reitz 1999:262). Bailey (1975) states that the ratio of shell weight to meat weight for oyster is 5:1. He also states that the ratio for both terrestrial and aquatic vertebrate animals is 1:25 (Bailey 1975:52). In this research I will be comparing shell species with shell species. The shells represented in the greatest proportions in the Macleay sites oyster (*Saccostrea glomerata*), cockle (*Anadara trapezia*), and mud whelk (*Pyrazus ebinenus*), are all robust shells which can be assumed to compare favourably with each other. I will also compare weight of terrestrial and marine animal bone as Bailey (1975) suggests this is a legitimate comparison. I will not compare the weight of shellfish remains to vertebrate fauna.

4.7 Re-Analysis of Vertebrate Fauna

4.7.1 Identifying Fishbone

Whilst I studied archaeological faunal analysis as part of my undergraduate degree there has been nowhere for me to receive any formal training in the identification of fishbone. In preparation for my Honours research I learnt to analyse and identify archaeological fish remains through stripping down as many fish specimens as I could obtain, learning about their skeletal structure and the differences between species in a totally hands-on manner. I made use of as many texts on fish anatomy and skeletal structure as I was able to locate, and made particular use of the texts related to archaeological fishbone analysis (Casteel 1976; Wheeler and Jones 1989; Lyman 1994; Reitz and Wing 1999). I have carried out taphonomic studies for my own interest, including the burning and breaking of bones, and observing how quickly animals can remove entire fish skeletons. In the past eight years I have examined fish remains from a number of sites along the coast from the present study area on the mid-north coast of New South Wales to Central Queensland. Some of this work formed part of my Honours research, and the remainder has been the result of my being employed by other researchers to provide speciality fishbone identification and analysis. I have also examined fish remains retrieved from a Maya site in Belize, Central America whilst on a training scholarship to extend my experience in the field. Over time I have continued to expand my comparative reference collection, and therefore my knowledge of fish anatomy. Consequently, I believe that my experience and enthusiasm for the analysis of archaeological fishbone assemblages has prepared me well for the current research.

The archaeological fish remains from both the Clybucca 3 and Stuarts Point I excavations had previously been examined by Coleman (1978) in her B.A. Honours thesis (see Chapter 3). Coleman had examined all of the vertebrate faunal material from all of the Lower Macleay River sites excavated by Connah in the 1970s. As this analysis of such a large amount of material was carried out in a very short time frame, I believed it necessary to re-examine the vertebrate marine fauna from the selected cuttings in more detail than previously attempted. My expectation was that by studying skeletal elements other than those of the dentition and cranium, which were studied by Coleman (1978), a more complete picture of the taxa available to Aboriginal fisher/hunter/gatherer people would be realised. This was based on my previous work on mullet identification (Vale 1998, 2001).

All of the vertebrate marine faunal material from Clybucca 3, Cuttings I and II, and Stuarts Point I, Cutting II, was re-sorted, and all of the previously unidentified fishbone was re-examined and sorted into skeletal elements. The previously identified fishbone was also re-examined to ensure that I was in agreement with the previous identifications. If I did not agree with Coleman's identifications, the new identification along with the previous one were entered into the data-base.

My own comparative reference collection of fish found on the mid-north coast of New South Wales was augmented with other species, or extra specimens of species already represented in the comparative collection, from the Archaeology Department of the University of New England's skeletal reference collection. The comparative collection skeletal elements were grouped into the same skeletal element from each taxon and arranged on boards. For example, all of the dentaries from the twenty-one specimens used were arranged together, then all of the articular, etc. This allowed for easy visual comparison of the specimens. The comparative specimens were attached to the boards with 'blu tac' so that they were able to be removed for examination of all aspects of the skeletal element. A list of the specimens in the comparative reference collection appears in Appendix II.

