INVESTIGATION OF POSSIBLE DIETARY DIFFERENCES BETWEEN THE INHABITANTS OF THE ROBBERG/PLETTENBERG BAY AND MATJES RIVER ROCK SHELTER IN THE LATER STONE AGE: AN ISOTOPIC APPROACH

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ABSTRACT

$\delta^{15}N$ and $\delta^{13}C$ measurements were used to investigate whether dietary differences existed between Later Stone Age people buried at Robberg/Plettenberg Bay and Matjes River Rock Shelter. Since isotopic values of marine foods from this area had not previously been measured, the first step was to sample shellfish and *Arctocephalus pusillus* (Cape Fur seals), representing the lower and higher trophic level marine foods important in prehistoric diets along the coast. 32 modern *Perna perna* samples from different collection stations near Robberg/Plettenberg Bay and Matjes River Rock Shelter were measured for $\delta^{15}N$ and $\delta^{13}C$ to find out whether localised differences exist in the marine systems. Ten samples were taken from archaeological bone of Cape fur seals from Nelson Bay Cave. Samples from 38 human skeletons from Nelson Bay Cave/Robberg/Plettenberg Bay and Matjes River Rock Shelter were measured. Eight humans from Robberg/Plettenberg Bay were also analysed for $\delta^{13}C$ in bone apatite, while radiocarbon dates were obtained for seven.

$\delta^{15}N$ results for *Perna perna* meat from the three collection stations indicate no difference in the nitrogen isotope values in the marine systems near the two sites. However, a difference in $\delta^{13}C$ values exists which might be due to variation in the photosynthetic pathways of algae. $\delta^{15}N$ for seals ranged between 15.1 to 19.1 ‰, similar to results reported in the literature. A significant difference was found to exist in the $\delta^{15}N$ values of mid- to late Holocene people from Robberg/Plettenberg Bay and Matjes River Rock Shelter respectively. $\delta^{13}C$ values track the $\delta^{15}N$ values. Results for apatite are similar to those reported by Sealy (1997) for skeletons from the southern Cape.

$\delta^{15}N$ values indicate that Holocene people from the period 4 300 to 2 000 BP from Robberg/Plettenberg Bay ate large quantities of high trophic level marine protein, probably seal meat. Their diets were different from those of people at Matjes River Rock Shelter, who had much lower $\delta^{15}N$ values. This difference must reflect the existence of a territorial boundary between the two areas, perhaps the estuary of the Bietou/Keurbooms River system. This is the best evidence in South African archaeology thus far for the existence of a boundary of this kind between two adjacent coastal groups.

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CHAPTER ONE
INTRODUCTION

The southern Cape has one of the richest and most complete Later Stone Age (L.S.A) sequences of any region in southern Africa. (The term "southern Cape" will be used in this thesis to indicate the southern parts of the Western and Eastern Cape Provinces). This is the area in which the L.S.A sequence of the subcontinent was originally defined. The study of Holocene hunter-gatherers is interesting because it offers an opportunity to compare their lifestyle with that of recent hunter-gatherers from the Kalahari, and thereby understand the extent to which the Kalahari picture is true for hunter-gatherers as a whole, or to which it maybe specific to that area and time. Similarities exist between the hunter-gatherers of the Kalahari and Later Stone Age hunter-gatherers elsewhere in southern Africa. Some of these similarities are reflected in the archaeological record, for instance the material culture. At the coast hunter-gatherers would have had acess to different resources: they ate crustaceans, shellfish, fish and marine mammals. This might have influenced the extent to which groups were mobile, with implications for social organisation and many other aspects of peoples' lives. Isotopic approaches used in this thesis, combined with evidence from the excavated deposits will help us to recognize and understand patterns in the archaeological record through time.

Rudner and Rudner (1973) identified approximately 19 sites on the Robberg Peninsula alone, of which several are large cave sites. This area was a focus of early archaeological activity in South Africa, much of it very roughly executed. From Cave D alone were recovered 100 bone points, a notched bone shaft, potsherds, ostrich eggshell beads, three skeletons and a painted stone showing 12 human figures painted in black. This lay painted side downwards on a skeleton. Painted stones, possibly depicting hunting scenes, together with 30 human skeletons, animal bones and 60 bone points were recovered from Cave F on the Robberg Peninsula. Human skeletons were also found at sites along the Keurbooms River (Bernstein 1935), and in the Tsitsikamma Coastal National Park at Drury's and Van Bonde's caves. Shell deposits and middens were found at all the above sites. Much of the archaeological material recovered in the early days has been lost, but some of it is preserved in museums. Well-controlled excavations by Goodwin at Oakhurst in the 1930's, by Inskeep and Klein at Nelson Bay Cave in the 1960s and 1970s, and by Deacon and Döckel at Matjes River Rock Shelter in the 1990s provide a secure basis for our archaeological understanding of the area.

Coastal sites are special in the sense that Holocene (the last 10 000 years) people used marine resources intensively, thus benefitting from access to a rich, reliable source of food. At sites like Nelson Bay Cave on the Robberg Peninsula, Matjes River River Rock Shelter and Oakhurst shellfish were used not only as a food resource, but for decoration as well. Nelson Bay Cave has the most complete and best-described Holocene sequence of any coastal site in southern Africa.

Sealy and Pfeiffer (2000) analysed stable carbon and nitrogen isotope ratios in human skeletal remains from 20 archaeological sites in the southern Cape (see Figure 1).

They found a significant difference between $\delta^{15}N$ values of skeletons from the Robberg Peninsula/Plettenberg Bay and from Matjes River Rock Shelter, an indication that people buried at these sites ate different foods. Due to the small sample

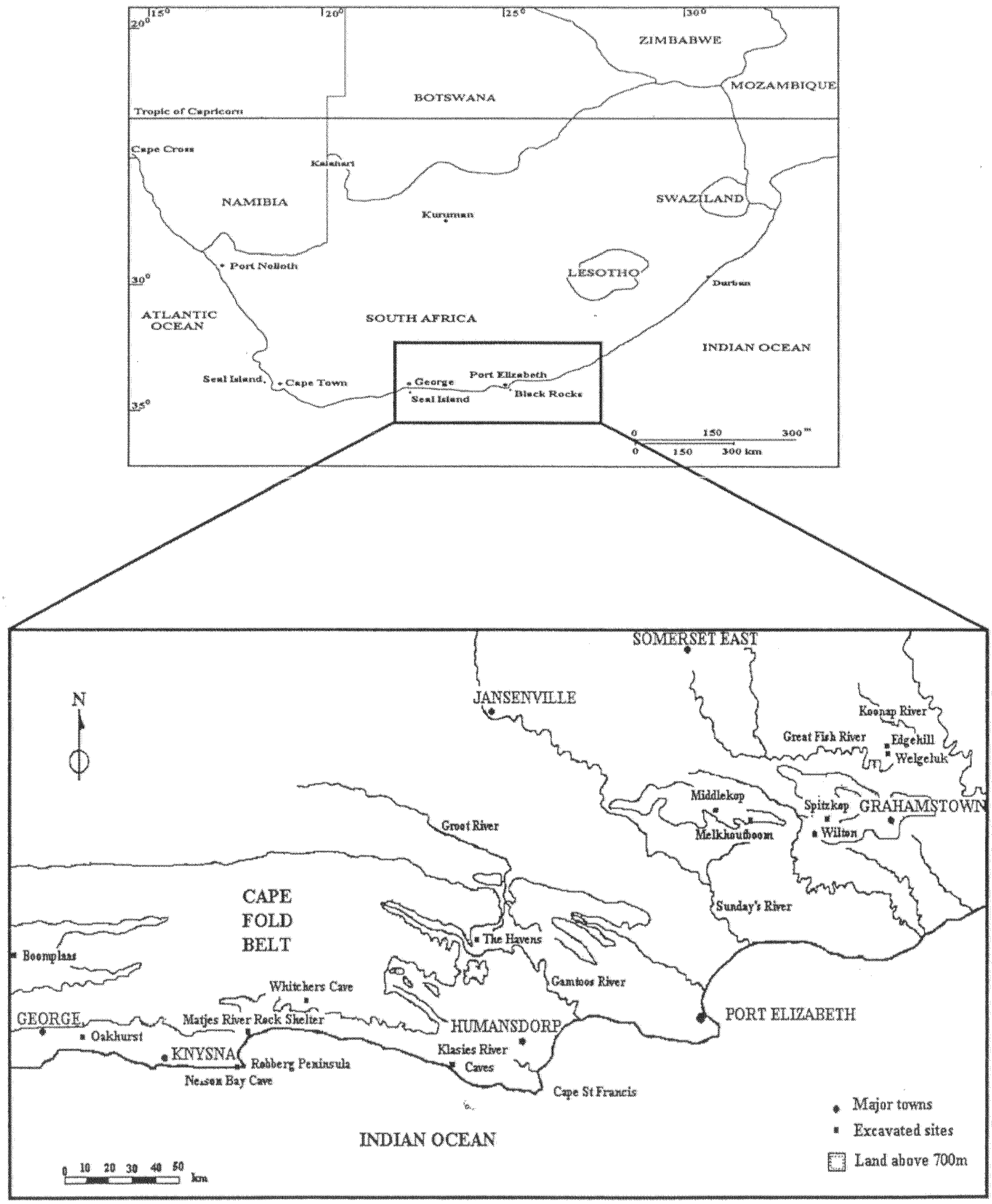


Figure 1: A map showing some southern Cape, Later Stone Age sites. (Punt *et al.* 1995, Hall and Binneman 1987)

In this thesis 38 additional human skeletons from Robberg /Plettenberg Bay and Matjes River Rock Shelter were analysed for $\delta^{15}N$ and $\delta^{13}C$. Seven of the skeletons were also radiocarbon dated. In addition isotopic analyses of marine foods from this area were carried out. 72 modern shellfish specimens were collected and measured to determine the distribution of nitrogen isotopes in the marine environments near the two sites. $\delta^{15}N$ and $\delta^{13}C$ values were obtained to investigate whether localised differences exist.

Ten archaeological seal bones from Nelson Bay Cave were sampled and the stable isotope ratios measured. (see Table 5.5). This was to find out what isotopic values would be like for carnivores at the top of the marine food web in this area. Shellfish remains and seal bones are important components in the food-waste at both Nelson Bay Cave and Matjes River Rock Shelter.

Measuring $\delta^{15}N$ and $\delta^{13}C$ of shellfish meat, archaeological seal bone and archaeological human bone will allow us to answer the following questions:

1. Will the analysis of shellfish from three collection sites indicate a difference in nitrogen isotope ratios in the marine systems around the Robberg Peninsula and Matjes River Rock Shelter?

2. Is there anything unusual in the $\delta^{15}N$ values of marine organisms around the Robberg Peninsula that might account for the high $\delta^{15}N$ results reported for the Robberg skeletons by Sealy and Pfeiffer (2000)?

3. Will analyses of additional human skeletons, from both Robberg /Plettenberg Bay and Matjes River Rock Shelter, support the Sealy and Pfeiffer (2000) finding of higher $\delta^{15}N$ values for the Robberg Peninsula?

4. Is there a significant difference for $\delta^{15}N$ values between males and females from Robberg/Plettenberg Bay?

5. Do the carbon isotope values of human skeletons 'track' the nitrogen isotope values?

6. Are the changes through time, reflected in the archaeological records of Nelson Bay Cave and Matjes River Rock Shelter, detectable in shifts in the isotopic ratios of skeletons?

Diet is directly measured through stable isotope values in archaeological human bone and indirectly through identification of excavated archaeological food waste. $\delta^{15}N$ and $\delta^{13}C$ results will indicate if differences existed in the diets of people from Nelson Bay Cave/Robberg/Plettenberg Bay, on the one hand and Matjes River Rock Shelter, on the other hand. Dietary differences could imply differences associated with availability of dietary resources, resource management, economy and catchment area. It has to be kept in mind that some foods leave no inedible residues in the archaeological record.

1.1 THESIS LAYOUT

This thesis is divided into six chapters. Chapter One is a general introduction. In Chapter Two, stable isotope methods are explained and how they are used to reconstruct prehistoric diets of inland and coastal populations. Variability between and within different food chains, both terrestrial and marine will be examined. In Chapter Three the results of archaeological work at Nelson Bay Cave and Matjes River Rock Shelter will be summarised, and considered in relation to our wider understanding of the Later Stone Age. Sampling and laboratory procedures will be outlined in Chapter Four, while results are reported in Chapter Five. In the final chapter, the isotopic results for human skeletons are evaluated in the light of the broader archaeological issues raised in Chapter Three, forming the basis of the discussion.

CHAPTER TWO

STABLE ISOTOPES

Stable isotopes of the elements nitrogen and carbon are valuable to the archaeologist in reconstructing the past, and by putting it into context through reconstructing palaeoenvironments. More important for this thesis, isotopes are used to reconstruct the behaviour of prehistoric populations through analysing their diets.

2.1. NOTATIONS AND STANDARDS

Isotopes are atoms whose nuclei contain different numbers of neutrons, but the same number of protons (Hoefs 1997). Isotopic species have different masses (Criss 1999). Isotopes undergo the same chemical reactions, but they react at different rates in both chemical and physical processes, leading to "fractionation", the process whereby change occurs in isotopic ratios. Different isotopes are unequally distributed in the various reservoirs of nitrogen and carbon. Stable isotope ratios are measured relative to standard reference materials and expressed in parts per thousand (‰) using the delta (δ) notation , as follows:

$$\delta = \{R_{sample} / R_{std} - 1\} \times 1000‰$$

R_{sample} is the isotopic ratio of the sample, and R_{std} the isotopic ratio for the standard. The standard for nitrogen is atmospheric N_2 [air]. In most instances $\delta^{15}N$ values for biological materials are positive, i.e. sample materials have higher $^{15}N/^{14}N$ ratios than air. By definition, standards have δ values of zero (0 ‰). A marine limestone, *Belemnitella americana* from the Peedee formation in South Carolina (PDB) is the standard for carbon (Craig 1953). The PDB standard is used as a basis for calibration of all other laboratory standards. $\delta^{13}C$ values of many biological materials are negative (i.e. ^{13}C depleted) compared to the standard.

2.2 NITROGEN IN THE TERRESTRIAL ENVIRONMENT

The natural abundance of ^{15}N is 0.3663%, and that of ^{14}N is 99.6337% (Delwiche and Steyn 1970). Measurements of $^{15}N/^{14}N$ were first used in archaeology to estimate the proportions of legumes in terrestrially based prehistoric diets (DeNiro and Epstein 1979). Terrestrial systems contain less ^{15}N than marine systems, so nitrogen isotopes can also be used to distinguish marine and terrestrial foods (e.g. Schoeninger *et al.* 1983; Schoeninger and DeNiro 1984; Ambrose *et al.* 1997; Sealy and Pfeiffer 2000).

As indicated in figure 2.1 there is relatively little isotopic fractionation associated with the conversion of atmospheric nitrogen gas to fixed soil nitrogen. There is, however, substantial fractionation associated with the breakdown of soil nitrogen and its return to atmospheric N_2 (denitrification). The heavy isotope

(^{15}N) remains behind in the soil, while the lighter isotope (^{14}N) is taken up in the atmosphere. This means that the pool of nitrogen in living systems is enriched in ^{15}N compared with the atmosphere.

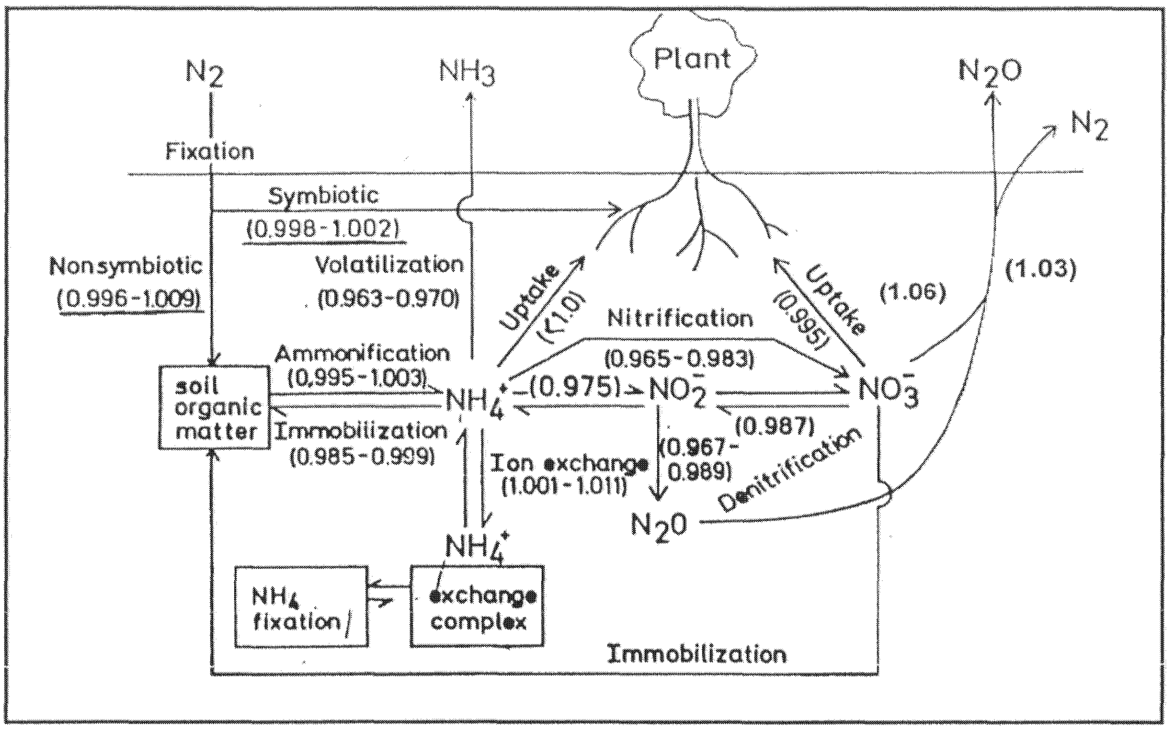


Figure 2.1: Nitrogen isotopic fractionation factors (α) in the biological nitrogen cycle (adapted from Marion 1987).

