# SEA SHELLS ASHORE

## A Study of the Role of Shellfish in Prehistoric Diet and Lifestyle at Eland's Bay, Southwestern Cape, South Africa

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## ABSTRACT

The primary aim of this research is to assess the role of shellfish in prehistoric diet and lifestyle with specific reference to the numerous archaeological sites in the vicinity of Eland's Bay (18°19'E 32°19'S). To give a wider regional context, available data on seven other sites along the southwest coast of South Africa have been included. The quantification, analysis and comparison of the faunal data from all these sites have proved informative on the adequacy and balance of prehistoric coastal diet and on aspects of human ecology and behaviour.

Based on site faunal analyses, the proportionate contributions to prehistoric diet of mulluscan and non-molluscan foods were calculated and compared in terms of their respective calorific and nutritional values. The reconstructed diet, when examined against modern standards and estimates of group numbers and time spent in the area, appears to have been adequate for human needs in energy and nutrition and reflects the high productivity of this coastal region and the ecotonal characteristics of the Eland's Bay situation at the junction of land, sea and estuary. The absence of signs of over-exploitation and the pattern of site locations adjacent to resource availability suggest that, despite population growth, the carrying capacity of the environment was never strained.

By quantifying and comparing calorific values of shell-fish remains in sites with the available biomass on the rocky shores at Eland's Bay and having regard to the ecology of the major species exploited, this analysis demonstrates that prehistoric groups while in this area may have been dependent on shellfish as a daily staple to the extent of one-third or more of total food intake (though rather less at other sites on the southwest coast), that the tactics and timing of gathering were consistent and cost-efficient and that shellfish exercised a significant influence on site location, foraging strategies, settlement and mobility patterns and responses over time to changing conditions.

A review of the two current models of seasonal mobility against the latest evidence in this report tends to support Parkington's hypothesis of coastal/inland seasonal movement perhaps as late as 1800 BP when pottery and domestic stock first appear and at the same time signs of disruption of the economic and social system. For the final post-1800 BP phase, Sealy's alternative hypothesis of 'strandloping' now seems the more plausible.

The research has generated hypotheses which require testing by further research with more refined techniques of analysis. Its conclusions are necessarily tentative and, in view of the high productivity of the marine/estuarine environment, may not be relevant to shell middens along other continental coastlines where marine/estuarine productivity differs.

## PREFACE

Archaeology is still regarded by many as the study of bones and stones from man's past; few are aware of the vast extension of its scope over the last two decades or the expansion in its network of intimate liaison with other disciplines. In this study, I have little to say about bones and even less about stones but, in exploring aspects of prehistoric shellfish exploitation, I have ventured into many non-archaeological fields. In doing so, I have enjoyed the unstinted co-operation and invaluable guidance from many colleagues named in the text and many more unnamed - to all of them I record my grateful thanks. Among the authors whose publications are cited, I am particularly indebted to Professor Geoff. Bailey and Dr Betty Meehan whose comprehensive and innovative studies of prehistoric and modern shellfish gatherers have given me many ideas.

This project would not have been possible without the willing and able help of many others - Jim Jobling and Tim Hart in the field, Royden Yates in analyses of samples, Ken Behr in helping to produce Figure 3.1 out of some 20 $m^2$ of student maps, Shirley Smith who drew the other figures, Jeanette Wood for a major exercise in typing and to my colleagues of the Spatial Archaeology Research Unit for many stimulating discussions - my thanks to all of them. The radiocarbon dates kindly provided by Dr John Vogel of the C.S.I.R. have proved of major importance. The discussion of diet and nutrition has had the benefit of scrutiny by Professor W. Gevers.

This exercise was initiated by John Parkington to answer a deceptively simple question; as its scope had to be expanded, his guidance, enthusiasm and perennial flow of ideas have been my major source of inspiration.

The generous financial assistance rendered by the Human Sciences Research Council and the Harry Oppenheimer Institute for African Studies towards the cost of this research is gratefully acknowledged. Opinions and conclusions expressed in this study are solely those of the author.

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# CHAPTER 1

## INTRODUCTION

Since 1968, the Eland's Bay area with its hinterland (Figures 1.1, 1.2 and 1.3) has been the subject of archaeological and multi-disciplinary research that in scope and intensity has been exceptional in the context of African Stone Age archaeology. The initiation and co-ordination of this rapidly expanding programme of research has been primarily the work of John Parkington. Archaeological activities have included the excavation of inland and coastal sites (Parkington & Poggenpoel 1971; Parkington 1976a and 1976b; Horwitz 1979; Robey 1984), analyses of stone artifact assemblages and their distributions (Pettigrew 1977; Sievers 1977; Thackeray 1977; Mazel 1978; Manhire et al. 1983; Kaplan & Kaufman 1983; Yates 1983; Manhire 1984), the implications of fish bone assemblages (Poggenpoel n.d.) and of fish otoliths (Patrick 1984), rock art studies (Maggs 1967; van Ryssen 1980; Manhire 1981; Maggs & Sealy 1983; Manhire et al. 1983; van Ryssen n.d.; Golson n.d.), seasonal mobility (Parkington 1972; 1976a; 1976b; 1981), dietary assessments (Rawlinson 1982; Sealy 1984; Sealy & van der Merwe n.d.) and the historic and ethnographic record (Parkington 1977 and n.d.). Research by colleagues

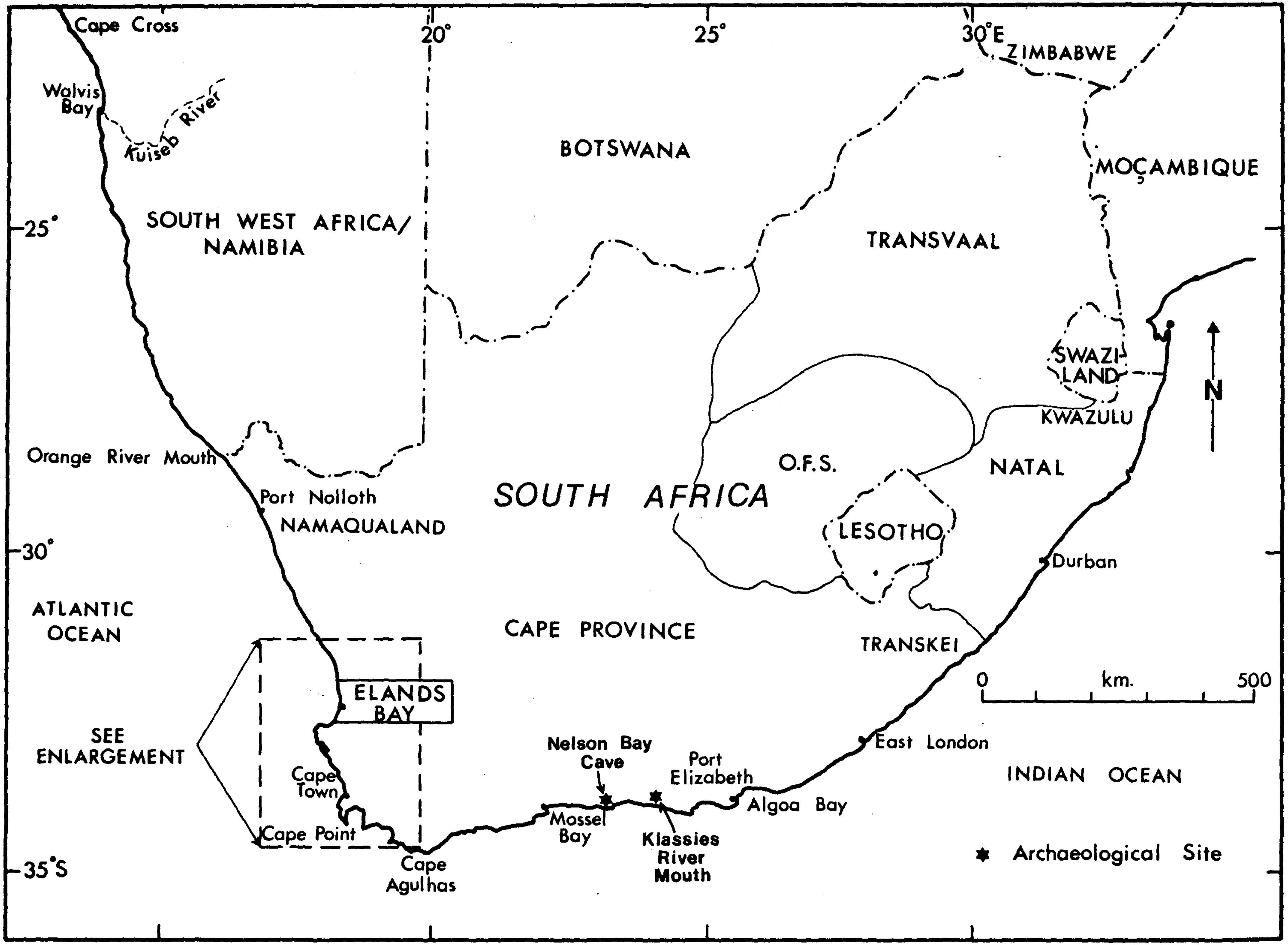

Cape Cross
20°
25°
30°E
ZIMBABWE
Walvis Bay
Kuiseb River
BOTSWANA
MOÇAMBIQUE
-25°
SOUTH WEST AFRICA/ NAMIBIA
TRANSVAAL
SWAZI-LAND
N
KWAZULU
Orange River Mouth
O.F.S.
NATAL
Port Nolloth
SOUTH AFRICA
NAMAQUALAND
LESOTHO
-30°
Durban
ATLANTIC OCEAN
CAPE PROVINCE
TRANSKEI
0 km. 500
ELANDS BAY
SEE ENLARGEMENT
Nelson Bay Cave
Port Elizabeth
East London
Cape Town
INDIAN OCEAN
Mossel Bay
Algoa Bay
Cape Point
Klassies River Mouth
Archaeological Site
-35°S
Cape Agulhas