Using the comparative reference collection, taxonomic identifications were made by carefully comparing each of the pieces of bone which could be identified to skeletal element. A magnifying lamp as well as hand held magnifying glasses were used to view all possible points of identification on the skeletal elements. The analysis was carried out over a period of approximately six months. All identifications were entered into a data-base, along with the weight (in grams to two decimal points) of the specimen, all measurements (in millimetres to one decimal point) which were able to be made, and orientation of the skeletal element. All weighing was done to two decimal places. Specimens which were able to be identified to skeletal element, but not able to be identified to taxon were also weighed, and measurements made if possible. Abrasion and breakage were the most common reasons for not being able to identify a skeletal element to taxon. The spines and pterygiophores were not identified to taxon, but were counted and weighed. Even though the spines and pterygiophores of some species of fish will allow for identification to taxon, these skeletal elements of the fish represented on the mid-north coast of New South Wales do not lend themselves to this level of identification, as they are very similar across all of the taxa. Most of the spines and pteryigiophores in the Macleay archaeological assemblages were broken - so that measurements could not be made on these specimens. All pieces of bone which could not be ascribed to a skeletal element were counted and weighed.

Like many archaeological fishbone assemblages, the fish remains from the two sites chosen for detailed examination contained many vertebrae (Casteel 1976, Wheeler and Jones 1989). Identification to taxon was possible for some of these, especially those which retained attachment points for the transverse processes and spines. All of the broken and abraded vertebrae which were able to be measured across the centrum diameter, were measured and weighed. The remaining vertebrae, which were too damaged to allow for centrum measurement were weighed.

There are many references in the literature on the benefits or otherwise of using MNI, NISP or weight of fishbone in the quantification of fishbone assemblages (Grayson 1984:16; Lyman 1994:97; Reitz and Wing 1999:145). In the descriptions of the fish remains recovered from Cuttings I and II of the Clybucca 3 and Cutting I of Stuarts Point I excavations which follow in the next two chapters, I present the NISP of all of the skeletal elements identified to taxon, along with the numbers of unidentified skeletal elements and the spines, pteryigiophores, and fragmented pieces. I include a total NISP and weight for each family identified, and the MNI for each family represented. In this research NISP represents the 'number of identified specimens', where 'identified' means identified to taxon. MNI refers to the minimum number of individual fish which could account for the number of skeletal elements identified to a taxon.

4.7.2 Estimation of the Size of Fish Represented

The calculation of the size of a fish from archaeological skeletal remains is somewhat problematic, but was important for this research because of the aim of identifying change over time in the fishbone assemblages (Section 4.2). The variety of body shapes and the absolute numbers of species of fish, along with taphonomic processes, combine to make a straightforward method of defining live body size from an archaeological specimen quite difficult. Nonetheless, it is also believed that there is a direct relationship between skeletal element size and body size in fish (Kefous 1977; Balme 1983; Casteel 1976; Wheeler and Jones 1989:139; Owen and Merrick 1994a; Attenbrow and Steele 1995).

Numerous researchers have defined means of calculating live body size from archaeological specimens (Casteel 1974; Kefous 1977; Prummel and Brinkhuizen 1990; Jonsson 1991; Leach et al 1996; Zohar et al 1997; Greenspan 1998; Leach and Davidson 2000; Leach et al 2001; Leach and Davidson 2001), however these formulae are often taxon specific and cannot be used 'ad hoc' for all species.

Owen and Merrick (1994) published a study examining the viability of calculating the live size of snapper (*Chrysophrys auratus*) from their skeletal elements and concluded that there was a direct relationship between skeletal size and live fish size. Owen and Merrick were highly critical of how fish had been sized in previous archaeological studies, enumerating many problems they perceived with the methodology of extrapolating from bone size to body size. The main focus of their criticism was the extrapolation of change in assemblage size over time from 'grouped vertebrae', using very small numbers of comparative specimens as the basis for calculating live size; the use of very few key measurements on the archaeological bone; and the estimation of meat weight, or dietary contribution. Their criticism of previous methodology is valid up to a point. However, for the archaeologist the challenge with the study of fish remains is to obtain the greatest amount of knowledge that one can from the material available. Large amounts of well-preserved archaeological fishbone, in a range of skeletal elements for each taxon identified, are rarely available from shell midden sites. Similarly, it is not always possible to obtain a reference collection of the size and range of species that would suit Owen and Merrick (1994:5) for the area which is being researched. Despite all of the criticism, their research is useful in that it confirmed that there was a direct relationship between skeletal size and standard length in *Chrysophrys auratus* for all of the skeletal elements studied. However, this leads to another problem - the measurement known as 'standard length'. Not all researchers measure fish specimens in 'standard length'. Other commonly used measurements for the length of a fish are 'total length' and 'fork length' (Figure 4.3).