2.2.1 Soils

Soils differ in space due to differences in climate, parent material, topography, profile depth and distribution of organisms (Delwiche and Steyn 1970). The amount of N in soils ranges from $2tNha^{-1}$ in warm deserts, to $16tNha^{-1}$ in subtropical wet forests and $20tNha.^{1}$ in rain tundra. The ^{15}N natural abundance may be lower where the soil organic matter is dominated by a large amount of recently added litter (Hopkins *et al.* 1998). Only a small fraction of the soil N may be involved in cycling. In arid soils small amounts of soil N are concentrated at the surface and are highly active. Large differences in $\delta^{15}N$ values reflect N cycling rates. Mineralised N is susceptible to plant uptake and loss from the soil because of nitrification and/or denitrification. Fractionation during these processes accounts for the ^{15}N enrichment of the soil N and for the fact that plants often have $\delta^{15}N$ values slightly lower than the soil N- (Handley *et al.* 1998). An increase in $\delta^{15}N$ of total soil occurs with depth in the soil profile (Delwiche and Steyn 1970; Ambrose 1991, Ehleringer *et al.* 1998). Soils with a high saline content and those in very hot and dry habitats have high $\delta^{15}N$ values. The $\delta^{15}N$ values of humic acids for non-saline soils collected at a depth of 0-5cm ranges from 3.7 to 7.5 ‰ (Ambrose 1991). Sediments from saline lakeshores had a $\delta^{15}N$ average of 9.9 ‰. In Natal, South Africa, it was found that saline soils, 500 km from the coast had a $\delta^{15}N$ enrichment of 4 ‰ compared with non-saline soils (Heaton 1987). Features on the landscape can also cause variations in $\delta^{15}N$ in soil. These variations are, however, small when compared to variations at different trophic levels.

2.2.2 Plants

Both C_3 plants and C_4 grasses have $\delta^{15}N$ values that commonly range from -1 to 6 ‰ (Heaton 1987). Non-N_2-fixing plants that grow near the coast have higher $\delta^{15}N$ values than plants that grow inland. This is due to sea spray that contains nitrate, which ultimately contributes to nitrogen values of coastal terrestrial plants. $\delta^{15}N$ values for plants growing inland in Namibia are 10 ‰ depleted in $\delta^{15}N$ compared with those that grow at the coast (Heaton 1987). High $\delta^{15}N$ values in plants reflect high values in the inorganic nutrient nitrogen (ammonium and nitrate) in soils. (see Figure 2.1). Ambrose (1991) found that plants that grew on saline soils in East Africa had a mean $\delta^{15}N$ value of 9.7 ‰ ($n = 4$), while plants that grew in forest soils had a value of 1.2 ± 2.7 ‰ ($n = 48$). In some instances plants may acquire nitrogen through urea and amino acids (Yoneyama *et al.* 1998). The range of $\delta^{15}N$ values in plants from individual sites is 4 ‰ (Heaton 1987). The mean $\delta^{15}N$ values for C_4 and C_3 plants are essentially the same, at 2.7 ± 2.2 ‰. ($n = 47$) and 2.5 ± 2.8 ‰ ($n = 41$) (Heaton 1987). In general, the $\delta^{15}N$ values of plants are similar to values obtained for soil.

2.2.3 Animals

Herbivores have $\delta^{15}N$ values that are more positive than the plants they eat by about 3 ‰ - 4 ‰. In the Naivasha Basin, central Rift Valley, Kenya, where the annual rainfall fall is 600 -1100mm per year, modern herbivores have a mean of 7.1± 1.7 ‰ (Ambrose 1991). According to Ambrose, foodwebs in hot and arid environments generally have higher $\delta^{15}N$ values than foodwebs in wet, cool ones. Herbivores from arid environments in east Africa have a mean $\delta^{15}N$ value of 10.8± 1.0 ‰. This environment receives about 250mm of rain per year. In southern Africa herbivores show much higher $\delta^{15}N$ values as annual rainfall decreases (Heaton 1987; Sealy *et al.* 1987).

This is partly because soil ^{15}N is enriched in arid environments (Schwarcz *et al.* 1999), and partly due to metabolic effects within the animals (see below). Herbivores that have developed physiological mechanisms to conserve water in hot and dry conditions usually have higher values than animal species in the same environment that are water dependent. Ambrose measured water-conserving and water-dependent species from low-altitude savannah grasslands in eastern and southern Africa (Table 2.1). The former show consistently higher $\delta^{15}N$ values than the latter.

Of the animals shown in Table 2.1, klipspringer, dik-dik, eland and hyraxes are browsers and have $\delta^{15}N$ values between 7 and 10 ‰ (Ambrose 1991). Most browsers are drought tolerant, while most grazers, like the buffalo, are obligate drinkers. Thus browsers tend to have more positive $\delta^{15}N$ values than grazers do. Altitude, too, has an effect: an increase of every 100m in altitude causes a decrease of 0.54 ‰ in the mean $\delta^{15}N$ values.

Carnivorous animals' $\delta^{15}N$ values are unusually enriched by about 3 - 4 ‰ compared with those of their prey. In the East African study discussed above, modern carnivores have a mean $\delta^{15}N$ value of 12.8 ± 2.4 ‰ , which indicates a fractionation of 5.7 ‰ between trophic levels (Ambrose and DeNiro 1986).

Table 2.1:The $\delta^{15}N$ values for water-conserving and water -dependent animal species from southern and eastern Africa. (Ambrose 1991, standard deviations and numbers of animals not supplied)

Animal (Water - conserving)	$\delta^{15}N$ ‰	Animal (Water - dependent)	$\delta^{15}N$ ‰
Eland	8.0	Baboon	5.8
Impala	8.0	Warthog	7.4
Sheep	8.5	Giraffe	6.9
Klipspringer	10.0	Buffalo	6.3
Dik-dik	9.4	Waterbuck	7.3
G. gazelle	8.9	Reedbuck	6.4
T. gazelle	9.7	Zebra	6.7
Heterohyrax	9.2	Wildebeest	7.9

The mean $\delta^{15}N$ for 12 carnivores from the Kasungu National Park in Malawi, which include spotted hyaena, leopard, lion, serval and genet is 7.5 ± 0.4 ‰, compared with 3.6 ± 1.2 ‰ for herbivores (Sealy *et al.* 1987). The average $\delta^{15}N$ value obtained by Schoeninger (1989) for four species of carnivore from Koobi Fora is 12.5, compared with 10.4 ‰ for three species of herbivore. This is not an ideal comparison, however, since the carnivores analysed did not necessarily eat these species of herbivore. Nevertheless, there is clearly enrichment in $\delta^{15}N$ with increasing trophic level.

Urea recycling in terrestrial animals (temperature and water regulation)

Animals from arid areas (especially water-conserving animals) may have positive $\delta^{15}N$ values (Hume *et-al.* 1980; Heaton *et al.* 1986; Sealy *et al.* 1987; Ambrose 1991; Schwarcz *et al.* 1999). This is due to increased output of isotopically light urea, leaving the animal's body enriched in ^{15}N. Values of up to 16‰ for archaeological samples from chickens (n = 3) found at Kellis 2, Egypt have been reported by Schwarcz *et al.* (1999). Iacumin *et al.* (1998) report a slightly higher $\delta^{15}N$ value of 16.5 ‰ for one cattle bone from the Middle Kerma period (4 450 to 3 700 BP) in the Sudan. Since the region under examination in this thesis is not an arid area, this phenomenon will not be discussed further.

2.3 NITROGEN IN THE MARINE ENVIRONMENT

About 70 % of the earth is covered in seawater, and there is about three times as much nitrogen in the ocean as on land. 20 teragrams of nitrogen is fixed in the oceans each year (Capone and Carpenter 1982). Isotopic fractionation occurs when N_2 crosses the boundary that separates water from air. The isotopic shift associated with this process is 0.9 ‰ (Miyake and Wada 1967). In addition the marine foodweb consists of longer food chains and more trophic levels than the terrestrial foodweb, contributing to the relative $\delta^{15}N$ enrichment of marine animals compared with terrestrial organisms. (see Figure 2.2). Nitrogen is the most important macronutrient for autotrophic production in the marine system (Owens and Watts 1998). Bone collagen of organisms that consume marine products will also be enriched. Both nitrogen fixation and denitrification take place in the ocean, as on land. By far the bulk of denitrification, however, occurs in the sea. This means that the residual enrichment in ^{15}N, referred to above, is much more a feature of the marine than the terrestrial systems. This is the major reason why marine organisms generally have higher $\delta^{15}N$ values than terrestrial organisms (Miyazaki *et al.* 1980; Schoeninger and DeNiro 1984; Sealy *et al.* 1987; Richards and Hedges 1999)

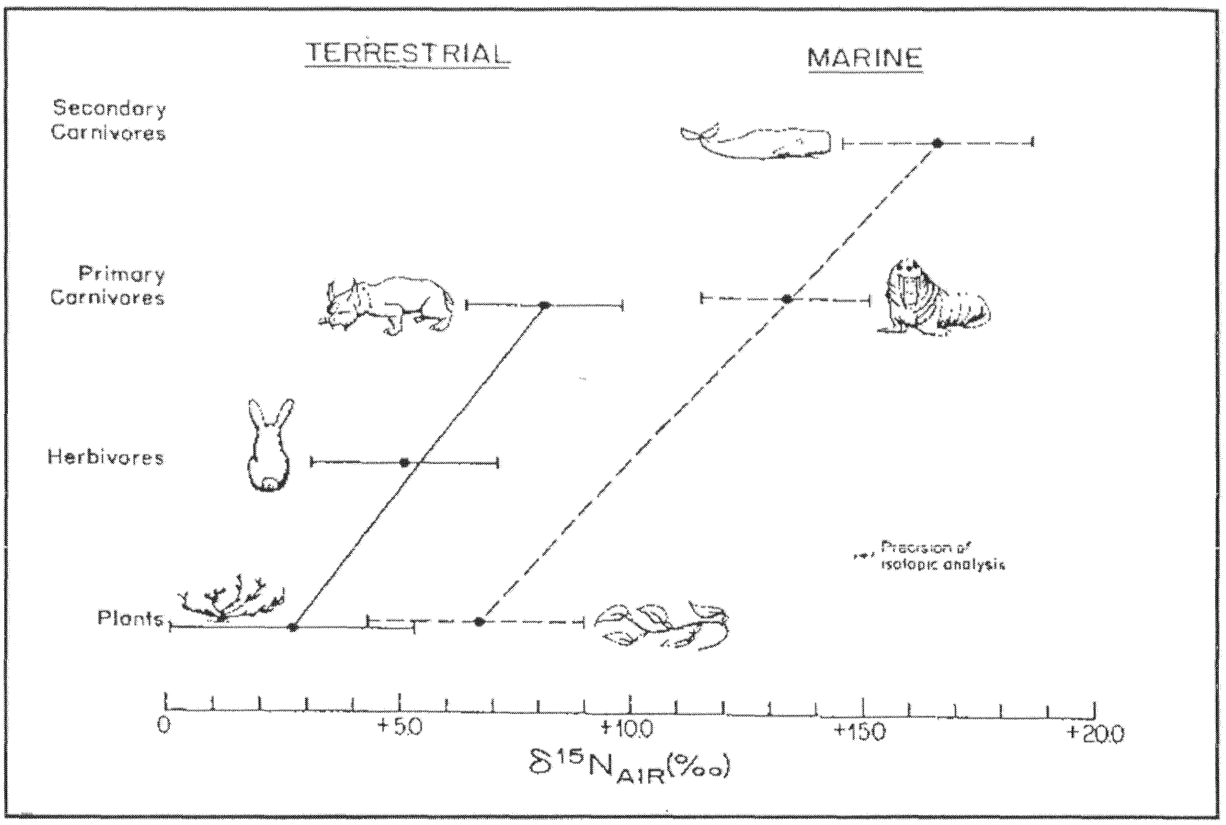


Figure 2. 2: $\delta^{15}N$ in the terrestrial and marine systems (Schoeninger and DeNiro 1984).

2.3.1 Marine sediments

Organic nitrogen is found in most marine organisms. These organisms decompose, with the result that ammonia is released, and deposited in marine sediments (Capone 1988). Miyake and Wada (1967) found that there is an increase in ^{15}N with depth of the sediment. For instance sediments in the west North Pacific Ocean at a depth of 200m had nitrate $\delta^{15}N$ of 0.8 ‰ compared to 1.5‰ at 1189m. Miyake and Wada also recorded an increase in ^{15}N of organic nitrogen and ammonia with increasing depth within the water column. Marine plants and animals living in great depths will reflect more positive values than those living at the surface of the oceans.

2.3.2 Plants

According to Needoba (2000) $\delta^{15}N$ values have a wide range due to cullular differences in nitrogen uptake of individual phytoplankton. Miyaka and Wada (1967) reported a mean of 5.6 ‰ for phytoplankton ($n = 4$), for and 7.5 ± 1.2 ‰ for marine algae from the west North Pacific Ocean. $\delta^{15}N$

values obtained by Sealy *et al.* (1987) from the west coast of South Africa showed an average of 7.6 ‰ for phytoplankton. The kelp *Laminaria pallida* had a $\delta^{15}N$ value of 3.2 ‰, indicating its low position in the marine food chain. *Ecklonia maxima*, also a kelp, had a $\delta^{15}N$ value of 7.3 ‰. Bustamente and Branch (1996) report values between 7.9 and 8.7 ‰ for detritus and seaweeds from the west coast of South Africa. (Table 2.2). These values indicate the fact that a substantial amount of nitrogen is regenerated through the microheterotrophic communities of bacteria and protozoa, especially in phytoplankton based systems (Newell *et al.* 1998).

2.3.3 Animals

The mean $\delta^{15}N$ reported for 11 species of benthic invertebrates (n = 33) from the Bay of Calvi, Corsica in the Mediterranean is 3.5 ± 1.4 ‰ (Pinnegar and Polumin 2000). Miyake and Wada (1967) reported a mean of 11 ‰ fot two samples of zooplankton from the northwest Pacific Ocean. Sealy *et al.* (1987) obtained values of 6.2 ‰ for zooplankton and 9.1‰ for mysids from the West Coast of South Africa.

Shellfish

Table 2.2: Nitrogen isotope values for marine organisms from the west coast of South Africa (from Bustamente and Branch 1996)

Organism	$\delta^{15}N$ ‰ & SD.
Laminaria pallida (Sea-weed) (*n* = 6)	8.7± 0.8
Ecklonia maxima (Sea-weed) (*n* = 5)	8.0 ± 0.8
Detritus (*n* = 4)	7.9 ± 0.5
Patella granularis(Grazer) (*n* = 1)	8.4
Haliotis midae (Grazer) (*n* = 1)	6.9
Patella granatina (Grazer) (*n* = 5)	6.0 ± 0.3
Patella argenvillei (Grazer) (*n* = 6)	6.3 ± 0.2
Mytilus galloprovincialis (Filter-feeder) (*n* = 6)	8.0 ± 0.5
Burnupena spp. (Carnivore) (*n* = 1)	10.4
Jasus lalandii (Carnivore) (*n* = 1)	11.7

The same authors report $\delta^{15}N$ values between 6.0 and 8.4 ‰ for grazing shellfish. These are slightly more varied than results between 7.1 and 8.4 ‰ in the study by Sealy *et al.* (1987). Values for filter-feeders are very similar, at 8.0 ± 0.5 ‰ for the mussel *M. galloprovincialis* (Bustamente and Branch 1996), 8.5 ‰ for the black mussel *Choromytilus meridionalis* (Sealy *et al.* 1987). Richards and Hedges (1999) reported a mean $\delta^{15}N$ of 8.8 ± 1.3 ‰ (*n* = 45) for shellfish meat from different regions around the world. Their value falls within the range of values reported from the south-western Cape. In the southern Cape, mussels like *P. perna* and the Mediterranean mussel *Mytilus galloprovincialis* eat phytoplankton and zooplankton. The carnivores, *Burnupena spp.* and *Jasus lalandii* have the highest $\delta^{15}N$ values because they feed on primary consumers.