Figure 1.1

2

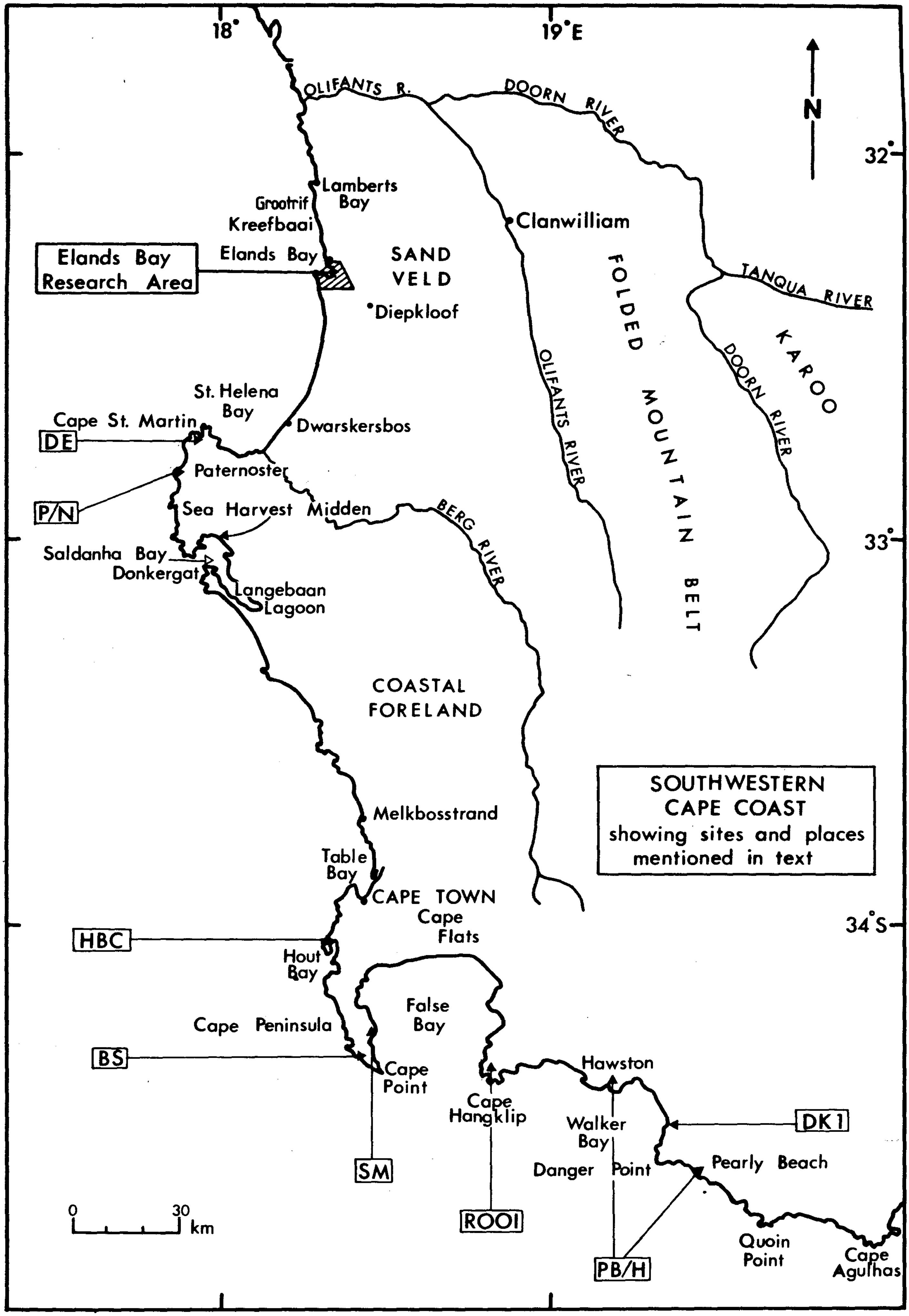

18°
19°E
N
32°
33°
34°S
OLIFANTS R.
DOORN RIVER
Lamberts Bay
Grootrif
Kreefbaai
Clanwilliam
Elands Bay Research Area
Elands Bay
SAND VELD
TANQUA RIVER
Diepkloof
FOLDED MOUNTAIN BELT
KAROO
DOORN RIVER
OLIFANTS RIVER
St. Helena Bay
Cape St. Martin
Dwarskersbos
DE
Paternoster
P/N
Sea Harvest Midden
BERG RIVER
Saldanha Bay
Donkergat
Langebaan Lagoon
COASTAL FORELAND
SOUTHWESTERN CAPE COAST
showing sites and places mentioned in text
Melkbosstrand
Table Bay
CAPE TOWN
Cape Flats
HBC
Hout Bay
False Bay
Cape Peninsula
BS
Cape Point
Hawston
Cape Hangklip
Walker Bay
DK1
Danger Point
Pearly Beach
SM
0
30
km
ROOI
PB/H
Quoin Point
Cape Agulhas