Standard length, the measurement used by Owen and Merrick (1994) measures a fish from the 'nose' to the base of the tail; while fork length is the measurement to the fork in the tail; and total length measures to the end of the tail. All of this creates difficulty in being able to compare one method with another. Therefore, in this research I use my own comparative collection - as limited as it is - to calculate a regression equation for Sparidae and Platycephalidae (the most common fishes identified from the Clybucca and Stuarts Point sites). This is then used on the measurements from the archaeological specimens to estimate the probable total length of the live fish. The estimation of live size allows comparability of intra- and inter-site fish assemblages of the chosen taxa, as a means of determining if the embayment was inhabited by very large or very small fish.

I also compare the measurements taken on the archaeological specimens from both sites and each analytical unit to identify changing size over time. This serves to lessen the probability of introducing errors brought about by the calculation of live size - which may not be wholly reliable due to the use of a simple regression equation based upon a small number of comparative specimens. Therefore leading to a large potential error in the size estimation.

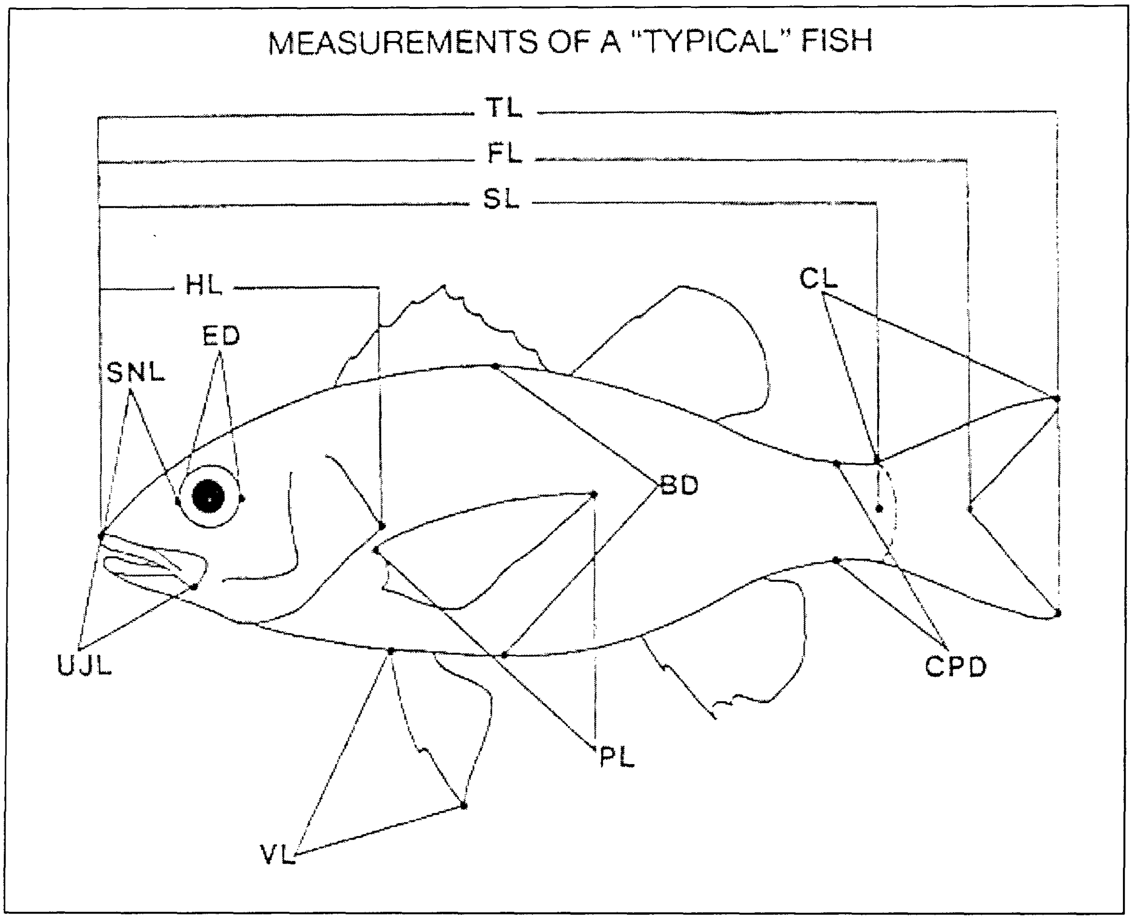

Figure 4.3 Common Fish Measurements
Key: TL - Total Length
FL - Fork Length
SL - Standard Length