Minagawa and Wada (1984) found that stepwise enrichment in ^{15}N with increasing trophic level ranged from 1.3 to 5.3 ‰ with an average of 3.4 ± 1.1 ‰ for marine organisms from the East China Sea, Bering Sea, Lake Ashinako and Usujiri. They also found that fractionation is independent of habitat. The fractionation factor for mussels was 2 ‰, for octopus 3.3 ‰, *Osteichthyes* (rock fish) 3.4 ‰ and for a sea gull 4.4 ‰.

Fish

Richards and Hedges (1999) measured the flesh and bone collagen of modern fish. Samples were taken from Great Britain (n= 49), Ecuador (n= 14), South Africa and British Columbia (n = 5). The mean $\delta^{15}N$ value for flesh is 13.0 ± 1.9 ‰. Miyake and Wada (1967) obtained a $\delta^{15}N$ value of 15.9 ‰ for marine fishes (n = 4) from the Pacific Ocean. The marine fish species, *Arctoscopus japonicus* had the most enriched value of 20.5 ‰.

Hobson *et al.* (1996) found that planktivorous fish from northeastern coastal Newfoundland have a mean $\delta^{15}N$ of 13.7 ‰ and piscivorous fish 17.7 ‰, reflecting their relative trophic positions in the marine foodchain. $\delta^{15}N$ values for anchovy bone collagen from the southern Benguela region in South Africa have a mean of between 10 to 11 ‰ (Sholto-Douglas 1992). Muscle tissue for *Sardinops sargax* (anchovy) from the Agulhas Bank has $\delta^{15}N$ values between 12.5 and 13 ‰, similar to those from the Benguela region. Sardine muscle from the Agulhas Bank however have more depleted values of 11 and 11.5 ‰. These small fish are low in the marine food chain. Sealy *et al.* (1987) obtained a $\delta^{15}N$ value of 13 ‰, for *Liza richardsonii,* formerly *cf. ramada* (haarder), 12.9 ‰ for *Pachymetopon blochii* (hottentot) and 15.3 ‰ for *Lithognathus lithognathus* (white steenbras) meat from the south-western Cape. Both *L.-richardsonii* and *P. blochii* are omnivores that feed on phytoplankton, sponges, molluscs and some small crustaceans. *L. lithognathus* is a carnivore that eats sand and mud prawns, molluscs (*Donax* and limpets), crustaceans and benthic invertebrates (Van der Elst and Adkin 1991, Smith and Heemstra 1986).

Seals

Richards and Hedges (1999) also measured collagen from modern and archaeological seal bone. The modern samples came from, California, Northwest Europe, British Columbia, South Africa and unknown locations. Archaeological bone came from British Columbia and Northwest Europe. The mean $\delta^{15}N$ value for all samples is 17.0 ± 2.1 ‰. Walker and De Niro (1986) reported a mean $\delta^{15}N$ value of 19.4 ‰ (n = 4) for marine mammals from Rincon Point in California. These included seals and pinnipeds. $\delta^{15}N$ values between 15.9 ‰ and 19.3 ‰ were obtained from bone collagen for modern fur seals (*A. pusillus)* from the southwestern Cape by Sealy *et al.* (1987). The high $\delta^{15}N$ value for seals reflects the fact that most seals are carnivores near the top of the marine food chain. There are some exceptions: Rau *et al.*-(1992) has reported values as low as 6 ‰ for crabeater seals from the Weddell Sea, in Antarctica. The diet of crabeater seals consists mostly (90%) of krill. Ross seals eat predominantly squid; a single Ross. seal had a $\delta^{15}N$ value of 9 ‰.

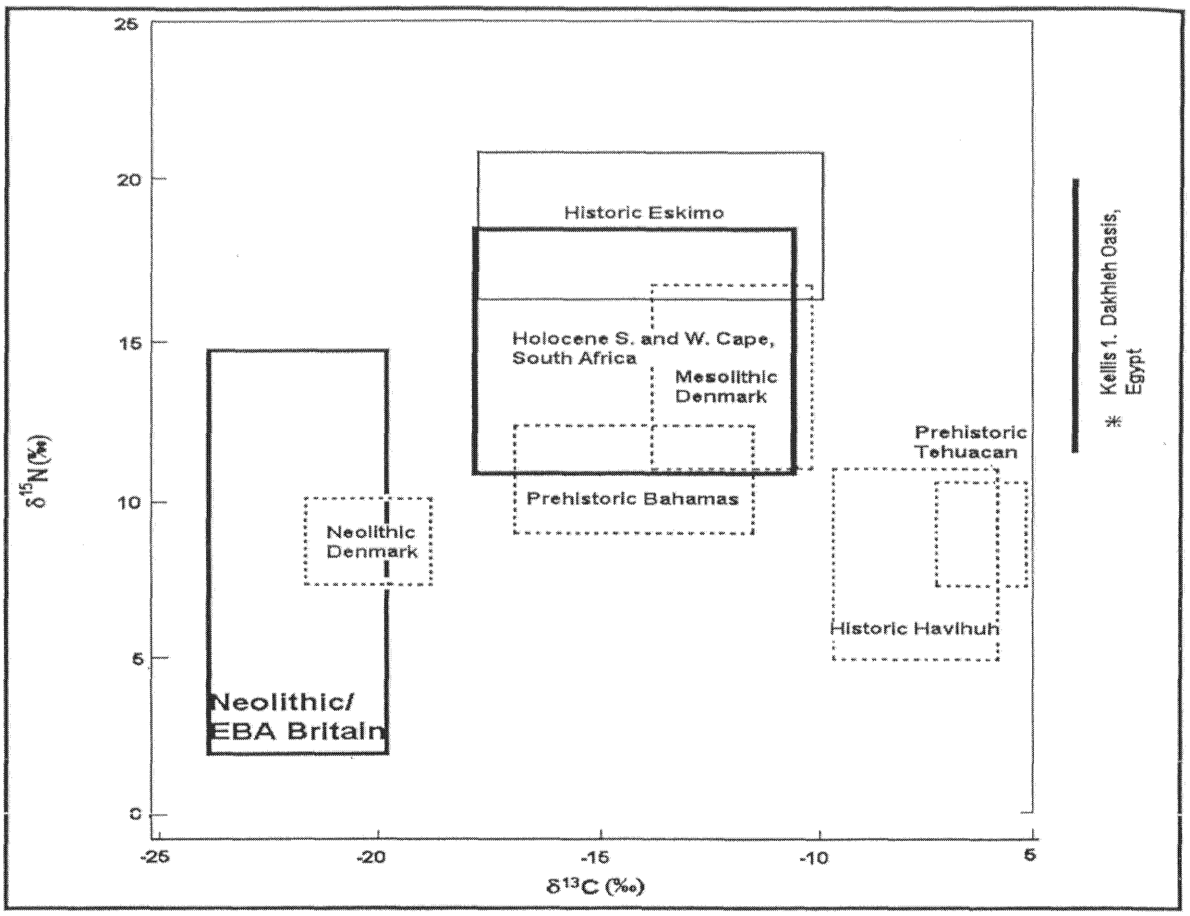


Figure 2. 3: Isotopic values for populations in different environments, with different diets (adapted from DeNiro 1987 and Pollard 1998). Boxes represent interquartile ranges.

(*Schwarcz *et al.* 1999 supplied only the $\delta^{15}N$ and not the $\delta^{13}C$ for humans)

Stepwise trophic level fractionation of N isotopes applies to humans, so the $\delta^{15}N$ values of humans depend on the diets they eat. Since virtually all N in the diet comes from protein, nitrogen isotope measurements reflect the protein component of foods eaten. People in well - watered areas (Neolithic / EBA Britons) have $\delta^{15}N$ values between about 2 and 15 ‰. (Figure 2.3). The lower values indicate that people ate terrestrial protein only; the more positive values indicate some marine protein consumption. People who do not eat marine food (Neolithic farmers in Denmark, people from prehistoric Tehuacan, the historic Havisu and Late Neolithic/ Early Bronze age people from the south of England) tend to have $\delta^{15}N$ values no higher than 10‰. (see Table 2.3). People who eat very large amounts of marine protein, such as the historic Eskimo or Inuit, have $\delta^{15}N$ values of approximately 16-21 ‰. Virtually all the protein component for these people comes from fish. Their $\delta^{15}N$ values probably approach the maximum for marine – based diets. $\delta^{15}N$ values for human bone collagen from the Late Ptolemaic-Early Roman period from Kellis 1 in Egypt ranged from 13 to 20 ‰ with a mean of 17.6 ‰ (Schwarcz *et al.* 1999). (see

Table 2.3). In this case, the positive values result from living in a very arid environment, rather than from the consumption of marine foods.

Later Iron Age people from South Africa ate C_4 grains with some meat, and perhaps milk (Ambrose and DeNiro 1986; 1987). Their diet was terrestrial, but parts of this region receive relatively low rainfall, leading to $\delta^{15}N$ values just below 10‰. (see Table 2.3). The $\delta^{15}N$ values for Neolithic pastoral people from Kenya are a little higher, perhaps indicating greater reliance on animal foods, but likely also complicated by aridity.

Table 2.3: $\delta^{15}N$ for human bone collagen

POPULATIONS WITH A PREDOMINANTLY TERRESTRIAL DIET	MEAN $\delta^{15}N$ VALUES
Late Neolithic /Early Bronze Age Wessex, south of England, Shrewton (*n* = 19)[1]	4.6 ± 2.8
EP - MP Cachuma Lake, Santa Barbara Channel area, California (Sba-485) (*n* = 4)[2]	9.8 ± 2.7 ‰
Kellis 1, Dakhleh Oasis, Egypt (*n* = 25)[3]	17.6 ‰
Savanna Pastoral Neolithic (SPN), Kenya (*n* = 10)[4]	12.6 ± 0.8 ‰
Later Iron Age, northern Transvaal, South Africa (*n* = 8)[4]	9.4 ± 1.0 ‰
POPULATIONS THAT ATE MARINE FOODS	**MEAN $\delta^{15}N$ VALUES**
Dos Pueblos School, Santa Barbara Channel area, California (Sba-143) (*n* = 1)[2]	14.6 ‰
Rincon Point, Santa Barbara Channel area (Sba-119) (*n* = 4)[2]	12.4 ± 3.4 ‰
Later Stone Age, Coastal hunter-gatherers,southern Cape (South Africa) (*n* = 80)[5]	13.1 ± 2.3‰
Later Stone Age, Coastal hunter-gatherers,south-western Cape (South Africa) (*n* = 77)[6]	14.6 ± 1.8 ‰
Marianas Archipelago, Western Pacific (3 islands)[7]	
Latte Period, Rota (*n* = 10)	9 ± 1.3 ‰
Latte Period, Guam (*n* = 5)	9.5 ± 0.5 ‰
Latte Period, Saipan (*n* = 8)	7.8 ± 0.9 ‰
Fisher-gatherers (European Mesolithic Period) (*n* = 15)[8]	14.5 ± 1.3 ‰
Muwu (marine hunter-gatherers) (*n* = 10)[2]	15.2 ± 2.9 ‰
Newfoundland (*n* = 19)[8]	20.3 ± 0.6 ‰
British Columbia (*n* = 29)[8]	18.6 ± 1.3 ‰

[1]Pollard 1998, [2] Walker and DeNiro 1986, [3] Schwarcz *et al.* 1999, [4] Ambrose and DeNiro 1986, [5]Sealy 1997 & Sealy and Pfeiffer 2000, [6] Sealy 1997 & Sealy and van der Merwe 1988, [7]Ambrose *et al.* 1997, [8]Richards and Hedges 1999

Isotopic studies of coastal populations that ate mixed marine and terrestrial diets are especially relevant to this thesis. The diets of prehistoric populations from three islands (Guam, Rota and Saipan) in the Marianas Archipelago were analysed by Ambrose *et al.* (1997) for $\delta^{15}N$ (Table 2.3). Ambrose *et al.* (1997) found that people who had lived on the island of Saipan had lower $\delta^{15}N$ values than populations living on the other two islands of Rota and Guam (Table 2.3). This means that prehistoric people on Saipan consumed food that had low protein contents, and from the apatite $\delta^{13}C$ they probably ate plant food with a C_4 signature. These $\delta^{15}N$ values are low for marine food-eating people, in part because of nitrogen fixation by blue-green algae in the shallow tropical sea. This leads to low marine $\delta^{15}N$ values, comparable to terrestrial ecosystems. Relatively low $\delta^{15}N$ values for people from the Bahamas are also due to this phenomenon (Figure 2.3).

Walker and DeNiro (1986) analysed the bone collagen of 40 human skeletons from the Santa Barbara Channel area in California for ^{15}N and ^{13}C. Two of these sites, Dos Pueblos School (Sba-143) and Rincon Point (SBa-119) are situated on the mainland coast where estuaries are present. According to Walker and De Niro, Early to Middle Period (5 000 to 1 400 BP) inhabitants of this area obtained a substantial amount of their food from the local salt marsh ecosystem, where nitrogen fixation is high and the ^{15}N concentration in the skeletal material reduced. People from Rincon Point ate a diet that had a high terrestrial input, but the site also contained burials that had high $\delta^{15}N$ values, suggesting that some inhabitants of this site had a large marine component in their diet.

$\delta^{15}N$ values from the European Mesolithic range between about 10 and 17‰ with a mean of 14.5 ± 1.3 ‰ (Richards and Hedges 1999). The mean is similar to that obtained for L.S.A people from the southwestern Cape, South Africa (14.6 ± 1.8 ‰) and the one individual from Dos Pueblos School, California (14.6 ‰) (see Figure 2.3 and Table 2.3). $\delta^{15}N$ values for skeletons from the southern Cape also fall within this range. These values indicate that considerable quantities of marine protein were consumed by these people, although these values fall below that of the Inuit and north-west coast native Americans who have values about 20 ‰ (Tauber 1981; Richards and Hedges 1999). Inuit consume seals, which generally have high ^{15}N values, ca. 16-19 ‰ (see above).

People who live in medium to high-rainfall areas (> 400mm p.a.) and who eat only terrestrial foods will tend to have low $\delta^{15}N$ values. Consumption of large quantities of animal protein will raise the values somewhat. Groups who live along the coast and whose diets include marine foods will have more enriched $\delta^{15}N$ values. The extent of enrichment depends on the quantity of marine food eaten, and also on the trophic level of the items consumed. Shellfish, with their relatively low $\delta^{15}N$ values, will lead to much less ^{15}N enrichment in consumers than high-trophic-level foods such as seal meat. Finally, people who live in hot arid environments (Schwarcz *et al.* 1999) will also have enriched $\delta^{15}N$ values, even if they eat no marine foods at all.

2.4 CARBON IN THE TERRESTRIAL ENVIRONMENT

Approximately 98.9 % of carbon is ^{12}C, while ^{13}C contributes 1.1 % (Pollard 1998). Atmospheric CO_2 has $\delta^{13}C$ of about -7 to –8 ‰ (Figure 2.4).

2.4.1 Plants

The major source of carbon isotopic fractionation in food chains is plant photosynthesis. Plants use the following photosynthetic pathways: C_3 (Calvin Benson) pathway, C_4 (Hatch-Slack) pathway or CAM (Crassulean Acid Metabolism).

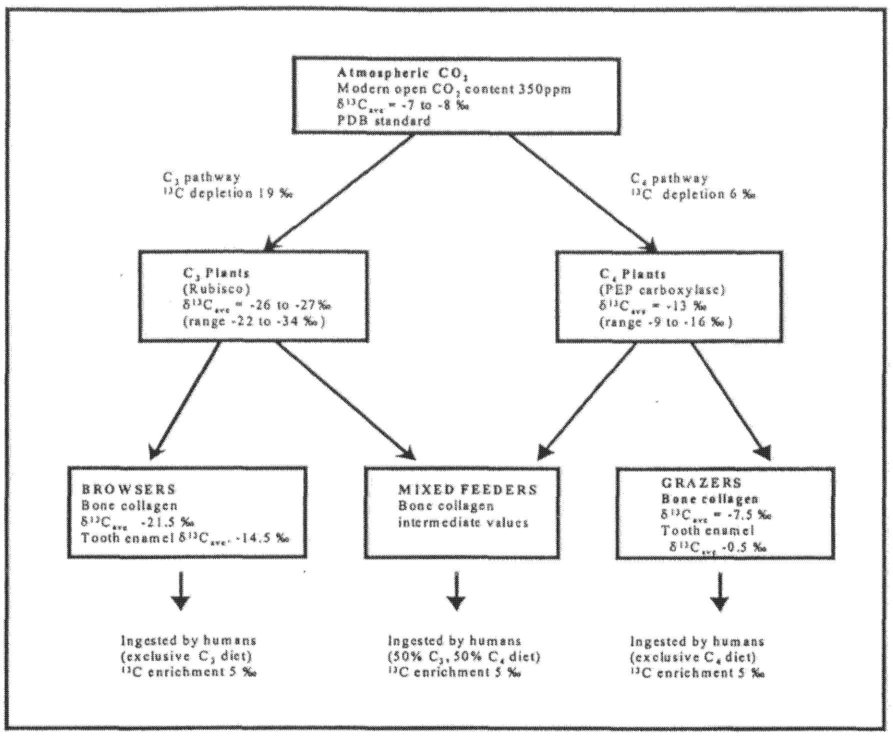


Figure 2.4: $\delta^{13}C$ values in the terrestrial foodweb (adapted from Van der Merwe and Vogel 1983; Lee-Thorp 1989, Cerling *et al.* 1999).