Figure 1.2

# SUBDIVISION OF SITE AREAS AND SHORELINE SECTORS AND LOCATION OF IMPORTANT SITES

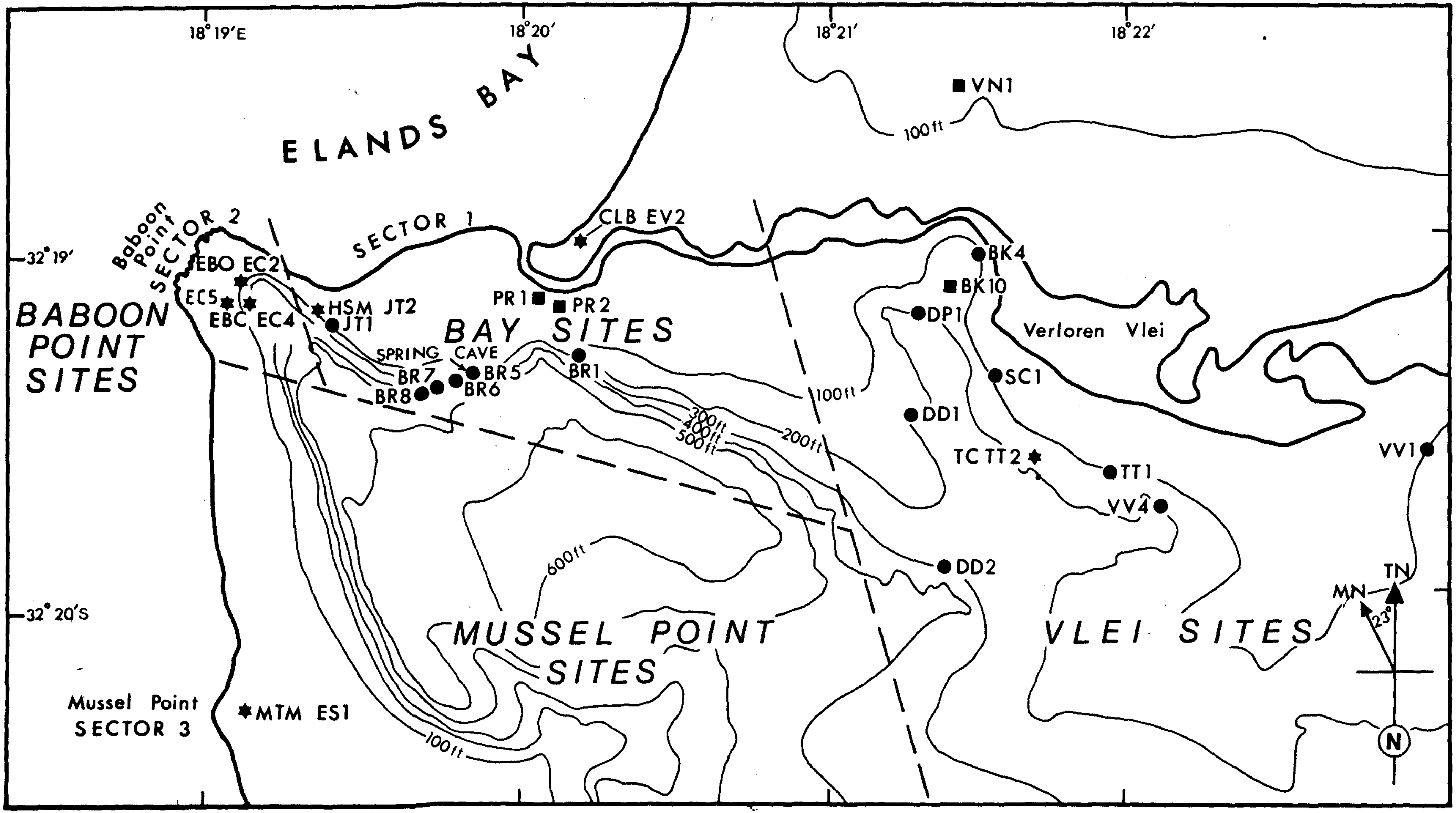



Figure 1.3

of other disciplines has included environmental studies (Robertson 1980; Sinclair 1980; Grindley n.d.), geo-archaeology (Butzer 1979; Miller 1981 and n.d.), the dynamics of deflation hollows (Lancaster n.d.) and the historical record of the contact period in the area during 1700 to 1740 (Penn n.d.).

An omission from this list is shellfish although all coastal sites in the area are shell middens. Analyses of shell remains to date have proved fruitful in generating hypotheses but the techniques of analysis and interpretation have in recent years reached a plateau; data have been wrung dry and little more can be extricated by present methods yet some important questions remain unanswered. We cannot say with any degree of certainty how important shellfish were to the prehistoric occupants of the area in terms of diet, foraging strategy, site location or mobility. This study was therefore initiated as an attempt to extend the present horizon, especially for the period from 1800 to 300 BP characterised by the presence of pottery. The more specific aims of the study were to :

- assess the energy and nutritional value of molluscan and non-molluscan food debris in coastal sites in order to gauge their relative importance to the consumers;

- assess the adequacy in quantity and quality of the diet;

- investigate the potential of molluscan data as a source of insights and inferences on prehistoric behaviour and environment;
- compare in broader perspective conclusions with results from earlier periods and from other sites along the southwestern coast.

South African shellfish studies owe much to the pioneer research of Elizabeth Voigt (formerly Speed) (Maggs & Speed 1967; Voigt & Bigalke 1973; Voigt 1975), to John Parkington (1972; 1976a; 1976b; 1981) and to the first systematic investigation of open station shell middens by Graham Avery (1977). Subsequent studies have adopted the lines of investigation, techniques of analysis and format of reporting originally formulated by these authors. Avery's work included a comprehensive review of the historical and ethnographic evidence on shellfish exploitation and among the innovative features was a comparison of shellmeat mass per cubic metre of deposit (1977: Table 8, 132) which has been adopted in modified form in this study.

Analyses of shell middens along other continental coastlines have produced a wide range of interpretations. Meighan (1969: 415) refers to "the past existence over most of the world of a type of culture dependent on shellfish as a staple food". Bailey (1975: X, 2) refers to the differences in interpretations of the importance of shellfood as a resource of minor significance to a major and occasionally dominant food supply and attributes them to the use of different methods of analysis and the biases inherent in the various forms of data; but from his excavations and a worldwide review of midden studies he concluded that shellfish have such a low economic potential as to exert little, if any, influence on the size of coastal populations or the location of their sites or settlements. The problem of interpretation is often compounded by the critical lack of precise data (Biggs 1969: 423); and parameters determined on the shellfish of a specific coastline may be misleading if applied elsewhere and inadequate as a basis for general conclusions on the role of shellfish - for instance, the use by Osborn (1977) of data from Cook (1946) without testing whether the minimal size and extraordinarily low protein content of Cook's Californian mussels are characteristic of mussels on the shores of Peru or elsewhere. Meehan (1982: 6-7) has commented on the dearth of data on shellfish-gathering and the curious bias in the archaeological literature against both shellfish and shellfish eaters. These views carry important implications for this study.

This report is one of four research projects initiated at the same time - Robey's excavation of Tortoise Cave (1984), Manhire's analysis of sandveld sites (1984) and Sealy's stable carbon isotope analyses of human bones from prehistoric burials and the associated food webs (1984). The prehistory of the area is now beginning to take more definite shape and to confirm the series of occupational phases originally proposed by Parkington (1976a) from which he has since formulated his theory of 'dynamic equilibrium' (pers.comm.) - solely terrestrial food debris from about 25 000 years ago replaced ca. 10 000/9 600 BP by terrestrial/marine remains which are present for another 2 000 years after which the area was abandoned until about 4400 BP; there is evidence from only two caves for the period from 4400 to 3000 BP but the general pattern shows little material change as a result of the break in occupation; from 3000 to 1800 BP caves were little used and activities concentrated on one large open site to exploit the rich mussel resources now becoming available as a result of receding seas; ca. 1800 BP pottery first appears and somewhat later sheep bones, the number of sites increases more than tenfold and tend to be oriented on or near the hills and deposits show signs of being mostly ephemeral. While this study is primarily concerned with the last phase from 1800 BP to 300 BP, discussion will touch on aspects of the earlier periods which led up to it.

For South African coastal archaeology this study is a venture into a comparatively new field. Assumptions have proved essential to progress at several stages in the project but further research should provide a broader data base and a refinement of techniques of analysis to give a more secure foundation for inference and interpretation. While I have endeavoured to be explicit on basic assumptions and the processes of analysis, the validity of the conclusions is necessarily a function of the validity of these assumptions and processes. We can on good authority assume that human energy needs, nutrition and physical capability have varied little if at all over the past 10 000 years, but we may never know, for instance, how much prehistoric food debris has been lost without trace or how much shellfish eating took place off-site.

Shellfish being the main subject of this research, a resume of the ecology of the major food species found along the shores of Eland's Bay is first given in Chapter 2. Thereafter, the methods used for surveys and sampling are described in Chapter 3 and the techniques and results of evaluating energy yields from archaeological food debris and their use in reconstructing prehistoric diet are outlined in Chapter 4, with an examination of this diet against known human needs in Chapter 5. Patterning in radiocarbon dating is discussed in Chapter 6, followed by the problems associated with a massive atypical midden MTM in Chapter 7, insights and inferences to be derived from the shellfish analyses in Chapter 8 and seasonal mobility models in Chapter 9. Chapter 10 relates the findings and conclusions with the original aims of the research.

# CHAPTER 2

## SHELLFISH ECOLOGY & ARCHAEOLOGICAL IMPLICATIONS

### 2.1 DOMINANT SPECIES

The common experience in studies of modern and prehistoric shellfish gathering has been that only a few dominant species of marine bivalves and gastropods contribute a material proportion to food intake (Ascher 1959; Bailey 1975: II, 2; Meehan 1982: 69; Tregoning & van der Elst n.d.; Siegfried *et al*. n.d. among others).

Analyses of shellfish samples from middens in the research area of Eland's Bay have similarly demonstrated that, as food items, only the following species need be considered :

| | |
|---|---|
| Limpets | *Patella granatina* (Linne 1758) |
| | *Patella granularis* (Linne 1758) |
| | *Patella argenvillei* (Krauss 1848) |
| | *Patella barbara* (Linne 1758) |
| Mussels | *Choromytilus meridionalis* (Krauss 1848) |
| | *Aulacomya ater* (Molina 1782) |
| Whelks | All species |

Other species present in samples can be ignored on account of rarity (e.g. the infratidal limpets *P. miniata* and

P. compressa, the limpet P. cochlear which is at the extreme northern limit of its range at Eland's Bay, and the white sand mussel Donax serra) or of miniscule size or low caloric yield and often brought to a site on the backs of other shells (e.g. the slipper limpet Crepidula porcellana and Balanus spp. - barnacles). This concentration on a few species only is supported by biological evidence (Rebelo 1982) that these species comprise virtually all of the shellfish biomass on the rocky shores at Eland's Bay.

An account of the ecology of shellfish can thus be restricted to these dominant species and the marine environment which they inhabit.

## 2.2 THE BENGUELA CURRENT

The slow-moving nutrient-rich Benguela Current which flows up the Atlantic coast of Southern Africa is of crucial importance to the marine fauna and flora of the area. The current originates partly from the subantarctic great gyral current and partly from the West Wind Drift of the 'Roaring Forties' which travels west-east; as the northern part encounters the tip of the African continent, the flow is deflected northwards along the coast and upwards into the shallower waters. Coriolis forces due to the rotation of the earth further deflect the surface waters away from the shore and deep cold water must rise up to replace it.