Predicting Size from the Comparative Collection

Despite the potential pitfalls listed above in calculation of body size of fish from archaeological specimens it is still a crucial variable in determining if the fish population has changed over time in an archaeological site. Consequently I will estimate the live size of the fish retrieved from the archaeological deposits, but I will also use the measurements made on the archaeological fishbone, to determine if there has been any change in the size of the fish represented in the sites over time.

Figure 4.4 is a generalised drawing of a fish cranium showing the location of skeletal elements. On this figure the supraoccipital is located on the top of the cranium, identified by the letters 'SOC' in the figure. The dentary is the lower bone of the jaw, identified by the letter 'D' on the left of the figure. The dentary symphysis is where the right and left halves of the dentary join in the middle of the lower jaw.

Since nearly all of the Platycephalidae dentaries were observed to be broken at the articular end, it was realised that measurement of the length of the element was not going to be a possibility. I therefore chose the dentary symphysis height as the comparative measurement. Three of the comparative collection specimens of Platycephalidae for which I had a dentary symphysis and the total length of the fish before it was prepared for the collection were measured (Appendix III).

Three of the comparative collection of Sparidae also had the necessary requisites of an intact supraoccipital and total length measurement before preparation for the reference collection (Appendix III).

I therefore use these measurements to calculate the regression formula for estimating the live size of the fish represented in the Macleay sites. Calculation of the regression equation was achieved using Excel spreadsheet (Wheeler and Jones 1989:141) The total length and the skeletal element measurements of the comparative specimens were graphed in a scatter plot and a regression line fitted to the graph (Figures 4.5 and 4.6).