The enzyme responsible for carboxylation in C_3 plants is ribulose bisphosphate carboxylase oxygenase (rubisco) (Ehleringer 1991). Rubisco reacts with one molecule of CO_2 to produce three molecules of 3-phosphoglyceric acid. The carbon is reduced, carbohydrate is formed and the ribulose bisphosphate regenerated. About 90% of plants use the C_3 biochemical pathway, including wheat, rice and almost all fruits and vegetables. The C_3 pathway is the oldest of the three pathways, with the strongest discrimination in favour of the isotopically light ^{12}C. $\delta^{13}C$ for C_3 plants averages around –27 ‰. Plants like sorghum, maize, millet etc. use the C_4 pathway, employing the enzyme phosphoenol pyruvate carboxylase (PEP). In C_4 plants less isotope fractionation takes place than in C_3 plants, so the mean $\delta^{13}C$ value for C_4 species is about –13 ‰ with a range between -7 to -15 ‰ (Peisker and Henderson 1992). In CAM plants both enzymes may be present and both pathways used at different times of day, leading to isotopic values that may be C_3-like (if the C_3 pathway dominates), C_4-like or in between. Significant differences exist in carbon isotopes between the anatomical parts and the biochemical fractions of plants (Turban-Just and Schramm 1998).

Environmental effects, microhabitat and light intensity can cause variations in $\delta^{13}C$ values (van der Merwe 1989, Ehleringer 1991, Tieszen 1991, Gillon *et al.* 1998). Variations can occur in the mean $\delta^{13}C$ values of CO_2 in dense forests. The "canopy effect" is due to the fact that air circulation in forests is restricted and not well mixed with atmospheric CO_2. As a result the leaves of the upper canopy can have $\delta^{13}C$ values as negative as -30 ‰, while leaf litter and the undergrowth have even more depleted values of -35 ‰. ^{13}C values as depleted as -36.5 ‰ have been reported for *Ataenidia conferta* from the subcanopy in the Ituri Forest, Zaire (Cerling 1999). According to Buchmann *et al.* (1998) carbon isotope discrimination is bigger at wet coastal areas than at dry inland sites.

2.4.2 Animals

Animals have $\delta^{13}C$ values more positive than their food, as secondary fractionation occurs when isotopes are passed up the food chain. The difference between collagen and diet is about 5.1 ‰ for large herbivores, so animals eating a pure C_3 diet would have bone collagen values around -22 ‰ (Vogel 1978; Sealy 2001, Figure 2.4). Small animals like rats can have diet-collagen fractionation as small as 3 ‰ (Ambrose and Norr 1993; Tieszen and Fagre 1993). Grazers that eat C_4 grasses have bone collagen $\delta^{13}C$ of around -7.5 ‰. Animals with mixed diets have intermediate values. Values for carbonate in tooth enamel, or in bone apatite are considerably more enriched. This is the case because carbonate in bone is derived from blood bicarbonate, which tends to be enriched in ^{13}C. Thus the diet-apatite spacing is around 11-14 ‰, compared with 5 ‰ or less for diet-collagen (Lee-Thorp *et al.* 1989; Ambrose and Norr 1993). The fractionation factor for diet to fat (lipids) varies between -2 and -5 ‰; while for diet to muscle tissue it is about 3 ‰ for herbivores (Ambrose and Norr 1993; Tiezen and Fagre 1993; Lee-Thorp *et al.* 1989). This fractionation is carried over to humans.

Both theoretical considerations and the results of controlled-diet experiments indicate that the carbon in apatite derives from a mixture of all dietary components (carbohydrates, proteins and fats). The carbon in collagen, however, probably derives to a greater extent from dietary protein. Experiments using rats fed a controlled diet produced animals in which collagen apparently derived mainly from dietary protein (Ambrose and Norr 1993). More recent experiments on pigs, however, indicate that although essential amino acids are inherited directly from protein in the diet, non-essential ones contain a significant amount of carbon from the energy component (Howland *et al.* 2001). The details of this biochemical routing have yet to be fully worked out (Sealy 2001). According to Ben-David and Schell (2001) mixing models do not give accurate estimates of proportions of foods in diets.

2.5 CARBON IN THE MARINE ENVIRONMENT

2.5.1 Plants

Dissolved carbonate in seawater is the main source of carbonate for marine plants and animals; and has a $\delta^{13}C$ value of 0 ‰ (Katzenberg 1992). Atmospheric carbon dioxide (CO_2) dissolves in seawater, causing the CO_2 to equilibrate with bicarbonate (HCO_3) and carbonate (CO_3) ions, with associated isotopic fractionation. Isotopic fractionation occurs throughout the marine food chain, with the higher trophic level organisms having more enriched $\delta^{13}C$ values. The $\delta^{13}C$ values of phytoplankton range from –33 to –5 ‰ (Johnston and Kennedy 1998; Fry and Sherr 1984). Hoefs (1997) reports a smaller range of variation in natural oceanic phytoplankton populations, of about 15 ‰. Rau *et al.* (1992) demonstrated that different latitudinal trends in the $\delta^{13}C$ composition of plankton exist between the northern and southern oceans. South of the equator the correlation between latitude and plankton ^{13}C content is significant, whereas a much weaker relationship exists in the northern oceans. $\delta^{13}C$ of plankton depend partly on the concentration of CO_2 in shallow waters.

Marine plants photosynthesise using enzymes from both the C_3 and C_4 pathways, leading to a very wide range of $\delta^{13}C$ values (Karekar and Joshi 1973, Johnston and Kennnedy 1998). Sealy (1986) reports values between –34.7 ‰ and for –10.2 ‰ for specimens of marine algae collected off the Cape coast. Since HCO_3^- is much more abundant in seawater than dissolved CO_2, marine algae utilise ^{13}C-enriched HCO_3^- in addition to CO_2, which explains why marine plants are often enriched in ^{13}C relative to land plants (Hoefs 1997). Bustamente and Branch (1996) reported $\delta^{13}C$ values of –13.0 ± 0.5 for *Laminaria* and –14.5 ± 0.5 for *Ecklonia*, both kelps from the temperate Atlantic coast near Cape Town. Both $\delta^{13}C$ values are like those of C_4 species. Plankton and benthic algae sampled from the same area had $\delta^{13}C$ values of -20 and -22 ‰.

2.5.2 Animals

Table 2.4: $\delta^{13}C$ values for marine organisms from the west coast of South Africa (from Bustamente and Branch 1996, Sealy and Van der Merwe 1986)

Organism	$\delta^{13}C$ ‰ & SD.
Laminaria pallida (Sea-weed) (*n* = 9)	-13.0 ± 0.5
Ecklonia maxima (Sea-weed) (*n* = 7)	-14.5 ± 0.5
Detritus (*n* = 4)	-14.4 ± 2.2
Patella granularis(Grazer) (*n* = 1)	-16.5
Haliotis midae (Grazer) (*n* = 1)	-16.7
Patella granatina (Grazer) (*n* = 6)	-15.2 ± 1.0
Patella argenvillei (Grazer) (*n* = 6)	-14.3 ± 0.9
Mytilus galloprovincialis (Filter-feeder) (*n* = 5)	-14.4 ± 0.4
Burnupena spp. (Carnivore) (*n* = 1)	-14.4
Jasus lalandii (Carnivore) (*n* = 1)	-12.6

Shellfish

Bustamante and Branch (1996) found that kelp-derived detritus is the main source of carbon for filter feeders such as *M. galloprovincialis*. They also feed on small algal organisms. These mussels might however also use other carbon sources, as described for zebra mussels, which also use dissolved organic carbon (Roditi *et al.* 2000). More food is available for both filter-feeders and grazing shellfish on exposed rocky shores.

M. galloprovincialis analysed by Bustamente and Branch had a $\delta^{13}C$ value of -14.4 ± 0.4 ‰. This is somewhat more positive than values for mussels reported by Sealy and Van der Merwe (1986), who found that mean values for *C. meridionalis* collected at different times of the year ranged from -15.9 to -19.4 ‰. Grazing shellfish had $\delta^{13}C$ values between -16.8 and -12.3 ‰ (Sealy and Van der Merwe 1986, Bustamente and Branch 1996).

Richards and Hedges (1999) analysed the flesh of shellfish from modern samples from Ecuador (n= 13), Great Britain (n= 20), South Africa (n= 9) and unknown locality (n= 4). The mean value for $\delta^{13}C$ is -15.9 ± 2.0 ‰ (n = 36). Studies analysing a wide range of animals show that there is variation in the $\delta^{13}C$ values of shellfish, depending on their position in the food chain.

Fish

Sholto-Douglas (1992) reported that anchovy bone collagen from the southern Benguela region had $\delta^{13}C$ values of -14.5 and -13.5 ‰. Muscle tissue was around -16.0 and -14.5 ‰. $\delta^{13}C$ values for muscle tissue for anchovy and sardine from the Agulhas Bank were similar to values from the southern Benguela region, namely -15.8 and -16.0 ‰. A single western Cape specimen of *Liza richardsonii* (formerly *ramada*), an algal /detritus feeder, had a $\delta^{13}C$ value of -15.8 ‰ (Sealy and Van der Merwe 1986). Fish may occupy different trophic levels in their life histories, due to ontogenic changes (Pinnegar and Polumin 2000). Katzenberg and Weber (1999) found that fish from freshwater sources, such as lakes, had very variable carbon isotope values. Fishes that are found near the shores of lakes (littoral fish species) had heavier $\delta^{13}C$ values than fishes that were caught in the open water (Dufour *et al.* 1999). The values range from -6 to -21 ‰ for littoral fish and -26 to -22.5 ‰ for fish from the open water.

Seals

Seals are marine carnivores that eat fish, both planktivorous and piscivorous fish. The mean $\delta^{13}C$ reported by Richards and Hedges (1999) for collagen from modern and archaeological seal bones is –12.3 ± 1.3 ‰. Lee-Thorp *et al.* (1989) obtained a mean of -11.9 ‰ for *A. pusillus* (n = 5) from the western Cape. The most enriched value of -11.3 ‰ was for a sub-adult, while the very young pup had the most depleted value of -12.6 ‰. This could be due to the fact that the pup was still suckling.

Humans

The horizontal axis in Figure 2.3 shows the variation in $\delta^{13}C$ values for humans who eat different kinds of diets in different parts of the world. People dependent on C_3 crops (and animals that ate C_3 diets) have $\delta^{13}C$ values between -24 and -19 ‰ (Neolithic/EBA Britain and Neolithic Denmark) (Sealy and van der Merwe 1988). Farmers who grew C_4 crops (historic Havihuh, prehistoric Tehuacan) have $\delta^{13}C$ values between -10 and -5 ‰. Populations that ate substantial quantities of marine foods have intermediate values (historic Inuit, Mesolithic Denmark, Holocene southern and western Cape, South Africa and prehistoric Bahamas).

Table 2.5 shows $\delta^{13}C$ values for Later Iron Age people from South Africa (-6.6 ± 0.5 ‰) which reflect the predominantly C_4 input into the diet, through eating C_4 cultigens and the meat of grazers (Table 2.5; Ambrose and DeNiro 1986). $\delta^{13}C$ values from Kenya for the period of the Savanna Pastoral Neolithic are also very enriched, at –5.7 ± 0.8 ‰.

Table 2.5: $\delta^{13}C$ for human bone collagen

POPULATIONS WITH A PREDOMINANTLY TERRESTRIAL DIET	MEAN $\delta^{13}C$ VALUES
EP - MP Cachuma Lake, Santa Barbara Channel area, California (Sba-485) (n = 4)[2]	-18.0 ± 1.2 ‰
Savanna Pastoral Neolithic (SPN), Kenya (n = 10)[3]	-5.7 ± 0.8 ‰
Later Iron Age, northern Transvaal, South Africa (n = 8)[3]	-6.6 ± 0.5 ‰
POPULATIONS THAT ATE MARINE FOODS	**MEAN $\delta^{13}C$ VALUES**
Prehistoric Lillooet area, British Columbia interior (n = 5)[1]	-15.4 ± 0.3 ‰
Dos Pueblos School, Santa Barbara Channel area, California (Sba-143) (n = 1)[2]	-15.8 ‰
Rincon Point, Santa Barbara Channel area (Sba-119) (n = 4)[2]	-16.0 ± 1.7 ‰
Later Stone Age, Coastal hunter-gatherers,southern Cape (South Africa) (n = 80)[4]	-13.8 ± 1.5 ‰
Later Stone Age, Coastal hunter-gatherers,south-western Cape (South Africa) (n = 77)[4]	-13.7 ± 1.8 ‰
Marianas Archipelago, Western Pacific (3 islands)[5]	
Latte Period, Rota (n = 10)	-18.2 ± 1.2 ‰
Latte Period, Guam (n = 5)	-17.5 ± 0.6 ‰
Latte Period, Saipan (n = 8)	-18.6 ± 0.3 ‰
Fisher-gatherers (Danish Mesolithic Period) (n = 6)[6]	-12 ± 2.0 ‰
Muwu (marine hunter-gatherers) (n =)[6]	-14.5 ± 1.2 ‰
British Columbia (n = 48)[6/7]	-13.5 ± 0.9 ‰

[1] Chisholm 1982,[2] Walker and DeNiro 1986, [3] Ambrose and DeNiro 1986,[4] Sealy 1997,[5]Ambrose *et al.* 1997,[6] Richards and Hedges 1999 & [7] Chisholm *et al.* 1983

Prehistoric peoples from British Columbia and the Santa Barbara Channel area in California have $\delta^{13}C$ values that indicate a substantial amount of marine foods in their diets. (see Table 2.5). The inhabitants of the Marianas Archipelago from the Latte Period have more negative $\delta^{13}C$ values, but given the local isotopic ecology these still indicate a significant marine input in their diets (Ambrose 1997). McGovern-Wilson and Quinn (1996) obtained $\delta^{13}C$ mean of -18.7 ± 0.8 ‰ for 10 individuals from Afetna, the northern part of Saipan. The mean $\delta^{13}C$ for six seventeenth –and eighteenth-century Dutch whalers is -19.2 ± 0.5 ‰ with a range of 1.5 ‰ (Schoeninger 1989). Schoeninger estimated that up to 50 % of the protein in their diet might have come from fish. These $\delta^{13}C$ values are similar to the values measured for Neolithic people from Denmark (DeNiro 1987) (see Figure- 2.3).

$\delta^{13}C$ values for ten individuals from Broadbeach, Australia ranged from -14.8 to -18.6 ‰ with a mean of -16.6 ± 1.2 ‰ (Hobson and Collier 1984). About 50% of the diet consisted of marine foods. In the southwestern and the southern Cape, values range from -18 to -11 ‰.

Thus $\delta^{13}C$ values reflect variation in terrestrial photosynthetic pathways, and also the proportions of marine and terrestrial food eaten. $\delta^{15}N$ measurements, on the other hand, are more useful in identifying the different marine inputs in the diet and the trophic position of an organism.

2.6 STABLE ISOTOPES AND THE PLETTENBERG BAY-KEURBOOMS REGION

2.6.1 Climate

The weather station closest to the research area, for which detailed records are available, is that of George (34°0′S, 22°23′E, 193m. above sea level). Climate statistics for the weather station in for the last 28 years record the highest temperatures between November to May. The highest mean daily temperature of 19.9°C was recorded in the month of February. Mean temperatures for months of June to September range from 12.9 to 13.9°C. Humidity is highest between September and March. Annual rainfall on the coast is 600mm and inland near the mountains it is 1000mm (South African Weather Bureau 2001). The annual average rainfall for the Plettenberg Bay area varies from 631 to 1200mm, with higher values in the more mountainous parts. Rain falls year round.

2.6.2 Plants

Both C_3 and C_4 grasses occur in the Plettenberg Bay area (see Figure 2.5). Grassy fynbos (Cowling 1983) is found on the Robberg Peninsula, and in the catchment area of the Keurbooms-Bietou estuary. This island of grassy fynbos is separated, by a band of afromontane forest, from the rest of the grassy fynbos inland. To the west of Nelson Bay Cave, there is a narrow band of dune thicket. These three vegetation types all have different plant communities. Clearly Nelson Bay Cave and Matjes River Rock Shelter are surrounded by different vegetation types, which might be reflected in the diet that Holocene people ate.