This upwelling process is reinforced in a way that is unique to this region - the prevailing southerly to southeasterly winds mainly in spring and summer induce off-shore transport of surface waters and their replacement by cold water from below. Since the air travelling from the cold sea to the hot land will not yield its moisture, the Atlantic coast is semi-arid to arid and coastal fogs are frequent. Upwelling is, however, a complex phenomenon for which the governing mechanisms are still the subject of research (Jury 1981: 299).

Upwelling waters rise from depths as great as 100 to 300 m and carry an abundance and diversity of nutrients which have been transported from the south below the euphotic zone where light does not penetrate and photosynthesis by phytoplankton and use of these nutrients is thus precluded. Upwelling is primarily responsible for the high fertility of marine fauna and flora of this region which ranks among the most productive areas of the world (Stander 1969: 656).

Sporadic upwelling produces other effects. While sea temperatures along the Atlantic coast tend to be fairly constant throughout the year within the range 18°C to 8°C with an average of 12°C, the water is generally colder in summer than in winter and temperature can fluctuate drastically from day to day; a drop from 17°C to 8°C was recorded over a seven-hour period which could stun some species. At other times, the prevailing winds of winter from the north and northwest can drive in warmer surface waters from off-shore or the warmer east coast Agulhas Current may encroach into the Benguela region, causing the temperature to rise to as high as 23°C, with resultant mass mortality of cold water fauna. It has been recognised that the Benguela region is 'noisy' and that its fauna is adapted to variation (Allanson 1984: 51). A wide faunal tolerance to changes in physical conditions might thus restrict the scope for archaeological inferences from molluscs regarding palaeoenvironments. A further consequence relevant to the diet of shellfish gatherers is that species living in unstable environments where the food supply can vary greatly in abundance, tend to store energy not only as fat but also as carbohydrate, an order that is reversed in some large and small molluscs, and the high glycogen level in molluscs has long been recognised (Griffiths 1977). Molluscs are thus among the few foods of animal origin that produce carbohydrates in addition to protein and fat.

## 2.3 MOLLUSCS AS PALAEOENVIRONMENTAL INDICATORS

Molluscs have been referred to as the most obvious group for evidence of palaeoecological conditions (Grindley 1969: 153) and as potential sources of information on marine palaeoenvironments (Voigt 1972: 93; Voigt & Bigalke 1973: 4), yet such inferences from the archaeological record of molluscs have been rare; some of them are cited (Table 2.1, p.27). Farrand commented on Strauss _et_ _al_. (1981: 676) that

> "much information is presented on the fauna of La Riera, especially molluscan and mammalian, including detailed tables of percentages and measurements, but essentially nothing is done with these data from a palaeoecological point of view".

The real potential of the molluscan data from the Holocene middens of the southwestern Cape lies in such fields as food preferences and foraging strategy rather than as indicators of palaeoenvironments. Conditions essentially similar to modern conditions were established at the Cape as long ago as 8 000 BP (Klein 1974: 274), although at Eland's Bay there was a period of hyper-aridity (Parkington 1980) and an absence of hunter-gatherers from the area from about 7 800 to 4 400 BP (Parkington 1976a; Robey 1984). Nevertheless, a more detailed probe into relevant aspects of molluscan ecology is required to assess the supposed potential of archaeological molluscan data as sources of palaeoenvironmental information.

## 2.4 SHELLFISH ECOLOGY

### 2.4.1 Introduction

Fortunately, a great deal is known about the biology of South African west coast limpets through the researches of Branch (1971; 1974a; 1974b; 1981) on which I have drawn for much of this chapter; I have supplemented it by information on the black mussel from Griffiths (1981) and on shellfish generally from Kilburn and Rippey (1982). A real life situation of molluscan distribution, zonation, density, biomass and size derived from sampling the rocky shores of Eland's Bay is given in Appendices S.1, S.2 and S.3 (p.347/353).

### 2.4.2 The Marine Environment

The southwest coast is very exposed with few sheltered bays or lagoons and no large off-shore islands to break the force of ocean swells. The continental shelf off this coast is 50 to 80 km in width with depth in some places up to 400 m. Vertical tide range is 1,8 m at spring tides but only 0,5 to 0,6 m at neap tides; the upper levels are thus submerged and the lower levels exposed only during spring tides. The prevalence of coastal fogs enables limpets to continue feeding when they would otherwise be immobile. Salinity is about 35 parts per mille but in rock pools may be concentrated by evaporation or diluted by rainfall.

### 2.4.3 Zonation Patterns

A gradient in the physical stresses experienced by molluscs can be recognised from their zonation pattern :

- the Littorina zone, between high-water neap and high-water spring, is washed only during high spring tides or stormy seas; the tiny snail *Littorina knysnaensis* is practically the sole inhabitant of this zone;
- the Balanoid zone, between high and low neap tides and thus covered and uncovered daily, forms a major part of the intertidal zone and supports large numbers of limpets; biologists distinguish an Upper Balanoid with mainly animal populations and a Lower Balanoid mostly covered with algae;
- the Argenvillei-Cochlear zone, uncovered only at low spring tides for two periods each day, of about three hours each; and
- the infratidal zone, which is always submerged.

Since zone boundaries are seldom clearly defined and some species of molluscs tend to migrate with age, a distinction into the upshore Balanoid zone, the downshore Argenvillei-

Cochlear zone, and the infratidal zone is adequate for this study. The upshore tends to be dominated by animals, as sporelings and diatoms are eaten by the limpets; in contrast, the downshore tends to be dominated by plants.

## 2.5 LIMPETS

### 2.5.1 Taxonomy

Four Orders are recognised within the class Gastropoda - Archaeogastropoda, Mesogastropoda, Heterogastropoda and Neogastropoda. The four limpet species with which this study is concerned fall within the Family Patellidae and the Order Archaeogastropoda; the prefix 'Archaeo' suggests little if any evolutionary change within an archaeological time scale. The use of the term Patellidae to refer to the local limpets is customary although taxonomically the Family Patellidae includes Helcion, Cellana, Acnae and Patelloidae species.

The stormy seas and the rugged and rocky outcrops along much of the South African coastline support limpet populations unequalled anywhere else in the world for species diversity, abundance, colouration and size.

### 2.5.2 Size

Archaeologically, limpet size is important from two aspects. First, as an animal's size increases with age, its body weight and therefore its calorific value increases exponentially; second, even although there is only a linear relationship between egg production and size, the output of large animals is in marked disproportion to numbers. Even a rate of predation as low as 2% of the largest *P. granatina* could produce drastic effects within two years, but these effects might remain archaeologically invisible unless selective predation were to be pursued intensively over a long period.

### 2.5.3 Habitat

Limpets prefer smooth gently sloping rocks and tend to avoid jagged or crumbly surfaces or unstable substrates. Sheltered wave-washed bays are richer than exposed promontories in the limpets *P. granatina* and *P. granularis*, but the low shore *P. argenvillei* is found mostly on flat fully exposed rock shelves. Limpet species frequencies in middens are thus indicative of the availability of species-specific habitats. Limpets attach to the rocks not by suction which would produce a force of only one atmosphere but by an adhesive mucus which can require up to five atmospheres (over 100 kg of force) to remove an animal once disturbed; and limpets can be disturbed simply by vibration and, once disturbed, their removal invariably damages the shell margin. Since no such damage has been noted in limpet shells from southwest coast middens, prehistoric gatherers must have been adept at removing limpets at the first attempt or then left them alone.

### 2.5.4 Feeding

Limpets are generalised grazers/browsers with an unrestricted diet which includes algae, lichens, diatoms and spores and feeding is related to the tidal rhythm. Most species establish a home base into which the shell is contoured to make a tight fit and forage up to 50 to 75 cm from this base. The home base leaves a scar on the rocks which is usually more marked for upshore than downshore species. All limpets establish territories which they will fight to maintain against invaders; limpets compete for food on a first-come first-served basis. Inter-specific competition between animals occupying the same zone is avoided by differences in feeding regimes and methods of food capture. For instance, only *P. granatina* and *P. argenvillei* use a method of lifting up the shell and smashing down on food.

### 2.5.5 Shell Shape, Surface Texture & Colour

Shell height and shape and surface texture, whether smooth, granular, ridged or spiny and colouration are species-specific adaptations to tidal and wave action, currents, water and heat gain or loss, abrasion and predator attack.

Shell weight and thickness are proportionally greater in downshore than upshore species. Colouration, derived from ingested pigments as a means of moderating the white of calcium in the shells, has been shown to vary with changes in the quality and quantity of the diet and *P. granularis* is known to develop one of three colours determined by its micro-environment - among black mussels, among barnacles and in other situations - which suggests a problem for future research. Colour is occasionally preserved in middens with a clean dry sandy matrix.