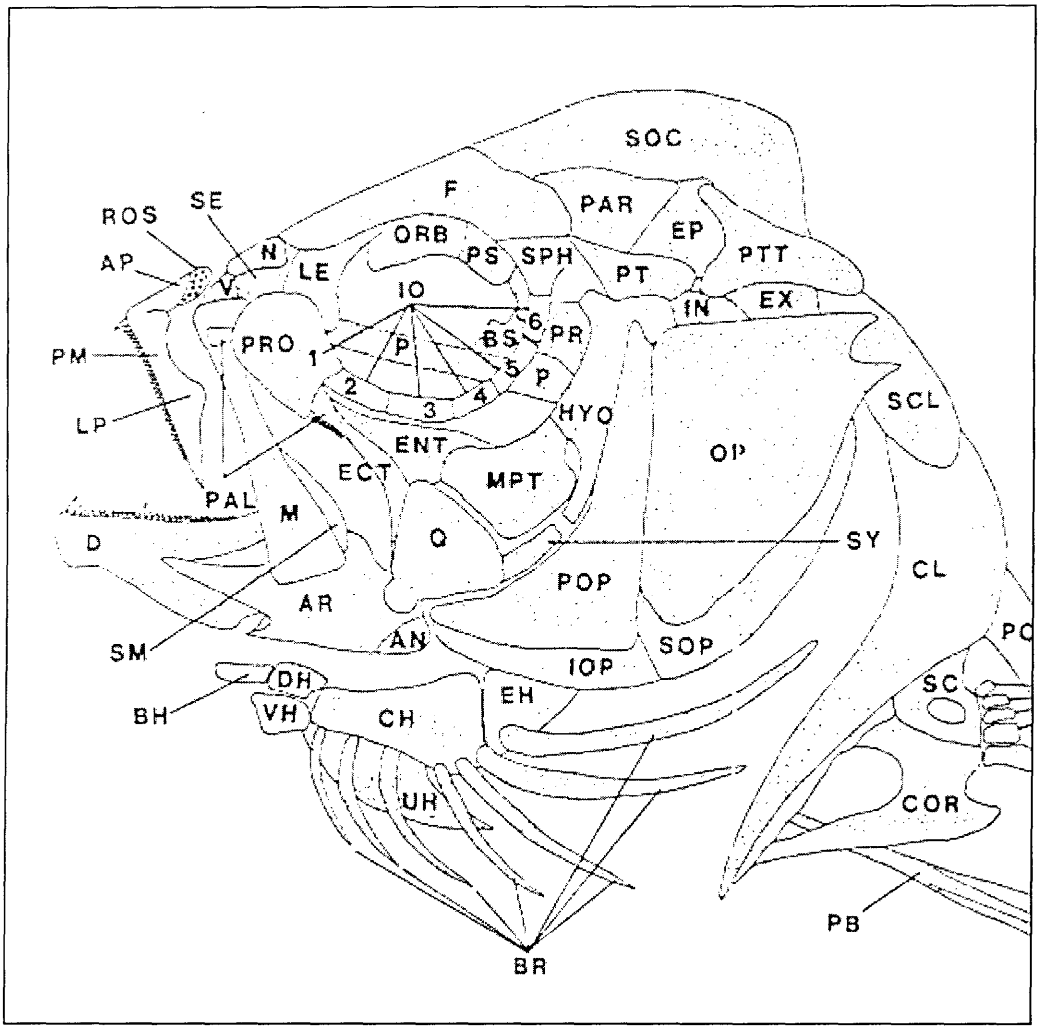

Figure 4.4 Location of Dentary and Supraoccipital

The regression analysis of the three comparative specimens from each of the families gave a confidence measurement of 0.9005 (Platycephalidae) and 0.9971 (Sparidae). The regression analysis also gave the measurements for slope and constant, which were then applied to the archaeological specimens.