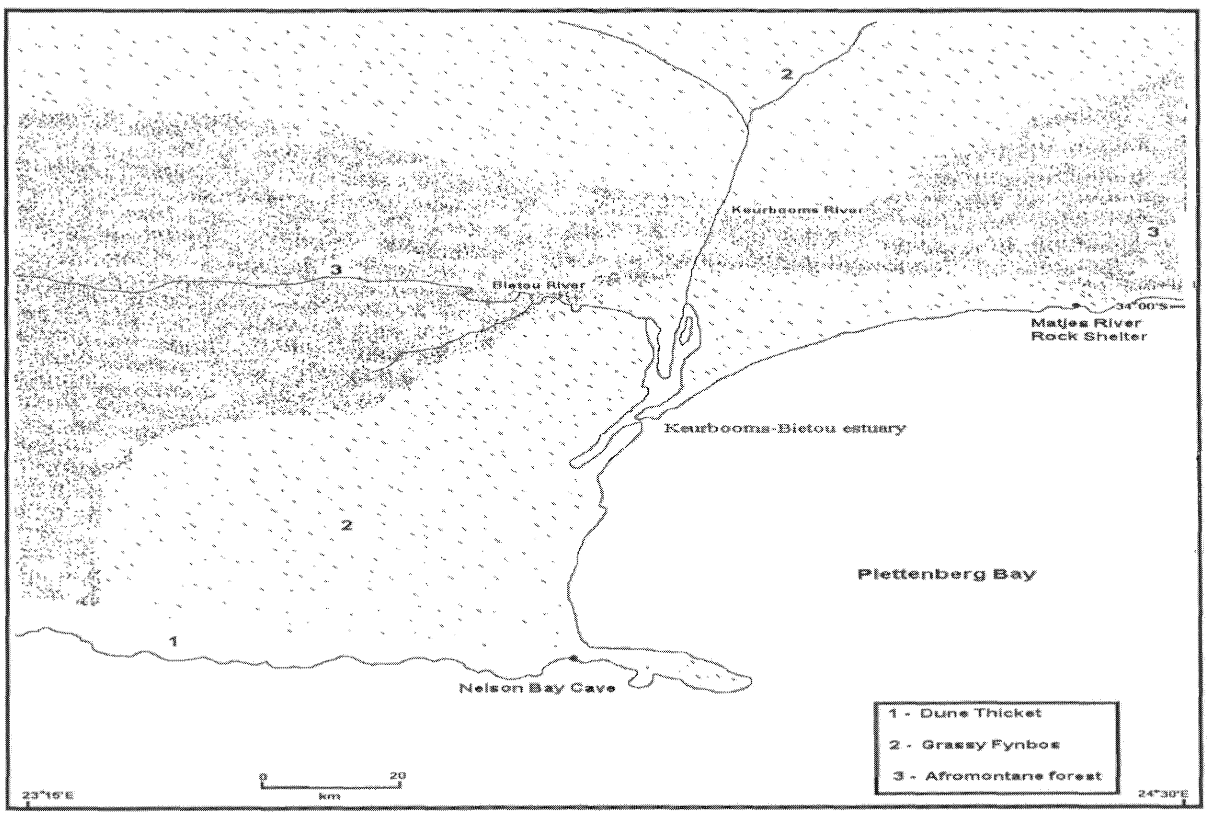


Figure 2.5: A map of the vegetation zones in the Plettenberg Bay-Keurbooms region (National Botanical Institute 1996).

Moving eastwards, the proportion of summer rainfall increases and less C_3 vegetation is present with more C_4 vegetation occurring. C_3 vegetation mostly consists of fynbos, restoids, and proteas. The temperature and the gradient of the slope on which the grasses grow are the determining factors in which photosynthetic pathway is dominant. Grass on north slopes, where higher temperatures and radiation occur, is usually C_4 grass. C_4 grass cover in the southern Cape is highest where the soils are very fertile, for instance in shale renosterveld and shrubland communities (Cowling 1983). The dominant C_4 species in the shrubland is *Themeda triandra,* which grows both in the summer and the winter, but shows stronger growth patterns in the summer. Other C_4 plants are *Sporobolus africanus* and *Tristachya leucothrix.* C_3 grasses, on the other hand, show strong growth patterns in the winter.

The mixture of C_3 and C_4 plants in the terrestrial vegetation of the southern Cape, especially in the Plettenberg Bay-Keurbooms region, means that carbon isotopes may not be reliable indicators of marine versus terrestrial contributions to prehistoric diets. Nitrogen isotopes, on the other hand, discriminate between terrestrial and marine inputs. $\delta^{15}N$ ratios are therefore the measurement of choice for the questions addressed in this thesis.

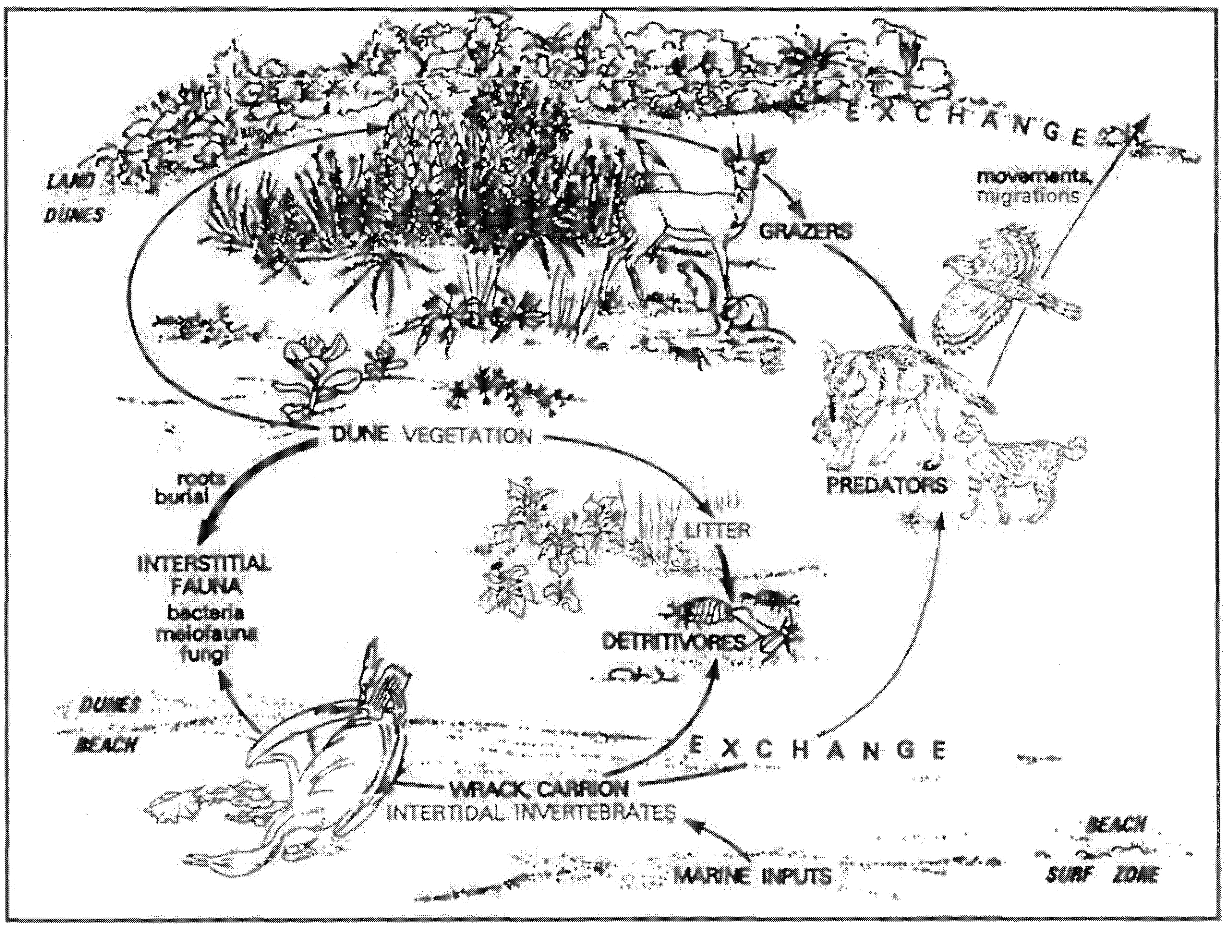


Figure 2.6: A coastal food chain in the southern Cape (Lübke and De Moor 1998).

2.6.3 Animals

The $\delta^{15}N$ values for modern tortoise, blue duiker, elephant, bushbuck and bushpig from Tsitsikamma range from 2 to 8 ‰ (Sealy *et al.* 1987). These results are what one would expect from a relatively high-rainfall area. The mean $\delta^{15}N$ value for archaeological *Syncerus caffer* (buffalo) from Nelson Bay Cave is 4.6 ± 1.0 ‰ (n = 26) and for *Hippotragus leucophaeus* (bloubok) (n= 8), 5.9 ± 1.2 ‰ (Sealy 1996). The similarity between the measurements for modern and archaeological animals confirms that terrestrial $\delta^{15}N$ values in this area have been low throughout the Holocene.

Carbon isotope ratios of animals in the southern Cape depend on the proportions of C_3 and C_4 based food they consume. A blue duiker (browser) from Knysna had a $\delta^{13}C$ value of - 20.3 ‰ (Vogel 1978). Sealy (1996) reported carbon and nitrogen isotope measurements on grazing herbivores from Nelson Bay Cave, principally *H. leucophaeus* and *S. caffer* and *Hippotragus equinus* (roan). Most of the animal bones come from the Holocene, but some are from the Last Glacial Maximum. The mean $\delta^{13}C$ value for *S. caffer* (n= 26) was -12.8 ± 1.5 ‰ and *H. leucophaeus* (n= 10), -11.48 ± 2.5 ‰. This indicates that at least 50 % of the diets of these animals consisted of C_4 grasses. The modern mixture of C_4 and C_3 grasses must have occurred throughout the Holocene. Rain must have fallen at least partly in the summer months as far back as Last Glacial Maximum, a pattern that is similar to that of today.

2.6.4 The marine system.

Plants (Seaweed)

Seaweeds generally do not survive in the archaeological record. Archaeobotanical evidence supporting the consumption of seaweeds is lacking in the southern Cape. In the Marianas archipelago, humans do consume seaweed. Since seaweed usually has low nitrogen content, its effect on bone collagen $\delta^{15}N$ values is likely to be insignificant in most cases.

Animals

When this thesis was begun, no $\delta^{15}N$ or $\delta^{13}C$ measurements were available for marine organisms collected along this area of the southern Cape coast. Studies of nearshore and intertidal species from the western Cape coast have been carried out by Bustamente and Branch (1996), Sealy (1986), Sealy and Van der Merwe (1986) and Sealy *et al.* (1987). The broad patterns described by these researchers, and summarised above, seem likely to apply also on the southern Cape coast. This issue will, however, be addressed in more detail in chapters 4 and 5.

Seals were an important item of diet at Nelson Bay Cave (Inskeep 1987, Chapter 3). Several zoological studies of southern Cape seals have been carried out, and are worth some discussion here.

The Rondeklippe colony of *A. pusillus* on the eastern side of the Robberg Peninsula is one of 28 colonies along the South African and Namibian coasts. (see Figure 1). A breeding colony is situated approximately 130km west of the Robberg Peninsula, near Mossel Bay (Black Rocks).

The seal colony on the Robberg Peninsula is a non-breeding colony. In the recent past, the colony has, at times, been small: in 1994 Stewardson and Brett (2000) recorded that only 11 animals were present, of which eight were adult males, one sub adult male, one female and one juvenile. Vagrant seals from the Mossel Bay colony and the Port Elizabeth colony swim to the Robberg area when fish are plentiful (David 1999). The colony on Robberg then increases to about 1000 seals. Seals are highly mobile, and they may swim many kilometres to forage. Martin (2001) found that an eight-month-old pup tagged off Seal Island, 2 kilometres from Simonstown, near Cape Town, was recaptured at Cape Cross in Namibia, a distance of 1 600km. Adult males will stay out at sea for months.

Pups suckle from their mothers during their first year and do not feed on the adult diet of fish and squid. A quarter of the seal population consists of pups. The important species on which adult seals prey are anchovy (17 %), horse mackerel (14 %), pilchards (12 %) and Cape hake (14 %). David (1987) identified 28 species in the stomach contents, which including crustaceans such as shrimp, amphipods, isopods (4.8%), rock lobster (3.2 %) and cephalopods (16.7 %). Seals from the south coast mainly eat squid (17%), octopus, horse mackerel and panga (David 1987). Periodically seabirds and gannets are taken.

Whales were an abundant, if irregular source of food for prehistoric people. Whalebones have been identified from many coastal many coastal L.S.A sites, including Nelson Bay Cave. Richards and Hedges (1999) reported measurements of bone collagen from modern whales from Alaska (n= 4), California (n= 11) and South Africa (n= 2). The mean value for $\delta^{15}N$ was 15.1 ± 1.1 ‰ and the mean $\delta^{13}C$ value was 13.7 ± 1.3 ‰.

The most common species of whale off the southern Cape coast is the southern right whale *(Eubalaena australis),* which feeds on fish, molluscs, arthropods and plankton. They are two to three levels above primary producers. Best and Schell (1996) analysed 11 baleen plates from southern right whales from South Africa, for $\delta^{13}C$. Values ranged from –18 to –23 ‰. Oscillations in the ^{13}C isotopes are due to the fact that southern right whales have different winter and summer feeding grounds, feeding along their migratory route.

2.6.5 The Keurbooms/Bietou estuary

This estuary is a major geographical feature within the research area. It is permanently open to the sea (Duvenhage and Morant 1984; Lübke and De Moor 1998) (Figure 2.5) and like other South African estuaries, provides an important nursery for young fish. In the inter-tidal flats, shrimps and pencil-bait burrow into the sand. On the southwestern end of the estuary is a lagoon with reeds growing along the bank, indicating that fresh water comes from Table Mountain quartzites in the cliffs behind the lagoon (Jacana 2000). *Zostera capensis* (Cape Eelgrass), invertebrate animals, a large population of shellfish and muddy sands occur in the lagoon.

Although a good deal of stable light isotope work has been done on inland lakes, little research has been done on estuaries and in particular the foodwebs and nutrient cycling that exist in these environments.

In estuaries, nitrogen determines and controls the rate of primary production; i.e. the amount of aquatic plant material that is produced (Holt 2000). Too little nitrogen in estuaries can cause a reduction in photosynthesis and thus productivity. An excess of nitrogen can cause eutrophication, which causes blooms of toxic algae. Isotopic values in estuaries tend to be different from these in the sea, due to the greater contribution of terrestrial run-off. The precise values, however, depend on the nature of the estuary, the extent to which it is open to the sea, etc. Variation of 0 to >30% in salt might occur depending on time and space (Capone 1988).

The presence of this estuary and a large lagoon in the Plettenberg Bay-Keurbooms region might be expected to have some localised effect on isotope ratios. This possibility is addressed in this thesis by the analysis of shellfish samples collected at different localities along the coast.

2.6.6 Humans: previous isotopic studies

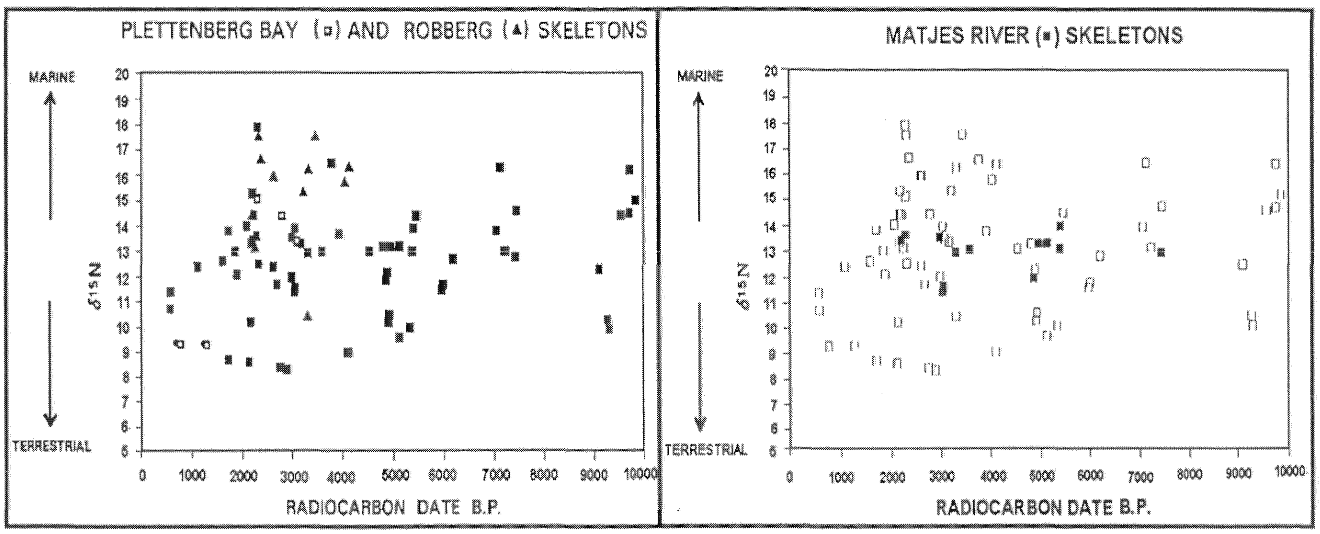


Figure 2.7: $\delta^{15}N$ plotted against radiocarbon date for human collagen from the southern Cape (from Sealy and Pfeiffer 2000).