### 2.5.6 Growth and Reproduction

Southwest coast limpets do not reveal any obvious growth rings. Limpets spawn once a year usually in late autumn to early winter but sexual maturity and growth rates vary between species (Table 2.2, p.28). Gonads have a higher calorific and nutritive value than somatic flesh and thus limpets are best eaten in the period before spawning but the total edible mass does not seem to increase proportionately. Spat can travel hundreds of kilometres before settlement and thus quickly recolonise areas subject to intensive predation provided space has not in the meantime been preempted by barnacles or other animals.

### 2.5.7 Inter-Zone Migration

With increasing age, some species tend to migrate upshore where competition is less and they are better able to withstand the harsher environment.

### 2.5.8 Biological Interactions

Generally, species live well within the range of the physical conditions which they can tolerate, whether temperature of sea or air, wave action, salinity, substrate or food availability. But especially for downshore species more subject to predators, it is the presence or absence of other organisms that determines what can live where, rather than the ability of individual species to tolerate physical stress. Important agents affecting settlement, growth and reproduction include inter-specific competition, algal growth, invasion by barnacles and predators.

## 2.6 THE BLACK MUSSEL (*Choromytilus meridionalis*)

### 2.6.1 Taxonomy

The black mussel is a member of the family *Mytilidae* of the Class *Bivalvia*. Kilburn and Rippey (1982: 22) make the cryptic comment that "cold water invaders from the South Atlantic probably include *Aulacomya ater* (the ribbed mussel) and Choromytilus meridionalis" which might account for the late appearance of mussels compared with limpets in the archaeological record as discussed in Chapter 4.

### 2.6.2 Size and Range

Maximum size : 154 mm

Range : Namibia to Algoa Bay but more abundant in the cold waters of the west coast.

### 2.6.3 Habitat

The black mussel favours fully exposed, gently sloping, slow draining rock platforms on which colonies form a densely packed almost continuous covering over the rock surfaces and sand filled gullies extending from 3/4 m subtidal to one metre above low spring tide level and somewhat higher in damp crevices. Density is much the same throughout but with the more restricted feeding time upshore, the growth there is slower and the animals smaller.

### 2.6.4 Feeding

Mussels are sessile filter-feeders and fasten to the rocks by the byssus (a beard of threads) which can extend through several centimetres of sand. The byssus also enables mussels to clump together which makes them the easiest shellfish to gather. Mussel feeding depends on strong wave action to maintain a high level of particulate organic material in suspension and to provide a continuous supply of fresh food. Under these conditions, filter-feeders in terms of numbers and biomass are much more important than limpets.

### 2.6.5 Growth and Reproduction

Black mussels can attain a shell length of 60 mm in one year and produce a standing crop of more than 20 000 kJ $m^{-2}$ which is high for a macro-invertebrate population. Gametogenesis occurs throughout the year and gametes are released mainly between July and February but may be as late as May, with productivity fairly constant at about 30 000 kJ $m^{-2}$ $y^{-1}$.

### 2.6.6 Mussel Mortality

Spat tend to settle below adults and as they grow push the adults to the surface. As a result, large numbers of adults are then removed by strong wave action and either get washed up on the shore or re-attach upshore. The dense packing of mussels in a limited space squeezes some mussels to the surface to form 'humps' which are similarly vulnerable to wave action. Such competition for space is a major cause of mussel mortality. Other causes include a build-up of sand between mussel and substrate which loosens the hold of the byssus, the summer settlement of algae on the shells of mussels which promotes silting and 'humping', over-heating and dessication particularly of mussels on the surface and attack by predators, mainly rock lobsters, birds, fish and starfish.

## 2.7 THE RIBBED MUSSEL (*Aulacomya ater*)

This species is also abundant along the west coast but is mostly subtidal (Field *et al*. 1980) and being thus comparatively rare in middens (Appendix N, p.340) its ecology does not require consideration.

## 2.8 WHELKS

Whelks fall within the family *Buccinidae* and the Order *Neogastropoda* and are scavengers of intertidal pools and rock crevices. Little is known of their biology and since they appear to interbreed, malacologists are not yet agreed on the dividing lines between species.

## 2.9 MOLLUSCAN BIOCHEMISTRY

A basic similarity in the biochemistry of molluscs can be inferred from the insignificant differences in their calorific values (Griffiths, D. 1977: 602). Caloric values determined for 13 southwest coast species, expressed in kilojoules per gram of dry flesh mass (after oven drying at 60°C to constant mass) give a mean value of 20 $\pm$ 1,7 kJ $g^{-1}$ (Table 2.3, p.30). Dry flesh weight is of the order of 19% $\pm$ 2% of wet flesh weight (Griffiths, R. 1981; Davies 1969; Branch *pers. comm.*); in other words, moisture content accounts for about 80% of raw shellmeat. Given the weight of dry or wet flesh, the other parameters can be estimated for any species of mollusc and thereby results from archaeological analyses can be checked and compared.

## 2.10 CONCLUSION

To the prehistoric hunter-gatherers, the southwest coast of South Africa offered a rich and easily gathered harvest of shellfood which was dependable and available all the year round, the only seasonal variation being a somewhat higher food value in the period before spawning. From the unique abundance and size of the molluscan fauna of this region, we can predict that shellfish contributed a major share to prehistoric diet. This hypothesis and other implications from the analyses of archaeological shellfish samples are discussed in succeeding chapters.

## TABLE 2.1

## MOLLUSCS AS PALAEOENVIRONMENTAL INDICATORS

Klein (1972) : Nelson Bay Cave (Fig. 1.1)

A rise in sea temperature is inferred from the stratigraphic replacement of the cold water mussel *C. meridionalis* by the warm water mussel *P. perna*

Voigt (1975: 93) : Klasies River Mouth Caves (Fig. 1.1)

A similar rise in sea temperature is inferred from the presence of the cold water *P. granatina* in the low pre-Late Stone Age layers and its absence from the upper Late Stone Age layers.

Martinez (1979: 316) : Coastal Sites of Chile

A warming of the waters off the north coast of Chile is inferred from the southward retreat of *Choromytilus* sp. and replacement by warm water fauna.

Strauss et al. (1981: 666) : La Riera Cave, Astorias, Spain

A change in foraging strategy from estuarine collecting to greater use of the open littoral is inferred from the marked reduction in size of limpets but the ecological implications are not discussed.

## TABLE 2.2

## ECOLOGY OF SHELLFISH - LIMPETS

*P. granularis*

| | |
|---|---|
| Maximum Size : | 75 mm |
| Range : | Entire South African coast but larger and more numerous on the west coast |
| Zonation : | Mostly upshore; numbers progressively decrease downshore |
| Growth & Reproduction : | Fairly rapid but variable growth rates with sexual maturity after one year's growth<br>High reproductive output; lifespan 7 years but only 1% survive beyond 5 years |
| Migration : | Some migrate upshore with age |

*P. granatina*

| | |
|---|---|
| Maximum Size : | 102 mm |
| Range : | Namibia to Danger Point; range restricted to the colder waters |
| Zonation : | Upshore and downshore but mostly downshore |
| Growth & Reproduction : | Rapid growth, reaching 80 mm by 3 years<br>Sexually mature at 30 - 35 mm after one year's growth with high reproductive output<br>Lifespan 7/8 years |

(Table 2.2 cont.)

P. argenvillei

| | |
|---|---|
| Maximum Size : | 104 mm |
| Range : | Namibia to Transkei |
| Zonation : | Usually form a belt at about low spring tide level |
| Growth & Reproduction : | Slow growth with low reproductive output; high survival rate and long lifespan<br>Populations remain fairly stable |

P. barbara

| | |
|---|---|
| Maximum Size : | 100 mm |
| Range : | Entire South African coast but larger and more numerous on the west coast |
| Zonation : | Low spring tide level to infratidal but also in submerged situations |
| Growth & Reproduction : | Same as for P. argenvillei |

TABLE 2.3

SHELLFISH

KILOJOULE VALUES PER GRAM OF DRY FLESH

| Species | kJ $g^{-1}$ | Source |
|---|---|---|
| *P. granatina* | 20,00 | Rebelo (1982) |
| *P. granularis* | 21,20 | - do - |
| *P. argenvillei* | 19,48 | - do - |
| *P. barbara* | 21,06 | - do - |
| *P. compressa* | 17,82 | Field *et al.* (1980: 95) |
| *P. tabularis* | 17,92 | - do - |
| *Haliotis midae* | 17,13 | - do - |
| *Turbo cidaris* | 20,97 | - do - |
| *Argobuccinum argus* | 21,63 | - do - |
| *Burnupena papyracae* | 21,41 | - do - |
| *Thais squamosa* | 22,62 | - do - |
| *Choromytilus meridionalis* | 19,50 | Griffiths (1981: 104) |
| *Perna perna* | 21,10 | Berry (1978) |
| Mean kJ yield of above species | 20,10 ± 1,70 | |