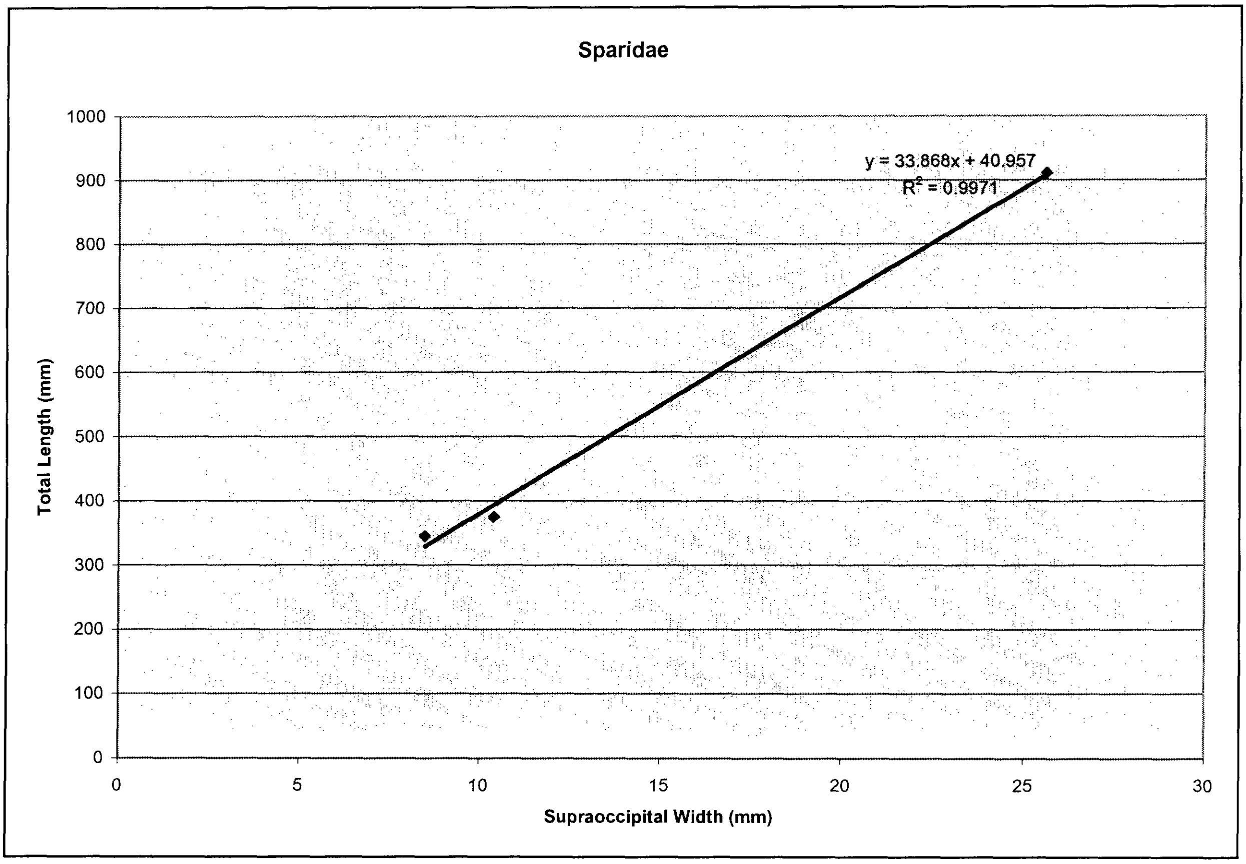

Figure 4.5 Sparidae Reference Specimens – Relationship between Supraoccipital Width and Total Length.

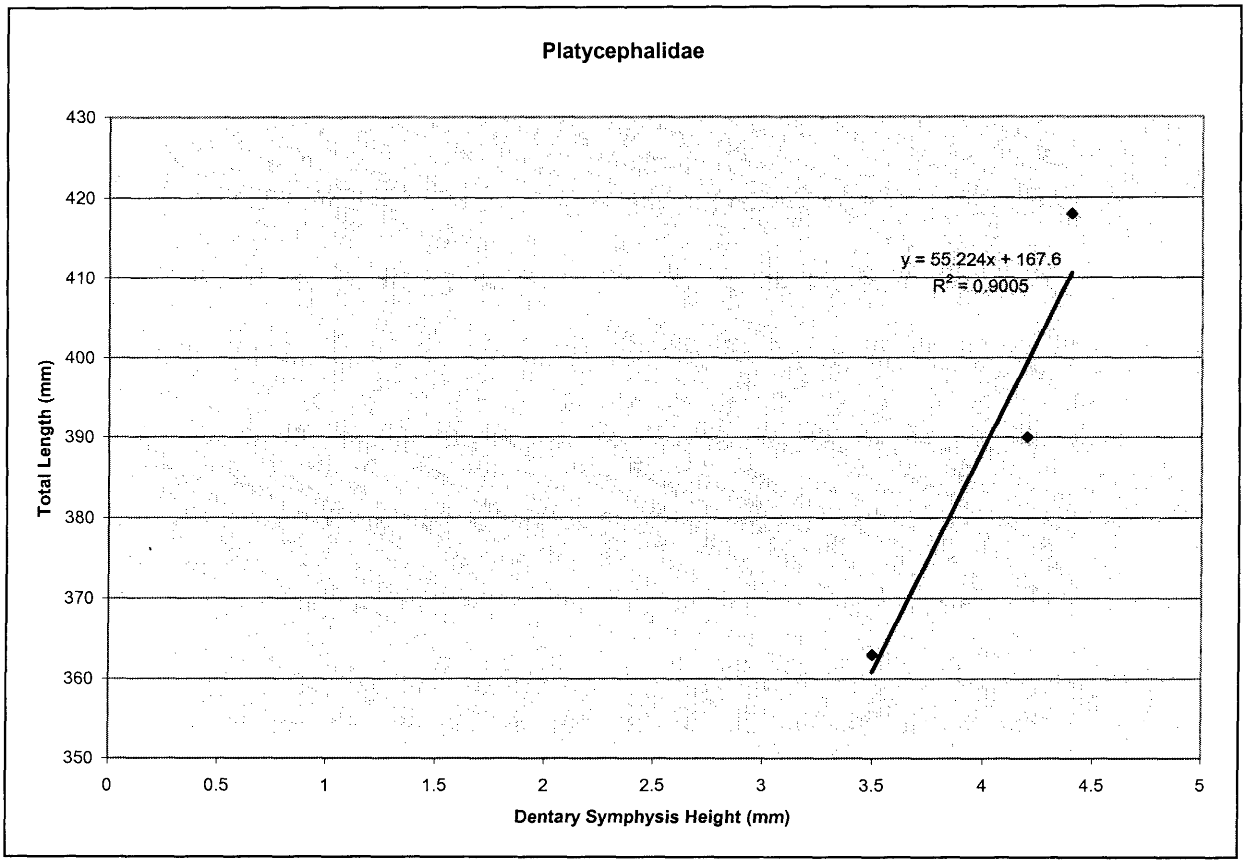

Figure 4.6 Platycephalidae Reference Specimens – Relationship between Dentary Symphysis Height and Total Length.