Sealy and Pfeiffer (2000) analysed $\delta^{13}C$ and $\delta^{15}N$ in 80 human skeletons from the southern Cape, between George and Tsitsikamma National Park. They were primarily interested in whether the isotopic values indicated dietary change through time, and in possible relationships between stature and diet. They found that 9 out of the 10 highest values for $\delta^{15}N$, ranging from 17.9‰ (UCT 107) to 15.7 ‰ (SAM-AP 3021) came from the Robberg / Plettenberg Bay from skeletons that dated between 2 000 and 4 000 BP (see Figure 2 7). Four of the nine individuals are male. Only two skeletons, SAM-AP 1879 & SAM-AP 3021 were older than 3 300 BP, too small a number to compare, with any degree of confidence, diets before and after this important date (see Chapter 3). The mean $\delta^{15}N$ value for all 18 skeletons from Robberg/Plettenberg Bay was 15.2 ± 1.7 ‰. These values are enriched when compared with other skeletons from the southern Cape between 2 000 and 4 000 BP. This is the only period for which Sealy and Pfeiffer had significant numbers of skeletons from Robberg/Plettenberg Bay.

Skeletons from Matjes River Rock Shelter, in contrast, were found to have nitrogen isotope ratios clustered towards the middle of the range. (See Figure 2.7.2). The mean $\delta^{15}N$ value for 13 individuals was 13.0 ± 0.9 ‰, with a range of 14.9 ‰ to 9.3 ‰. Based on $\delta^{15}N$ values, the degree of reliance on marine foods was significantly different at Matjes River Rock Shelter than at Robberg. These two sites are only 15 kilometres apart on the coast, although a major estuary (Figure 2.5), that of the Keurbooms-Bietou rivers separates these sites.

2.7 SUMMARY

In this chapter the patterning of stable isotopes of nitrogen and carbon in terrestrial and marine environments has been described. The general pattern of how these isotopes are distributed is well understood, although many of the details remain to be worked out. In the southern Cape with its relatively high, year round rainfall, the $\delta^{15}N$ values in terrestrial organisms are low (<10 ‰) and $\delta^{13}C$ values are variable, reflecting both C_3 and C_4 vegetation. Isotope values for marine organisms have not previously been investigated in the southern Cape. According to evidence available for other areas, both in South Africa and in other countries, it is expected that $\delta^{15}N$ values in marine systems will be more positive than those on land. These values are passed on through the food chain to other consumers, including humans, which allows archaeologists to study prehistoric human diets by analysing archaeological bone (or other preserved tissue). On the basis of the modest sample of archaeological skeletons analysed thus far, $\delta^{15}N$ values for humans from Robberg /Plettenberg Bay indicate a strong marine input in the diet, while at Matjes River Rock Shelter more terrestrial input is shown.

CHAPTER THREE

THE LATER STONE AGE OF THE PLETTENBERG BAY - KEURBOOMS REGION

Archaeological sites in the southern Cape have an unusually long and complete sequence. The sequence in the southern Cape extends as far back as the Early Stone Age, and includes the Middle Stone Age (M.S.A) and the Later Stone Age (L.S.A). Plant and bone preservation is generally much better than in the rest of South Africa (Deacon and Deacon 1999). Abundant human skeletal remains have been recovered from southern Cape archaeological sites. The changes in stone tool industries and food waste are mostly well recorded.

The archaeology of two major coastal sites, namely Nelson Bay Cave and Matjes River Rock Shelter will be summarised. The lithic technology will be described using the scheme for the Later Stone Age developed by Janette Deacon (1984, Deacon and Deacon 1999). The durability of stone and the high proportion of lithic artefacts compared to artefacts made from other raw materials that survives in the archaeological record make lithics the best item to define change from one industry to another (Deacon 1974). Deacon's classificatory scheme for the Later Stone Age was developed, in part, on the basis of artefact assemblages for the southern Cape, so it is appropriate here, through attention should be paid to Parkington's cautions (1980, 1986) about cultural boundaries and the functions of the tools. Food-waste indicates what kinds of food resources were hunted and gathered. Lastly, models of settlement patterns proposed for different periods of the Holocene will be discussed.

3.1 PALAEOCLIMATE AND VEGETATION

There are a number of indicators of climate, vegetation and sea level changes. These indicators include pollen blown into caves, the size and range of small mammals caught and eaten by owls, the range of woody plants selected and large mammals hunted, fish and shellfish remains at Nelson Bay Cave and oxygen isotopes in stalagmites.

For much of the M.S.A, the climate surrounding Nelson Bay Cave was temperate and warm. Fine loamy textures of soils indicate that moist conditions were present (Deacon and Lancaster 1988). In the late-M.S.A, the climate changed, with frost occurring due to a temperature that was up to 10 °C colder than present. During the Last Glacial Maximum (LGM) about18 000 BP, the land to the south of Nelson Bay Cave was exposed; Nelson Bay Cave would have been 120 kilometres from the coast with open-air sites on the coastal plain (Klein 1974).

Soils were favourable for grasslands (Deacon *et al.* 1984; Deacon and Lancaster 1988; Deacon and Deacon 1999) while the diversity of plant species was low. Evidence for the presence of grasslands comes from the remains of giant buffalo (*Pelorovis antiquus*), giant horse or zebra (*Equus capensis*) and the giant hartebeest (*Megalotragus priscus*). A combination of effective hunting practices, climate and vegetation change caused the extinction of these grazers, at about 10 000 BP.

Evidence from marine mollusc shells using oxygen isotopes, indicates that a colder sea surface was present in the early Holocene (Shackleton 1973). Between 10 500 and 10 000 BP drier conditions occurred and the climate started to warm up. At 7 000 BP forests were established and expanding. Xylem analysis shows that by 6 400 BP thicket taxa like *Euclea/Diospyros* were established. Temperatures rose by as much as 2^0 C in the mid-Holocene (5 800 to 5 000 BP) (Cohen and Tyson 1995). Warmer conditions and higher temperatures lasted for the next 1 500 years.

At 2 000 BP conditions were still warm, but moist, while forests were retreating and the present vegetation pattern started to develop. Bushveld and False Macchia replaced forests. According to Inskeep, forests and fynbos, which would have included plant foods like *Watsonia* and other genera of *Iridaceae* would have been available to L.S.A people.

3.2 ARCHAEOLOGY OF THE ROBBERG PENINSULA

Much archaeological information was lost when uncontrolled excavations started on Robberg early in the twentieth century.

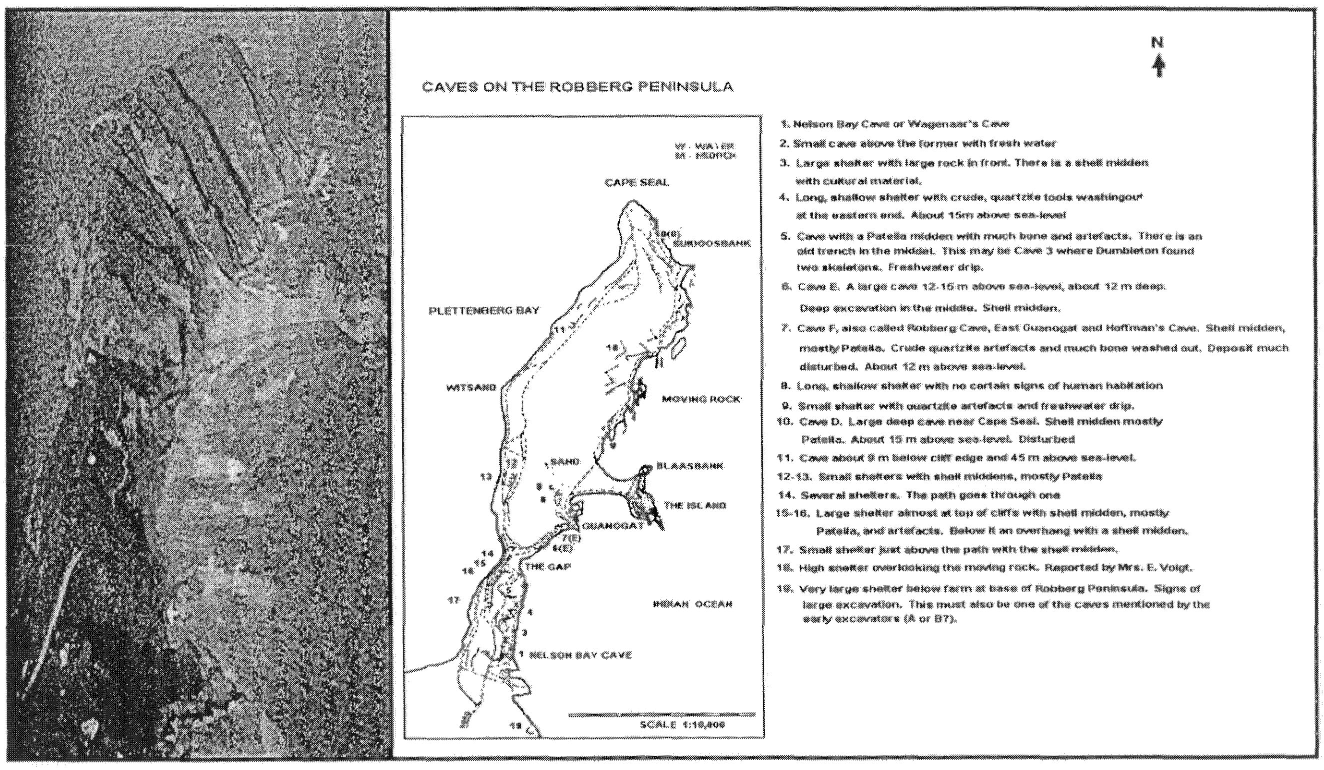


Figure 3.1: The Robberg Peninsula, showing 19 archaeological sites. (Obtained from Jacana 2000 and Rudner and Rudner 1973). (The white arrow indicates the location of Nelson Bay Cave).

In 1880, F. H. Newdigate drew the attention of workers at the South African Museum to the rich archaeological finds of Plettenberg Bay and the Robberg Peninsula. In 1908 Dr. L.Peringuey Director of the Museum, asked Mr. R. E. Dumbleton to investigate. Dumbleton reported five caves on the Robberg Peninsula, and he described the shell middens and human skeletons that he had found (Rudner and Rudner 1973) (see Figure 3.1).

Between 1908 and 1927, W.G Sharples and others sent about 48 human skeletons from the Robberg area to the South African Museum. He and other collectors forwarded about 18 painted stones, many of which were probably associated with the burials. Sharples found about 100 polished bone points on the eastern side of the Robberg Peninsula (Deacon and Michael 1993).

No stratigraphy or written records were kept of these finds. Farmers further damaged these caves when they collected "guano" from these sites. Controlled excavations began only in the mid twentieth century (Klein 1972a, b; Deacon 1978,1984 and Inskeep 1987). Inskeep first excavated at Nelson Bay Cave in 1964/5. He excavated mostly the Classic Wilton, the Post Wilton and the Pottery Wilton, i.e. deposits that were younger than about 6 000 BP (Inskeep 1987). (see Figure 3.3). Klein (1972a, b) excavated L.S.A deposits that included the Robberg, Albany and the Wilton industries during the two excavation seasons. Taken together, these investigations make Nelson Bay Cave one of the best-recorded archaeological sites in South Africa. The discussion below is limited to the L.S.A and especially the mid-to -late Holocene.

3.2.1 Nelson Bay Cave

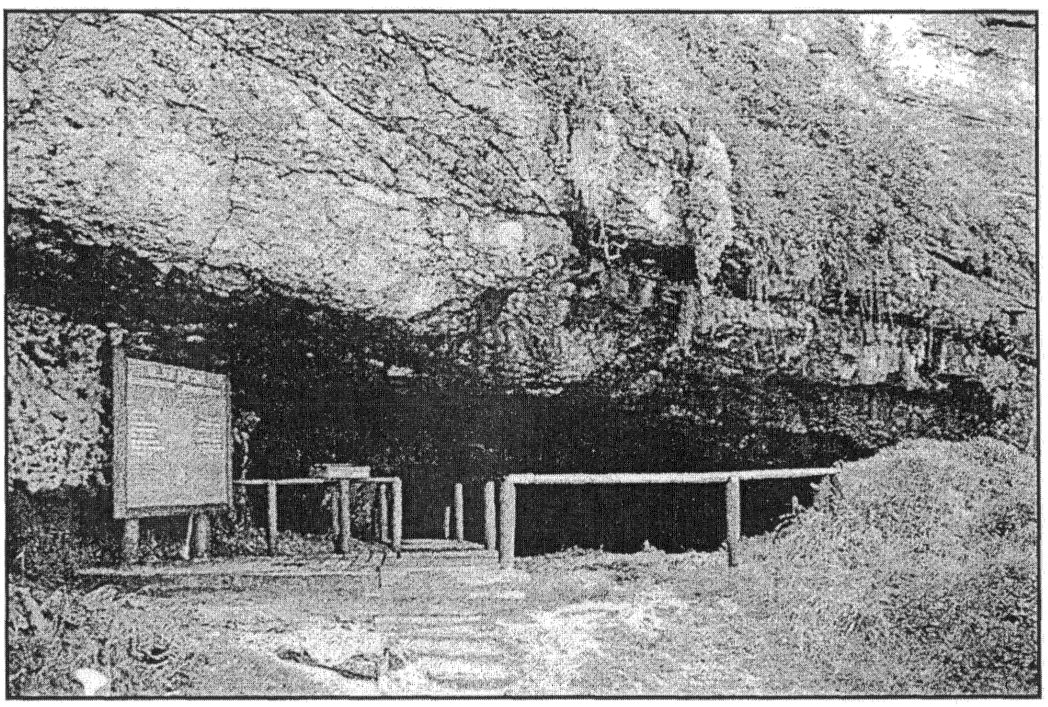


Figure 3.2: The entrance to Nelson Bay Cave (Jacana 2000)

Nelson Bay Cave is a large cavern, about 15 metres wide and 30 metres deep. The cave was formed in the breccia at the junction between quartzite sandstone of the Uitenhage Group (Cretaceous) and quartzite of the Table Mountain Group (Silurian) (Butzer 1973). (see Figure 3.2). The cave breccia was eroded by wave action when the sea level was higher than at present. Quartzite rubble formed from wave cutting; the rubble could also have come from the initial fissure, which opened the cave.