# CHAPTER 3

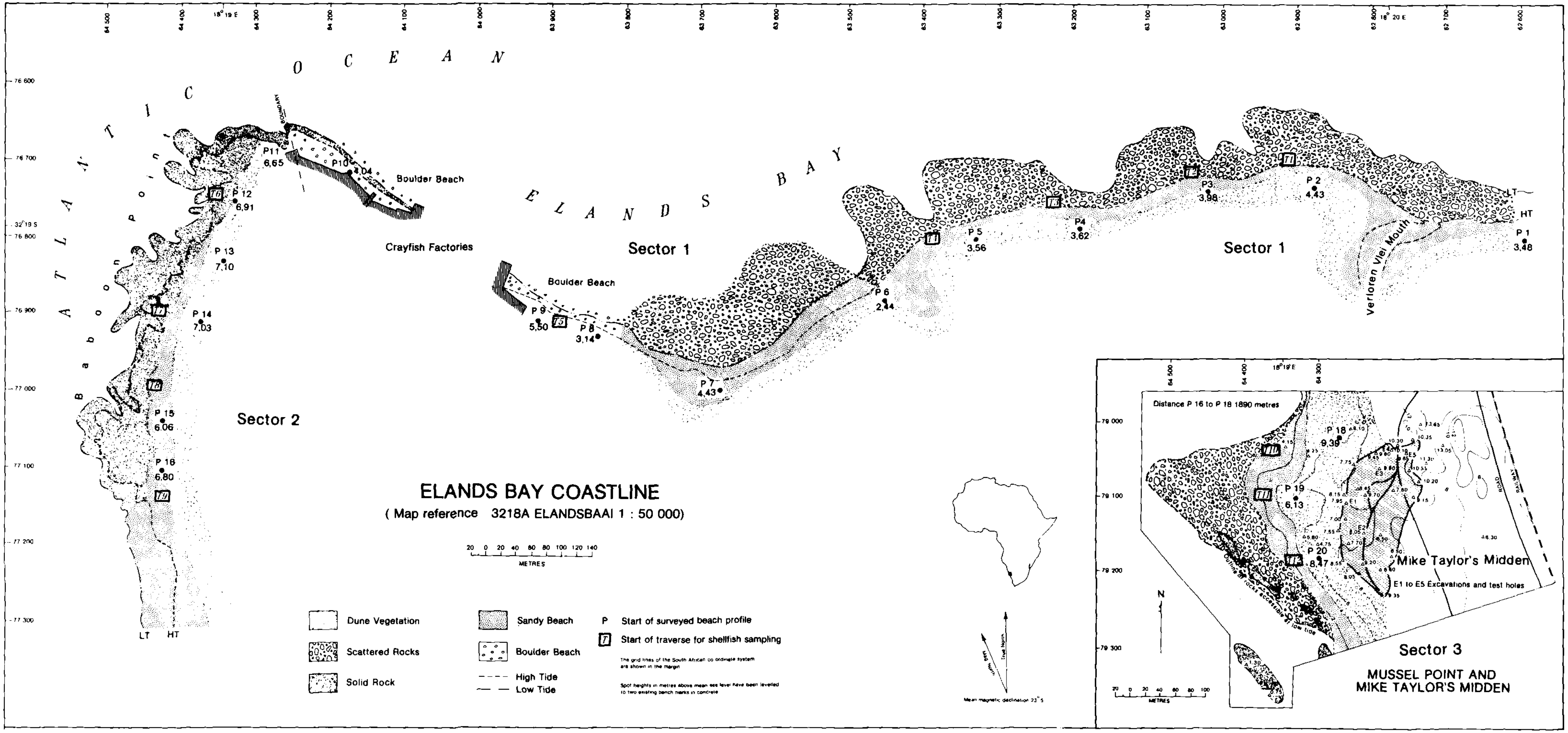
# SURVEYING AND SAMPLING

## 3.1 RESEARCH AREA

The research area comprises some 25 $km^2$ around Eland's Bay (Figure 1.3, p.4). The inland boundary ranges up to 6 km from the shore to include all sites in the vicinity. Shellfish remains at sites beyond this range have been reported by Parkington (1976a), Manhire (1984) and others, but quantities do not suggest that shellfish contributed a material proportion to the diet nor are these sites referred to as middens. The coastal boundaries are ecological - to the north of the Bay and to the south of Mussel Point are extensive sandy beaches which, on the west coast, support only 15 to 20 species of macrofauna not usually visible in their undisturbed natural environment (Bally 1981: 109), in contrast to rocky outcrops which can support up to 80 common species and over 250 species altogether (McQuaid 1980). Along the sandy beaches to the north and south are numerous discrete scatters of the white sand mussel Donax serra which seems to have been the only sandy shore species exploited in any numbers and which may be indicative of 'strandloping', if we can be sure of a cultural origin. White sand mussels are rarely found in middens where rocky of the University of Cape Town under the leadership of Tony Rebelo sampled the rocky shores by means of 16 intertidal transects (Figure 3.1) and from the analysis of the collated data produced a report on the species frequencies, numbers and distribution of shellfish (Rebelo 1982).

### 3.2.3 Shoreline Survey

Since Rebelo's report provided only shellfish values per $m^2$ based on transect sampling, estimates of the shellfish-bearing areas of the rocks were required to calculate biomass. For this purpose, Heinz Rüther of the Land Survey Department of the University of Cape Town personally arranged and supervised teams of colleagues and students to survey the coastline from which a map (Figure 3.1) and beach profiles (Figure 3.2) were drawn. The superficial areas were calculated by graphics facility from original drawings to scale 1 : 500 and reduced by Rebelo's estimates of non-shellfish-bearing areas. Tidelines (Figure 3.1) approximate spring highs and lows. Rebelo's original Sector 2 (Crayfish Factories) was later merged with Sector 1, as his Sector 2 is a steep, narrow boulder beach, difficult of access (Figures 3.1 and 3.2), with only one species of archaeological interest (*P. granularis*) in significant numbers.