It has been suggested that large numbers of comparative specimens (a minimum of 40) which have been caught over at least a twelve month time period to allow for changes in weight of fish during the spawning, are necessary for calculating the relationship between skeletal element size and whole body size (Owen and Merrick 1994a). However, in this instance, I do not need to know the actual size of the fish represented in the Clybucca and Stuarts Point sites, but only if there has been a significant change in the size of the fish represented over time. This is therefore what the measurements taken on the dentary symphysis of the Platycephalidae and the supraoccipital of the Sparidae are used to determine.

4.8 Grouping Spits into Analytical Units

Archaeological shell middens are often considered poorly stratified as they may consist of a single lens of densely packed shell with no apparent differentiation. Loosely packed shell can allow the movement of other material such as bone or stone through the midden, disrupting the integrity of the stratigraphy (Waselkov 1987:146). However, if the stratigraphy of a shell midden can be interpreted it offers the basic methodology for examining both cultural history and site formation processes (Stein 1992:71). Because of the difficulty of identifying depositional layers in closely packed shell middens, many midden excavations are carried out using arbitrary spits - a situation which causes dismay to some archaeologists, who believe that important layering is ignored by those who choose to excavate in arbitrary spits (Frankel 1991:42). Clearly, if a shell midden excavation could be carried out by excavating depositional layers as they appear during the excavation, this would be preferable. However, it is not always possible to recognise depositional layers in a shell midden as an excavation proceeds.

Both the Clybucca 3 and Stuarts Point 1 sites were excavated in arbitrary spits of 10 cm, but section drawings were made at the completion of the excavation which allow interpretation of the depositional layers to be made. The depositional layers identified in this analysis will be termed ‘analytical units’. By dividing the cuttings into analytical units I am attempting to group the archaeological cultural remains into the components deposited in a similar time frame, for the purpose of identifying any change in the depositions over time. Therefore these units come under Stein’s (1992:80) classification of ethnostratigraphic units. Ethnostratigraphic units are defined as, layered strata which is characterised by the presence of classes of artefacts. Stein’s (1992:74) other two classifications for stratigraphic units do not apply to the Macleay sites, being lithostratic, which relies on a presence of lithologic characteristics, and biostratigraphic units, which uses fossil animal evidence to define stratigraphy. The Macleay sites are essentially shell heaps constructed by humans, with little or no natural matrix. The scale of resolution required for this analysis is determined by the radiocarbon dates available. This is the finest resolution which can be made on the Macleay sites, where it was not possible to date every spit excavated. Frankel (1988:41) proposed that the scale of archaeological analytical units will be determined by research questions and the level of resolution possible from the material available. For the present research, refining the scale to that where the analytical units can be placed within a time-frame, allows for the analysis of change over time within the marine faunal assemblage.

In defining the analytical units for Cutting I of the Clybucca 3 excavation I make full use of the excavation notes and the plan and section drawings of the excavations. I used the radiocarbon dates obtained in 1972 to help achieve the grouping of the arbitrary spits into analytical units. Also, I attempted to cross reference the stratigraphy from Cutting I with Cutting II, the cutting from which the weight of shell excavated is available, so as to obtain a full picture of the depositional processes at the site.

Likewise, Cutting II from Stuarts Point 1 was grouped into analytical units in order to identify temporal change in the marine faunal assemblages. This cutting was re-dated, and the new dates for the site are presented in Chapter 6.

4.9 Limiting Factors Associated With the Data

The excavation of the Lower Macleay archaeological shell midden sites was carried out in the 1970s; Clybucca 3 in 1972 and Stuarts Point I in 1975. At this time the emphasis in Australian archaeology, and therefore the questions being asked of the data, were on stone artefactual assemblages and radiocarbon dates. The sites selected for research and the data collected from these sites reflected this emphasis in research questions on defining the antiquity of Aboriginal archaeological sites, and defining a stone tool typological sequence for Australia.