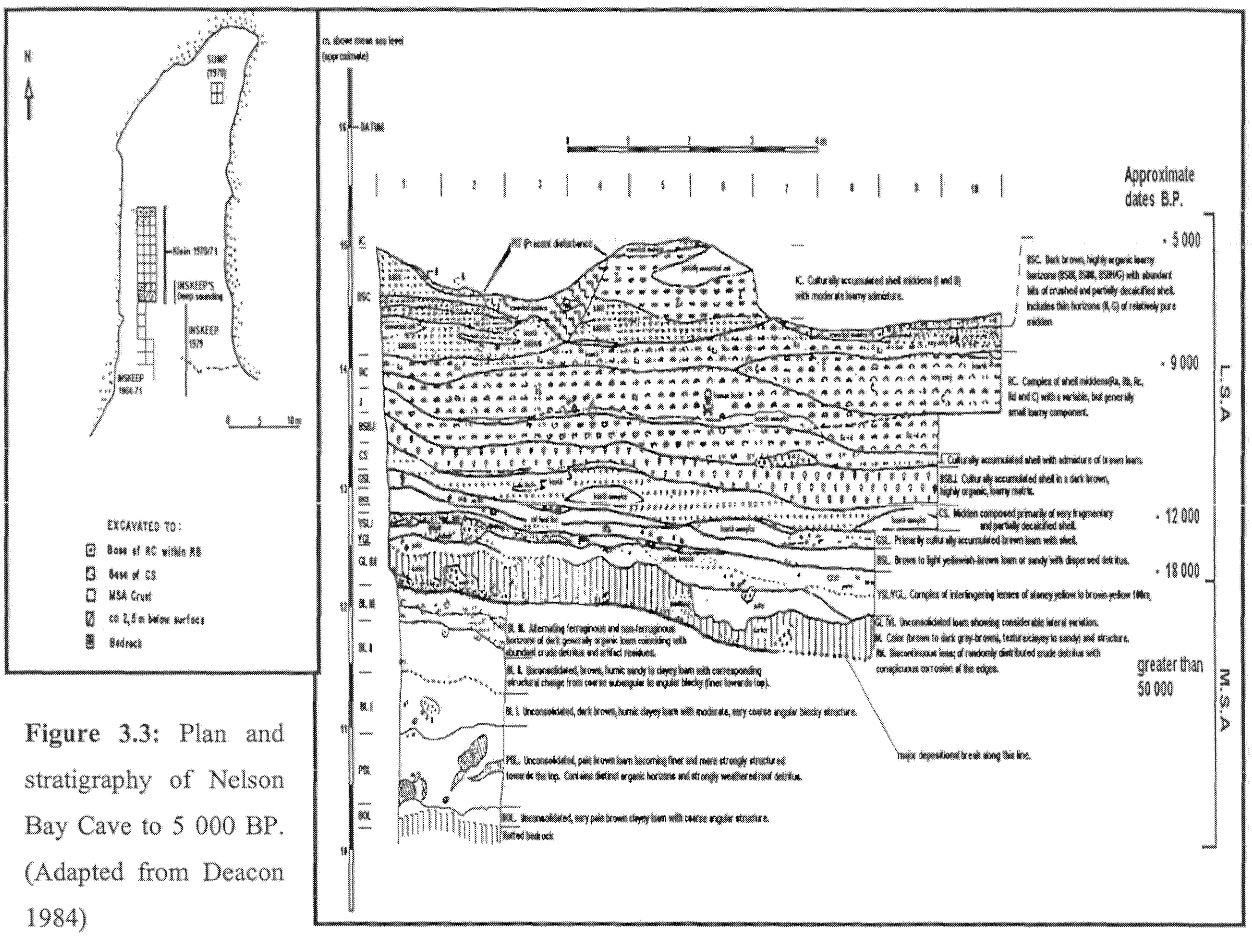


Figure 3.3: Plan and stratigraphy of Nelson Bay Cave to 5 000 BP. (Adapted from Deacon 1984)

The archaeology of Nelson Bay Cave is well-recorded (Klein 1972a, b; Deacon 1979, 1984, Inskeep 1987 and Deacon and Deacon 1999). In the L.S.A, the earliest industry is the Robberg, which is replaced by the Albany at about 12 000 BP. The Albany industry lasts until circa 7 000 BP, when it is replaced by the Wilton industry. At 3 300 BP this is replaced by the Post-Wilton industry. The last cultural period identified at Nelson Bay Cave is that associated with the presence of herders, from approximately 1 000 BP.

The Robberg industry

The Robberg Industry was named after the Robberg Peninsula, since it was first clearly identified at Nelson Bay Cave. This industry derives from the units Yellow Grey Loam (YGL), Yellow Stony Loam (YSL) and the Brown Stony Loam (BSL). This grouping of units is about half a metre thick (Klein 1972a, Figure 3.3). Two radiocarbon dates have been obtained from these units. Ostrich eggshell fragments from a test pit, at a level corresponding to YGL were dated to 18 660 ± 110 BP (GrN-5884) and charcoal from YSL to 16 700 ± 240 BP (I-6516) (Deacon 1984). Charcoal from the interface between YSL and BSL dated to 10 600 ± 150 BP (UW-218).

Lithics

Although considerable quantities of stone were recovered from these units, the number of formal tools recovered from these units is the lowest in the sequence (0.1 -0.2%). When formal tools are present they include backed bladelets and scrapers, but these are not standardized as in the Albany (Deacon and Deacon 1999). Miscellaneous retouched pieces, backed microliths and nine scrapers, with a mean length of 18mm, were found in these layers. Most stone tools are informal, with bladelets and bladelet cores the most regular component. These are the distinguishing features of the Robberg Industry. Quartz was the raw material preferred by the Robberg people.

Non-lithic artefacts

Non-lithic artefacts from Robberg levels include polished bone points, bone and ostrich eggshell beads, and tortoiseshell bowls or containers. Remains of ochre and engraved patterns on ostrich eggshell flasks indicate that decoration / art was already being used.

Food-waste

People at Nelson Bay Cave mostly had access to terrestrial foods. Terrestrial animal remains found in YGL and YSL include *Syncerus caffer, Taurotragus oryx, Hippotragus leucophaeus* and even some ostrich remains which indicate that grasslands must have been present. Remains of 39 *Procavia capensis* (rock hyraxes) were also found in these units. Plant material from these units is not preserved so we do not know what role plant foods may have played in Robberg times.

The Albany

The Albany was first identified in the Albany district of the eastern Cape, and includes all Smithfield" assemblages that were identified on stratigraphic grounds, as earlier than the Wilton (Klein 1974). It forms part of the Oakhurst Complex, in the terminology used by some researchers (Sampson 1970, Wadley 1997). This industry is characterised by large scrapers and adzes, which, in the southern Cape, are often made from quartzite. At Nelson Bay Cave the units that have yielded Albany material include Rice B (RB), Jake (J), Brown Soil Below Jake (BSBJ), Crushed Shell (CS) and Grey-Brown Shelly Loam (GSL) (see Figure 3.3). This group of units is approximately 1.2 to 1.9m thick. Twelve dates were obtained for this industry ranging from 11 950 ± 150 BP (UW-177) for charcoal from unit GSL (see stratigraphy) to 8 070 ± 240 BP (UW-181) for charcoal from Rice B (Deacon 1984).

Lithics

More than 90% of Albany artefacts at Nelson Bay Cave are manufactured from quartzite. Large scrapers and miscellaneous retouched pieces are characteristic of these layers (Deacon 1978, 1984). About 0.04 to 0.4 % of stone tools are retouched (Deacon 1984).

Non-lithic artefacts

A feature of this industry is the high frequency of polished bone points and bone tools (Deacon and Deacon 1999). Bone beads have been found in these layers, also ostrich eggshell beads and bone "fish gorges". These gorges seem to be restricted to the Albany.

Food-waste

The four categories of mammals give a clear indication that, by the end of the Albany, large grazers have mostly been replaced in the archaeological record by smaller antelope such as steenbok/grysbok. Rock hyrax also becomes much more common. (see Figure 3.4)

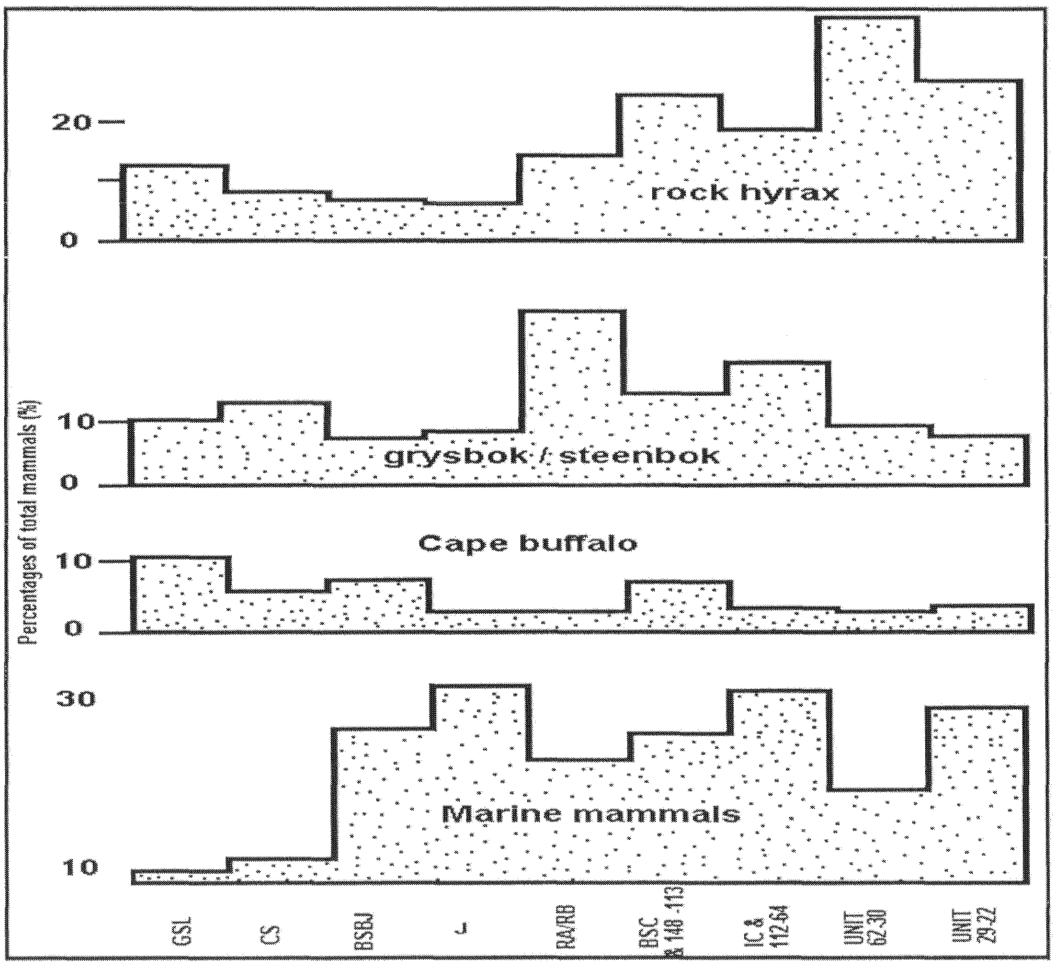


Figure 3.4: The four biggest categories of mammals from Nelson Bay Cave. (Inskeep 1987)

Due to rising post-glacial sea levels, marine foods make their first appearance in the Albany levels at Nelson Bay Cave. Seal and dolphin remains were found in these layers. In units GBS/CS *Choromytilus meridionalis* reaches 40 % of shellfish. This species is today restricted to the cold west coast of South Africa, and its presence at Nelson Bay Cave in the early Holocene may be indicative of water temperatures colder than those of today. It is later replaced by *P. perna*. One of the highest incidences of *P. perna* (more than 40%) occurs between units CS and RB in the Albany. For most of the sequence, the *Patella spp., P. perna* and *D. serra* are the only shellfish species that contribute more than 20% of the shellfish record (Deacon 1984). More than 80% of fish remains in these units come from the musselcracker (*Sparodon durbanensis*). Dassie fish (*Diplodus sargus*) are common in GSL, while Biskop *(Cymatoceps nasutus)* are more frequently found in the late Albany and Wilton levels (Klein-1972a).

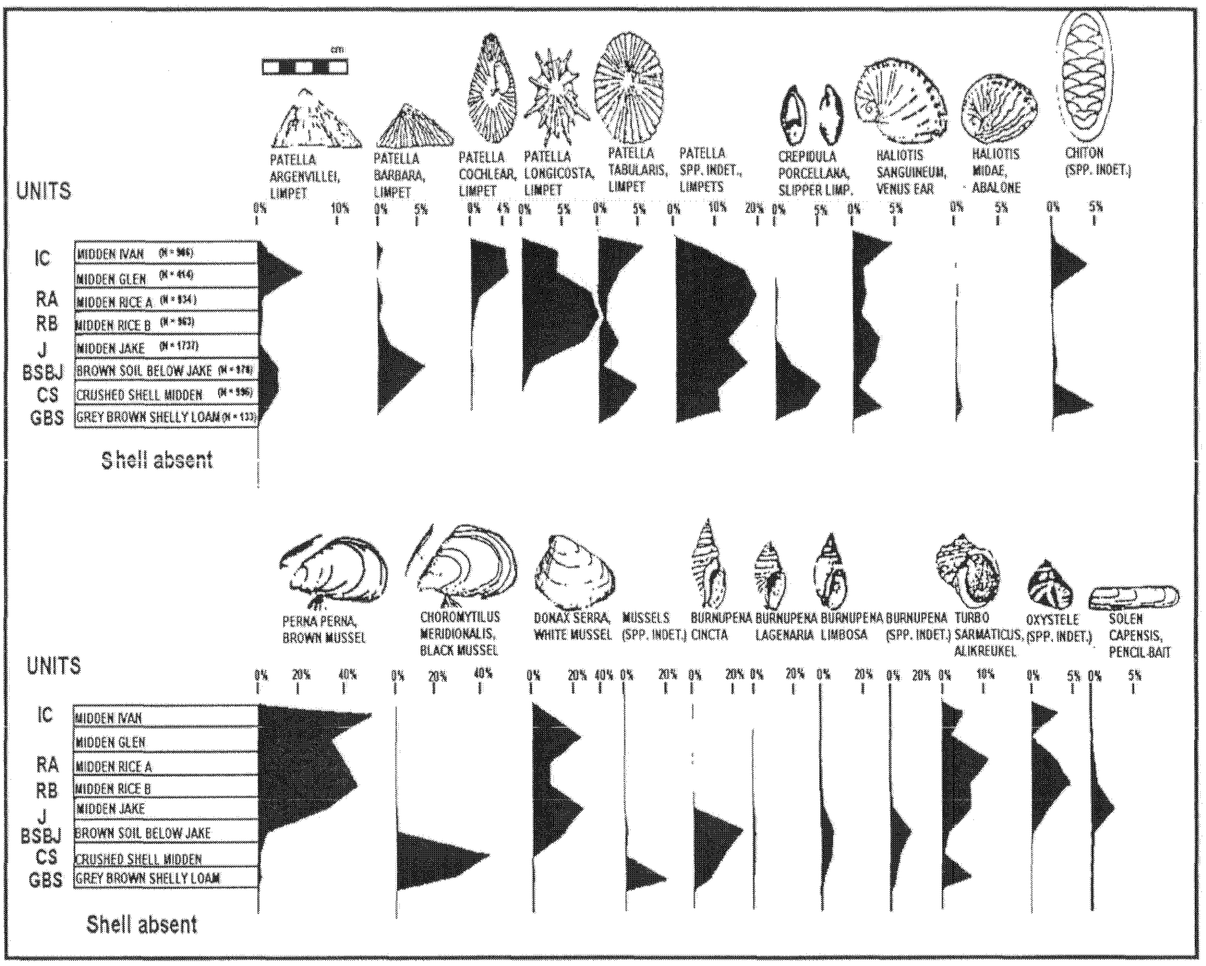


Figure 3.5: The percentages of shellfish species from Nelson Bay Cave from different early/mid Holocene horizons. (Klein 1972a)

The Wilton

Both Klein's and Inskeep's excavations yielded Wilton remains: Klein's units Rice A (RA), Brown Soil Complex (BSC) and Ivan Complex (IC) (including middens Ivan and Betty) and Inskeep's units 148 to 64.

Klein's six dates obtained for this industry range from 6 070 ± 125 BP (UW-222) for charcoal from unit Rice A to 4 860 ± 65 BP (UW-217) for the shell of *Patella* sp. from unit IC (Deacon 1984). A date of 9 080 ± 185 (UW-179), for Rice A, is anomalous and very likely wrong. Inskeep (1987) obtained a radiocarbon date of 5890 ± 70 (Pta-2909) for charcoal from his basal unit 148 named Xerxes. Material generally attributable to the Wilton was found right up to Inskeep's unit 64, dated 3 350 ± 60 BP (Pta-2910), although some change in artefact assemblages was noted at unit 135/134.

Lithics

In this period there is an increase in the production of formal tools. The proportion of formal tools reaches 2.5 % in IC, the highest in the sequence. Small scrapers, segments and backed pieces are relatively common in Klein's units BSC and IC, and Inskeep's units 148-105. Segments are restricted to units below 105, which is not precisely dated, but its age must lie between 4 520 ± 60 (Pta-2916), unit 78 and 5 860 ± 70 (Pta-2915), unit 129. It is interesting that backed scrapers occur in units 77-78, and may thus be younger than the segments. Backed tools therefore become an insignificant part of the formal tool assemblage before the major transition at unit 64 is reached. Small scrapers, however, remain important right up to unit 64 (see Table 3.1). The highest incidence of cores made out of chalcedony, silcrete and quartz in the whole lithic assemblage is found in these units. Silcrete and chalcedony are not available in the immediate vicinity of Nelson Bay Cave and must have been obtained from some distance away, possibly by trade or exchange. Between units 135 and 64, a large proportion of the formal tools is made from chalcedony (Inskeep 1987). This contrasts markedly with the greater importance of quartzite in units 148-135.

Non-lithic artefacts

Only two bone "arrowheads" have been found in the units 135-148 as opposed to 12 in units 134 to 64 (Inskeep 1987). A single ivory plaque was recovered from unit 104. 76 Ostrich eggshell beads were recovered from these units, together with oes fragments weighing 68.8g.