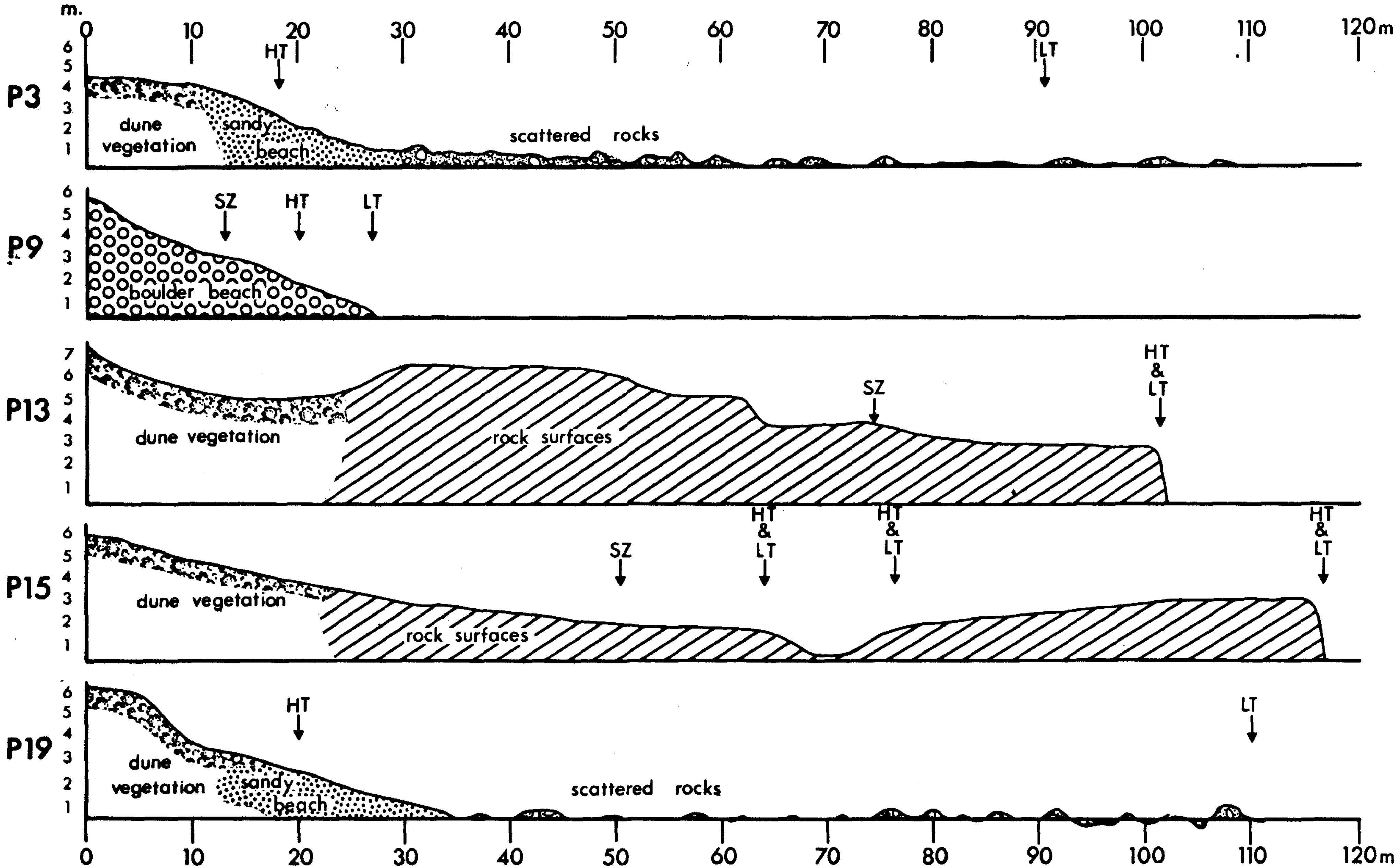


O C E A N
A T L A N T I C
Baboon Point
ELANDS BAY
Boulder Beach
Crayfish Factories
Sector 1
Sector 2
Verloren Vlei Mouth
ELANDS BAY COASTLINE
( Map reference 3218A ELANDSBAAI 1 : 50 000)
METRES
Dune Vegetation
Scattered Rocks
Solid Rock
Sandy Beach
Boulder Beach
High Tide
Low Tide
P Start of surveyed beach profile
Start of traverse for shellfish sampling
Distance P 16 to P 18 1890 metres
Mike Taylor's Midden
E1 to E5 Excavations and test holes
Sector 3
MUSSEL POINT AND
MIKE TAYLOR'S MIDDEN

ELANDS BAY COASTLINE — BEACH PROFILES

Location of profiles shown on map Figure 3.1

VERTICAL SCALE 1 : 250 HORIZONTAL SCALE 1 : 500




HT = HIGH TIDE LT = LOW TIDE SZ = LIMIT OF SPRAY ZONE

Figure 3.2

Minimum Numbers of Individuals (MNI)

| | Total MNI | Mean MNI per Site |
|---|---|---|
| Limpets | 3 414 | 107 |
| Mussels | 2 907 | 91 |
| Whelks | 759 | 24 |
| Total | 7 080 | 222 |

Weight Details

| | Total Weight (kg) | Mean Weight per Sample (kg) |
|---|---|---|
| Shell Remains | 86,0 | 2,69 ± 1,80 |
| Barnacles (23 sites only) | 1,5 | 0,07 ± 0,13 |
| Waste | 25,0 | 0,78 ± 0,80 |
| Total | 112,5 | 3,54 ± 2,00 |

## 3.3.2 Reliability of Samples

The reliability of these samples as representative of sub-surface deposits may tend to vary inversely with depth of deposit, but the potential margin of error is limited by these factors :

(a) Multiple samples taken from the same site indicate a degree of homogeneity (Appendix B, p.302).

(b) Two of the 32 sampled sites did not exceed a depth of deposit of 10 cm; of the other 30, the average depth was only 30 ± 22 cm and average maximum depth 44 ± 38 cm. In only two sites (BR 1 and BR 5) did maximum depth exceed one metre in places.

(c) Analysis of these samples has produced results that are not inconsistent with results from excavated sites.

(d) The average kilojoule yield per animal has been determined at 24 kJ for limpets compared with 28 kJ for mussels, so that errors in the limpet/mussel ratios and in energy calculations would be of limited effect.

The even distribution of shellfish remains throughout middens makes this category of food debris the most suitable for quantification by sampling in lieu of excavation. Treganza and Cook (1948) did excavate an entire midden to assess the accuracy of micro-sampling and concluded that 10 to 15 samples of about one to two kg each from a large Californian mound were representative to within an acceptable margin of error. Greenwood (1961) later reduced the required sample weight to 0,5 kg. Bailey's column samples (1975: VI, 17) ranged from 12 to 20 kg for a large Australian oyster mound, although he suggested, but did not test, that smaller samples might suffice without undue distortion.

Micro-sampling may have advantages over the macro-sampling of single sites where there are numerous sites over large areas and in some circumstances may be the only practicable technique within constraints on research. Micro-sampling is more cost-efficient; it may be informative on potential biases and on depositional and post-depositional processes and may suggest patterns in distribution that might otherwise go undetected. Leewarch and O'Brien (1981) have suggested for American Plains sites that at each stage in the accumulation of deposits, surface trampling causes mixing of materials to a depth of 30 cm, with a resultant degree of isomorphism of surface to subsurface assemblages. Redman and Watson (1970), using statistical sampling techniques, demonstrated for a Turkish tell that the top 50 cm can be assumed to be almost identical to surface collections. While these empirical observations are not necessarily applicable to shell middens, and changes in shellfish species frequencies in subsurface deposits may be important to interpretation, the comparatively shallow deposits in many of the sampled sites indicative of ephemeral occupation, should tend to restrict the possibilities for differences between surface and subsurface deposits. Further, the depth of test pits from which this type of sample was taken was either 25 cm or 30 cm.

## 3.4 ANALYSES OF SAMPLES

Analyses of samples were recorded on a Shellfish Analysis Form (Appendix C, p.303).

### 3.4.1 Segregation by Species

Shellfish remains were segregated into species on the criteria of surface markings, morphology, colour, lustre and thickness of shell. External ribbing distinguishes the ribbed mussel *Aulacomya ater* from the black mussel *C. meridionalis* and both can be distinguished from *Patella* species; but the differentiation into *Patella* species is not always possible, even with the use of a hand magnifier. The treatment of these unidentifiable *Patella* residues is discussed in Chapter 4. Whelks are easily identifiable but segregation into species is seldom possible and proved to be unnecessary.

### 3.4.2 Count of Minimum Numbers

The minimum numbers of mussels were calculated on the greater of the counts of left and right hinges and for limpets and whelks, on the number of apices.

### 3.4.3 Effects of Sieve Mesh Size on Shell Counts

All samples were sieved through a 3 mm mesh prior to sorting; but shellfish data from reports on excavated sites indicated occasional sieving through 12 mm mesh only and some hinges and apices would be lost through the larger mesh. From tests of differential sieving (Appendix D, p.304) the MNI for Patella species was increased by 5% and for C. meridionalis by 25% for these samples.

## 3.5 NON-MOLLUSCAN MATERIALS FROM SAMPLED SITES

These remains are listed in Appendix E (p.305).

## 3.6 ESTIMATION OF VOLUMES OF DEPOSIT

The energy yields from all types of food debris have been based on the standard unit of kilojoules per cubic metre of deposit. To estimate group numbers or time spent in the area each year, which are essential to an understanding of ecological relationships (Meighan 1958: 3), requires that an attempt must be made to estimate the volumes of deposit.

Open sites and the talus slopes below caves have well defined, shellfish-bearing surfaces whose superficial area can be measured. Mean depth can be established from a series of test holes and multiplication of these two factors gives an estimate of volume. The problem with many cave deposits arises from the irregularities in surface outline and depth to bedrock; for the surface area, triangulation or other simple techniques were used and for depth of deposit, a series of probes to bedrock at one metre intervals both across and into the cave gave an estimate of mean depth of deposit. Shawcross (1967: 121) used a similar method.

Figure 1.3 gives the location of all sites in the area, where the estimated volume of deposit exceeds 10 $m^3$ and also shows a broad geographical grouping of sites based on similarity in limpet/mussel ratios. Appendix F (p.307) lists for all sites the estimated volumes of deposit by type of site. Site MTM is excluded and will be discussed in Chapter 7.

There are two interesting features of the cave sites. Some two-thirds of the bulk of shellfish remains were outside the protection of the cave roof and were mostly on the talus slopes for which volume estimates can be more reliable; and many of these sites had platforms in front or nearby on which shell remains had accumulated or were scattered.

## 3.7 REMOVAL AND DISTURBANCE OF DEPOSITS

### 3.7.1 Removal

A major problem in shellfish studies arises from apparent or potential removal or disturbance of deposits. Bailey's estimates of the original volume of the Ballina oyster mound refer to potential losses of the order of thousands of cubic metres (1975: VI, 16-17), but at Eland's Bay we are concerned with loss of deposit on a much smaller scale. We can discount the three major economic incentives for disturbance or removal : the expectation of finding valuable objects within the deposit, the value of the land on which the deposit is situated, and the commercial value of the deposit itself (Ceci 1984). There is only minor evidence of unrecorded pre-archaeological digging at two or three Eland's Bay sites. The Eland's Bay area has so far remained comparatively undeveloped and agricultural productivity is limited by poor soils, by low rainfall which cannot be supplemented by irrigation from the brackish waters of the Vlei, and by past over-exploitation (Sinclair 1980; Robertson 1980); and industrial exploitation of shell remains from west coast sites is unknown on any material scale.