With this emphasis on creating a chronology of occupation for the Australian mainland and identifying stone tool sequences, little consideration was given to the collection of small faunal remains. Aspects of small faunal analysis which are now considered vital such as pH testing of the soil matrix and fine-mesh sieving, were usually not practiced on excavation sites. What is probably remarkable is that Campbell did pH test the soil from her coring of Lower Macleay sites, and that a flotation device was used during the Stuarts Point excavation. However, these incidents of 'before their time' methodology were not practised at all excavations, leading to somewhat patchy data collection. Even though flotation screening was used in the Stuarts Point excavations, the methods of collecting the heavy fraction has resulted in this data being unusable for interpretation of small faunal material from the site. This will be discussed in detail in Chapter 6.

Both of the sites used in this research were excavated in arbitrary spits, necessitating an interpretation of the stratigraphy from the excavation notes and section drawings in order to assign the arbitrary spits to depositional or analytical layers. Along with the use of arbitrary spits, the area of the Cuttings were changed during the excavation. Both of the sites were commenced as two metre by two metre Cuttings, but circumstances during the excavation forced this to be changed to one metre by two metres at Layer 2, Spit 4 at Stuarts Point, and Spit 2, Cutting I and Spit 4, Cutting II at Clybucca. I have accounted for the discrepancies in the amount of material excavated within the Cuttings by halving the quantities of shellfish and vertebrate faunal material in the spits excavated as two by two metres. I was forced to do this because the total weight of the matrix was not recorded - which would have allowed calculation of an estimate of the percentage of cultural material to soil.

The storage of the archaeological material also created some problems. While all of the material excavated was transported to the University of New England, its storage site was moved three times since its excavation, before reaching its present storage site at Clarks Farm adjacent to the university. Over the years containers have been moved around and labels on boxes have been lost. While I managed to save a bag of broken shell from being used in the creation of an excavation pit for the teaching of archaeological field methods, I cannot be entirely certain that other bags have not been put to similar use in the past. Finding shell from the appropriate spits for radiocarbon dating of Stuarts Point proved to be an interesting exercise. While I am reasonably sure that most of the shell excavated is still in storage, there is little order or method to how it is stored. And, while there is still uncertainty as to the extent of the collection, I felt that a reanalysis of the shell would not be viable. There was one aspect of the archiving of the material which was incredibly useful. All of the faunal bags had been stored with metal tags designating the site, layer and spit from which they were excavated. These tags were in perfect condition so that I could be certain of the provenance of the faunal material that I was reanalysing.

Professor Connah was extremely helpful to this research. He provided all of his field notes and section drawings for photocopying, making this research not only possible but viable.

The analysis of archaeological fishbone assemblages has never been in the forefront of Australian archaeology, and consequently there are very few comparative collections for use by archaeologists in the identification of fish remains, or for use in the estimation of size. I have developed my own collection over the previous six years, adding to it when possible, but even so I acknowledge its limitations. Firstly it is based on species likely to have been used by Aboriginal people on the mid-north coast of New South Wales, rather than on a complete collection of all of the fish inhabiting these waters. The fish identified as a part of the prehistoric diet tend to be similar to those caught and eaten in the present day, and therefore are easier to come by, and a researcher is more likely to gain numerous specimens of the same taxon for research such as skeletal element size comparison. Even so, there has been very little study of the relationship between skeletal element size and whole fish size done on Australian fish species.

4.10 Conclusion

In this chapter I have described my methods for examining the Macleay archaeological sites of Clybucca 3 and Stuarts Point 1, which are:

1. An examination of the excavation notes and section drawings from Professor Connah;
2. The re-dating of the Stuarts Point 1 shell midden;
3. The re-examination of the shellfish assemblages for changes in species represented over time;
4. The re-analysis of the vertebrate faunal assemblages for changes in species represented over time;
5. An examination of the skeletal size of fish represented for changing patterns over time, and the estimation of fish sizes represented in the archaeological fishbone assemblages;
6. The grouping of the arbitrarily excavated spits into analytical units which represent time periods;
7. A comparison of the data represented in the two sites in relation to the hypotheses for environmental change on the east coast of Australia during the Mid- to Late-Holocene.

The results of the re-examination and re-analysis of Clybucca 3 will be presented in Chapter 5, and the results from Stuarts Point 1, along with the re-dating of the site, in

Chapter 6. In Chapter 7 I will present the results of the grouping of the arbitrary spits into analytical layers, the results of the re-examination of the shellfish assemblages, and the re-analysis of the vertebrate fauna.