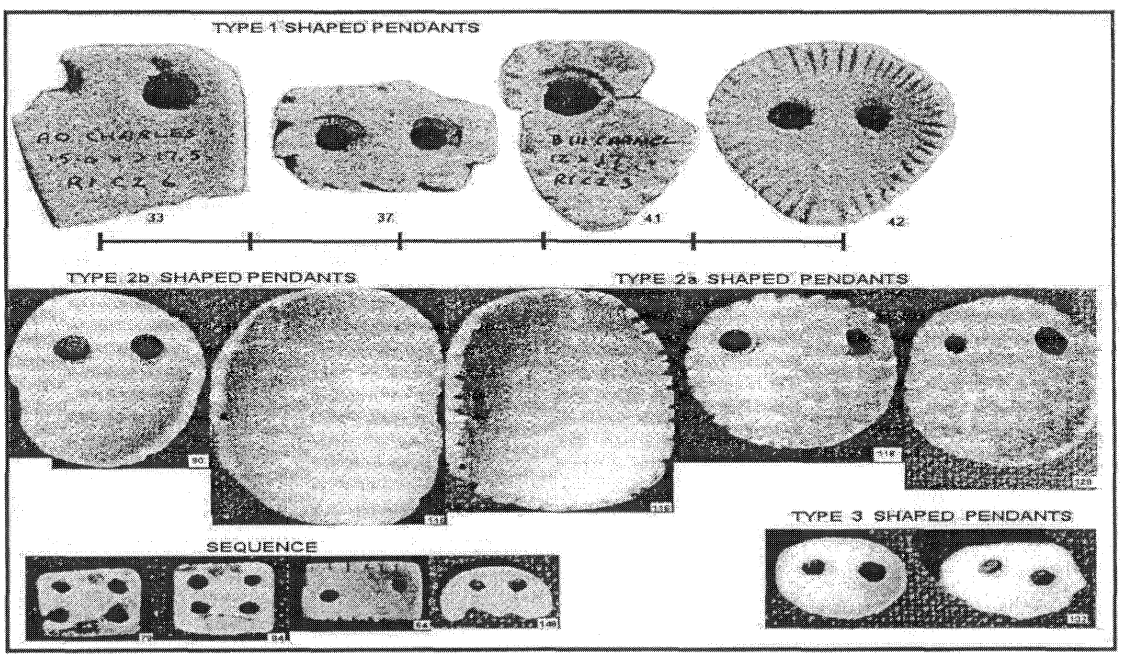


Figure 3.6: Different types of shell pendants from Nelson Bay Cave (Inskeep 1987)

A piece of decorated oes was found in unit 78 and a piece with a fine line on it in unit 120. Items of decoration include pendants made from marine shells. "Type 3" pendants have been recovered from below unit 105 (see Figure 3.6). These pendants are thin and wide; and mostly made from *Oxystele sinensis* and other smaller shellfish species. " Type 2a" pendants are oval, edge-nicked and made of nacreous shell. They have a prominent curvature. Six specimens were found in units 112 to 129. (see Figure 3.6). Six "Type 2b" pendants were found in units 90 to 143. These are like "Type 2a" pendants, but without nicks, these may be unfinished examples (Inskeep 1987).

Food-waste

Smaller browsing animals like grysbok, steenbok and bushbuck were increasingly caught at Nelson Bay Cave. A minimum number of 36 and 46 Cape fur seals for units RA/RB and IC have been identified, the highest for the whole sequence (Deacon 1984). The incidence of rock hyrax (*Procavia capensis*) and grysbok (*Raphicerus melanotis*) is the highest in these layers (see Figure 3.4). Smaller fish are caught, but with an increase in total number of species (Klein 1974). In units RA to IC *Patella*, *P. perna* and *D. serra* still dominate the shellfish assemblage. There is however a decrease in the *Patella* and *D. serra* remains in unit IC (Deacon 1984). Fish remains of species such as *R.globiceps* and *P.saltatrix* are the most common in these units. Seeds have been identified from five edible plants, which include *Watsonia spp.* and *Euclea racemosa.*

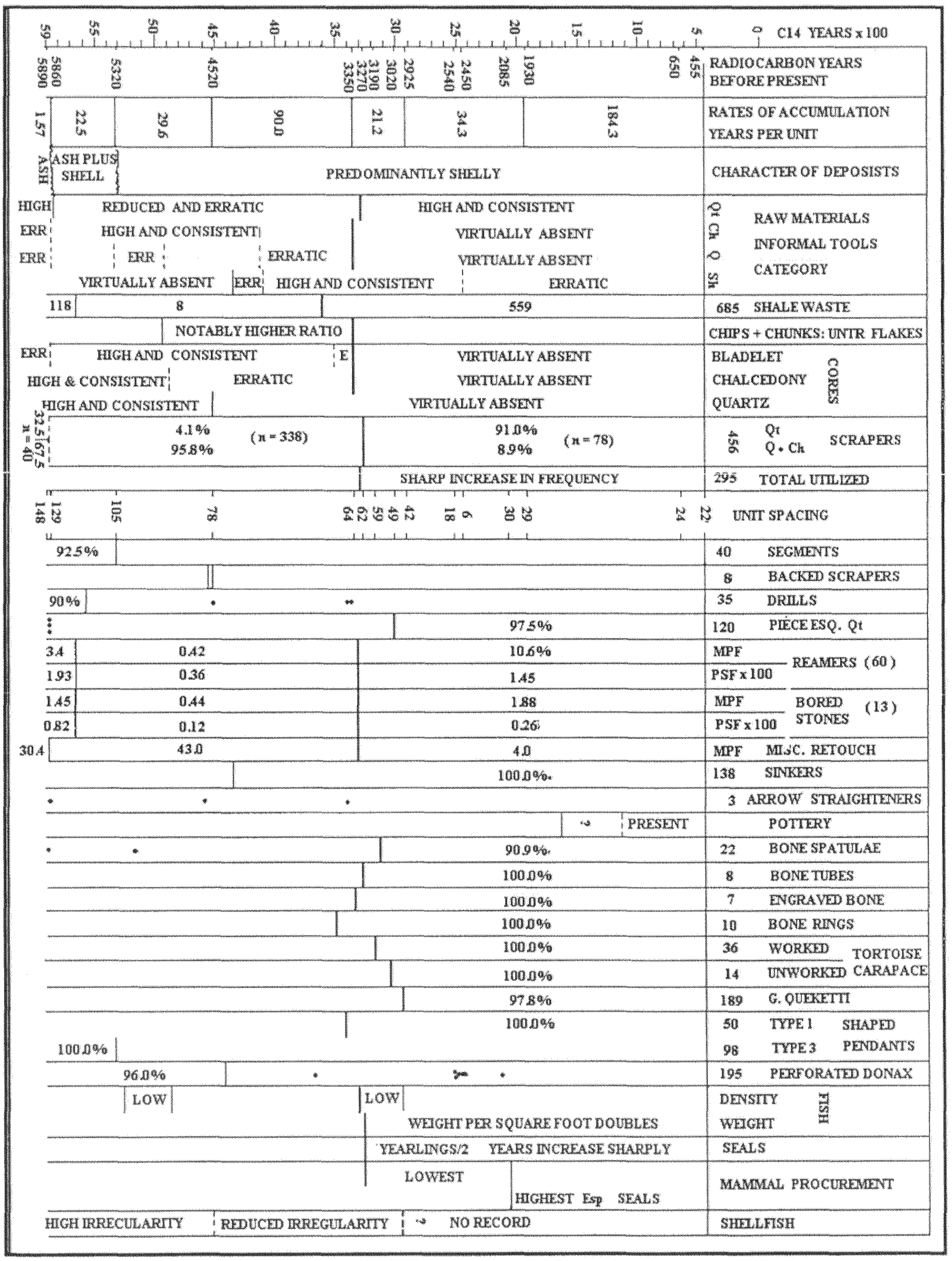
Human burials

Burial no. five is of an individual between the ages 13 to 16 years and is dated to 5 860 ± 70 BP. The sex is unknown and the skeleton is very incomplete. The burial was cut into units 132, 137, 138 and 140; and buried on its right side with the head to the south. 820 ostrich eggshell beads were recovered from the grave. To the west of the right humerus, fragments of a tortoise carapace bowl were found. Other grave goods included seven quartz crystals, ochre pencil, a hammerstone, half a grooved stone and some *P. perna* shells. Compared with the other five burials recovered by Inskeep (1987), burial five had the most grave goods.

The Post-Wilton

Inskeep excavated this material only towards the front of the cave. The oldest radiocarbon date obtained by Inskeep (1987) for the Post-Wilton came from layer 62 for charcoal dated to 3 270 ± 70 (Pta-3097). The youngest date was obtained from charcoal from Layer 22, dated to 455 ± 30 BP (Pta-1361). Within the Post-Wilton, the pre-pottery units 62 to 30 will be described separately from units 29 to 22, which contain pottery and sheep bones.

Table 3.1: A summary of changes in the archaeological record at Nelson Bay Cave at approximately 3 300 BP, from Inskeep (1987).



Lithics

From unit 62 to 30 locally available quartzite is again the predominant raw material, in conjunction with shale. Stone artefacts are generally informal, with far fewer scrapers than in units 148-64. There are very few backed pieces. Instead there are numerous quartzite piece esquillées, 138 stone sinkers were recovered after unit 64, and tanged points and smoothed shale "palettes" are a feature of these units.

Non-lithic artefacts

Bone work is very characteristic of the units above 62. Bone spatulas, engraved bone, bone rings, and worked tortoise bone occur in these units. Arrowheads and linkshafts are prominent in these units. Tortoise shell remains from unit 59 could possibly have been intended for the manufacture of bowls, perhaps, according to Inskeep (1987) as part of an exchange system between the coast and the interior.

All 50 "Type 1" shell pendants come from the Post-Wilton. (see Figure 3.6). These are similar in shape to "Type 2" described above, but were made from larger shells so that the curvature is less pronounced. In addition, pendants made from *Glycymeris queketti* shells are common in the Post-Wilton, but do not appear in older levels (see Table 3.1).

Food-waste

Initially, quantities of fish remains are low, but according to Inskeep (1987) the weight per square foot for fish doubles from unit 62 onwards. From the same unit (3 270 ± 70 BP) (Pta-3097) remains of seal yearlings and two-year-olds increase dramatically in the archaeological record. (see Table 3.1). The most common mammals were seals and hyraxes and a few larger animals like buffalo.

A detailed analysis of shellfish in the units above 43 is not available. However the pattern of shellfish remains in units 62-43 is broadly similar to that in the Wilton units, except that *P. perna and P. cochlear* seem to be consistently more common in the more recent levels. *P. perna* generally comprises over 50% of the shells. *P. cochlear* is the most abundant limpet, with other species present at lower frequencies. It is unfortunately not possible, on the evidence available, to assess whether shellfish remains are significantly more common above unit 64 than below.

Human burials

Only two burials will be discussed in this section since isotopic values were obtained from them. The other burials are those of infants or small children, whose isotopic values are not directly comparable to those of adults.

Burial Two

This female skeleton was found in the talus slope, and is estimated to be between 2 500 and 3 000 years old. This woman was probably between the ages of 32 and 52 at death. The skeleton was found in a flexed position, on its left side, with the lower legs drawn up to just below the femora. The only grave goods were large stones, recovered in the vicinity of the pelvis and the knees. One of the stones seems to have lain on the knees of the skeleton (Inskeep 1987).

Burial Four

This burial is probably slightly older than 3 300 BP, but its stratigraphic position may also be consistent with a rather older date. The skeleton is that of a male between the ages of 30 and 40. Preservation is good and the skeleton is complete. This body was buried on its right side and the feet drawn tightly up under the buttocks. The lower arms were bent, while the hands were brought up to rest on the left side of the skull. Inskeep (1987) raised the possibility that the body might have been wrapped in a kaross when it was buried, because it was so tightly flexed.

Grave goods recovered from this burial include 245 ostrich eggshell beads found near the thorax, indicating that they might have been worn around the neck. A type one shell pendant was found near the right hand side of the mandible, and a number of other pendants lay stacked behind and under the skull. A small bird carpo-metacarpus was found on either side of the temple. According to Inskeep (1987), these might have been used as adornments on either side of the head. Two large fish dentaries (*Sparodon durbanensis*) were found near the drawn-up knees of the skeleton.

The Pottery Post-Wilton

Pottery was found from unit 31 upward, but it is uncertain whether sherds from units 31-28 were in situ or not. Pottery from unit 27 is probably fairly securely associated with the level from which it came. The dating of this part of the sequence is confusing, with dates of 2 950 ± 80 BP (Pta-1485) for unit 31, 2 085-± 35 BP (Pta-1363) for unit 30, 1 930 ± 60 BP (GrN-5703) for unit 29, and 2 560 ± 60 BP (Pta-3363) for unit 28. A conservative interpretation of these dates can do no more than conclude that the pottery is likely to date to within the last 2 000 years, as at other sites along the western Cape coast. Pottery is scarce at Nelson Bay Cave: "The entire weight of pottery for a period of at least 1 000 years, equals that of one small pot!" (Inskeep 1987:156). Most potsherds were plain, with decoration only on one rim sherd and two body sherds. No lugs were recovered, and only one possible spout.

Lithics

Stone artefacts in the pottery layers at Nelson Bay Cave are similar to those in the pre-pottery, post-Wilton levels, but formal tools become even more uncommon. Informal quartzite and shale artefacts dominate the assemblage.

Non-lithic artefacts (Other than pottery)

"Type 1" shaped shell pendants and *Glycymeris* pendants were found, as in units 62-30. Both worked and unworked tortoise carapace was recovered from these units. Two examples of engraved bone were found in units 28 and 34 and bone splinters in unit 22, varying from 35 to 58mm long. Some polish was noted on one of the splinters: Inskeep (1987) suggested it could have been used for fishing.

Food-waste

The oldest sheep bone at Nelson Bay Cave, from unit 29, has been directly (ams) dated to 1 100 ± 80 BP (OxA-873). Unit 29 is dated to 1 930 ± 60 BP(GrN-5703), so this finding shows that the specimen had moved downwards through the deposit from a younger level. A minimum of ten sheep bones have been identified from units 29, 27, 24, 23 and 22. Others may be represented in the category of small/medium bovids. Sheep are present in fairly small numbers, however, so that Inskeep has suggested that they might have been obtained by hunter-gatherers through capture or barter from pastoralists (1987). Fish and seal remains are abundant in units 31-22, as in the pre-pottery Post-Wilton. Shellfish counts are not available.

3.3 THE ARCHAEOLOGY OF MATJES RIVER ROCK SHELTER.

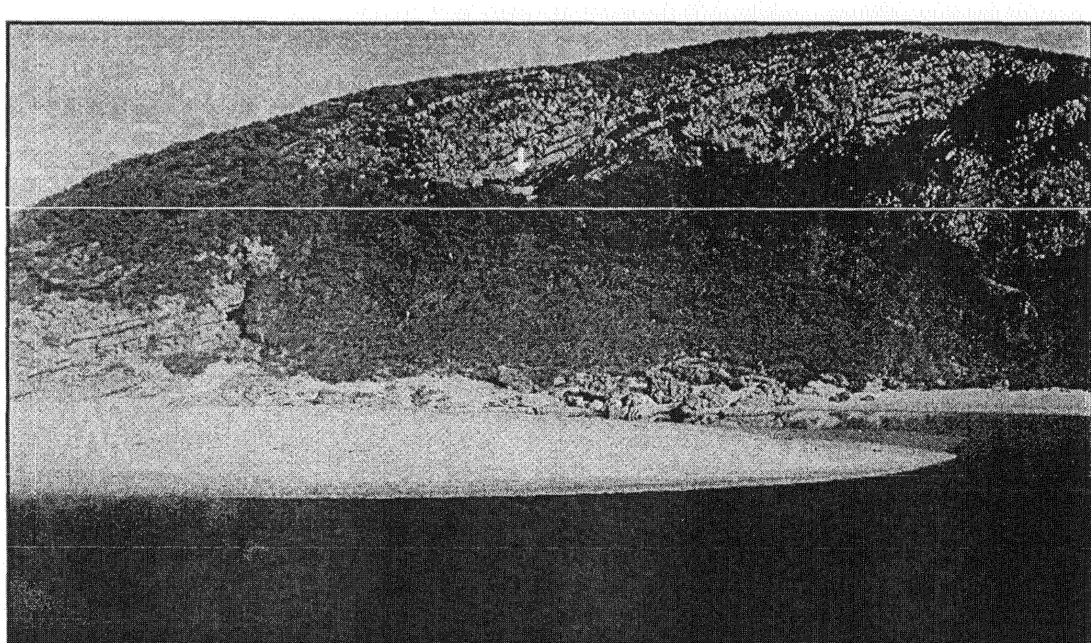


Figure 3.7: Matjes River Rock Shelter on the western bank of the Matjes River. (photo: Fiona Clayton)
(Arrow shows position of the site)

Matjes River Rock Shelter is an overhang, 45m above sea level and faces eastward. The small Matjes River is directly below the site. (Figure 3.7) Common rocks in the area are shales and sandstone from the Table Mountain Group. The site is close to both rocky and sandy shorelines. The first excavations at this site date back to the 1920's and it has yielded the largest number of human burials (over 100) recovered from a single site in southern Africa (Inskeep 1986; Morris 1992). Unfortunately, due to poor excavation, curation and record keeping most of the material has been lost. Human remains from this site are fragmented and the exact context from which most of the burials come is uncertain.