Many tons of deposit have been removed from the Kreefbaai midden to the north (Figure 1.2) for the surfacing of farm roads, but the only signs of removal from Eland's Bay sites relate to the sites PR 1 and MTM. PR 1 is a large shell scatter near the Vlei mouth, with a residual horseshoe-shaped mound on its perimeter from which ground indications suggest that up to 300 $m^3$ may have been removed; PR 1 has recently been dated to 2 600 years ago (Table 6.1, p.178). MTM has certainly been disturbed by displacement and possibly by removal, for which estimation is not possible; the $^{14}C$ dates, however, for MTM (Table 6.1) have established that this accumulation is almost entirely pre-pottery.

For the pottery period from 1800 BP, all the indications are that loss of deposit by deliberate removal on a major scale can be ignored. Even the local farmers do not seem to have shown interest in using the deposits for agricultural purposes - to provide the soil with needed nutrients and to improve its workability and moisture retention.

### 3.7.2 Off-Site Processing and Eating of Shellfish

Meehan (1982: 112-8) distinguished home bases and 'dinner-time' camps from processing sites where shellfish meat is removed for consumption elsewhere. While South African historical and ethnographic records (Raven-Hart 1967; Voigt & Bigalke 1973; Budack 1977; Tregoning & van der Elst n.d.) recount the occasional eating of raw shellfish while gathering, de-shelling for eating elsewhere is not mentioned. The evidence of shells at inland sites suggests that shellfish were carried away whole and not de-shelled, despite the weight of the inedible shell, perhaps for the reason that the flesh keeps better while still attached to the shell - and modern shellfish gatherers around the Cape do the same (pers. observation). Further, while limpet flesh is easily detached, black mussels are difficult to prise open even with a sharp tool and smashing them on the rocks is apt to produce a mix of flesh and shell fragments. The only easy way to open mussels is by mild cooking to relax the strong adductor muscles and detach the flesh (Griffiths : pers.comm.). Prehistoric practice seems likely to have been the same as modern, that shellfish were carried away whole from the shore. De-shelling, unless within the range of tidal action, should have left visible evidence.

On these grounds, therefore, it has been assumed that prehistoric off-site consumption did not take place to any significant degree.

### 3.7.3 Erosion by Wind and Water

Such erosion is a further potential cause of loss of deposits; certainly, all cave and rock shelter sites are well outside the range of Holocene sea level fluctuations (Flemming 1977) and of flooding by the Vlei. Prior to 1800 BP, higher sea levels could have submerged open sites within range, but the concern in this context is with post-1800 BP sites. Similarly, flooding of the Vlei as a result of heavy rains in the catchment areas may have caused erosion or removal of sites along its banks; but such lost sites are likely to have been of small volume as typically extant sites in the area (EV 1 to EV 6) are all isolated shell lenses with no more than a few cubic metres of deposit in each.

Downslope erosion of shell remains from cave sites is a characteristic of all cave sites except EBC, but these talus slopes usually have clearly defined boundaries to the shellfish-bearing surfaces.

Present day sand dunes may have had very different configurations in the past, resulting in exposure or concealment of archaeological sites. Only three sites have been exposed by deflation : EV 1 (Horwitz 1979) and ES 2 and ES 3, which are insignificant shell scatters in the dunes between Baboon Point and Mussel Point. All three sites are similar to the numerous sites located along the Saldanha-Paternoster coast (Buchanan _et al_. 1978), where the pattern was small _in situ_ lenses in the dunes with a fan of archaeological debris downslope. These indications suggest that any sites presently concealed in the dunes at Eland's Bay are likely to be few and of small volume.

### 3.7.4 Shell Artifacts

Not all shells were discarded as waste after eating the flesh. Coastal middens have produced shells that show clear evidence of deliberate perforations or retouching of the shell margin; and some shells have been found so far out of their geographic range as to suggest exchange networks (Pettigrew 1977: 12). Our concern is, however, with their more prosaic dietary contribution.

## 3.8 CONCLUSION

There must be very little of the research area that has not been covered by the deliberate search for sites or by archaeological teams over the last 15 years; if any site remains undiscovered or presently concealed, its omission is unlikely to affect the overall analysis. Sample size and estimates of site volumes represent the best compromise between objectives and constraints, but results will be tested by future excavations. If meaningful patterns emerge from the analyses reported in this study and these patterns are consistent with cognate patterns from full scale excavations, then we may conclude that patterning uniquely derived from micro-sampling but un-discoverable by macro-sampling of single sites may also reflect real aspects of prehistoric behaviour.

The spread of volume estimates over many sites and the general shallowness of deposits should tend to restrict the scope for error and give grounds for assuming that the collated data provide an adequate basis for analysis, inference and interpretation.

# TABLE 3.1

## SITE PREFIXES USED TO IDENTIFY LOCALITIES

Prefixes used from Verloren Vlei westwards to Baboon Point and then south to Mussel Point are listed below :

| Prefix | Area | No. of Sites |
|---|---|---|
| VV | Verloren Vlei Village (original settlement) | 3 |
| TT | Tortoise Cave area | 2 |
| SC | School | 3 |
| DD | Dam (dry) | 3 |
| BK | Babbiansberg Kop | 12 |
| DP | Du Plessis' Cave area | 3 |
| BR | Babbiansberg Ridge | 8 |
| EV | Eland's Bay Village | 6 |
| PR | Public Resort (proposed) | 2 |
| JT | Jetties (crayfish factories) | 6 |
| EC | Eland's Bay Cave area | 6 |
| ES | Eland's Bay South (Mussel Point) | 9 |
| VN | Verloren Vlei North | 2 |
| PK | Platklip (South of Map, Fig. 1.3) | 2 |
| | Total Number of Archaeological Sites | 67 |
| | Rock art only site | 1 |
| | Sites with secondary or mixed deposits | 2 |
| | Caves and rock shelters with no archaeological deposits | 7 |
| | | 77 |

# CHAPTER 4

# COUNTING CALORIES TO RECONSTRUCT PREHISTORIC DIETS

## 4.1 EVALUATION OF ENERGY YIELDS FROM FAUNAL REMAINS

### 4.1.1 Introduction

Archaeological analyses still tend to evaluate energy yields from prehistoric foods in the outmoded but popular kilocalorie, but this study is based on kilojoules (1 kilocalorie = 4,186 kilojoules). In nutritional studies, energy values are quoted in kilojoules per 100 grams of the raw edible portion of each food item which provides a useful common denominator applicable to all types of archaeological food debris. Quantification on this basis is more informative than the simple quantification of meat or protein content only or qualitative statements based on relative frequencies.

### 4.1.2 Techniques of Quantification

The techniques devised for assessing the energy yields from each category of food are described in paragraphs 4.3 to 4.12. The application of these yields to the archaeological data from sites has produced the following :

| | |
|---|---|
| - Reconstructed Diets | Appendices G.1 to G.6, (pp.309/314) |
| - Summaries for Each Food Category | Appendices H.1 to H.8 (pp.315/322) |
| - Comparisons of Shellfish Contributions to Total Diet | Appendix I (p.323) |
| - Reconstructed Diet for All Coastal Sites | Appendix J (pp.324/325) |

Any error in the initial quantification is likely to be progressively magnified through subsequent calculations. Shellfish energy yields have therefore been intensively investigated, but for other foods, a broad indication of their proportionate contribution to diet only has been attempted. Further investigation into non-molluscan contributions to diet and refinements of the techniques for their evaluation provide scope for future research.

### 4.1.3 Sources of Archaeological Data on Food Remains

Sources are listed below with the abbreviations used in the text :

Eland's Bay Area (EB) : Sampled Sites (32)

EBC - Eland's Bay Cave (Parkington 1976a; 1976b)
EBO - Eland's Bay Open (Horwitz 1979)
HSM - Hail Stone Midden (Horwitz 1979)
CLB - Connie's Limpet Bar (Horwitz 1979)
POM - Post Office Midden (Horwitz 1979)

Other Sites on the Southwestern Coast of the Cape Province

DE - Duiker Eiland (Robertshaw 1979)
PN - Paternoster (Robertshaw 1977)
HBC - Hout Bay Cave (Buchanan 1977)
BS - Bonteberg Shelter (Maggs & Speed 1967)
SM - Smitswinkelbaai Cave (Poggenpoel & Robertshaw 1981)
ROI - Rooiels Cave (Smith 1981)
PB/H - Pearly Beach/Hawston (Avery 1977)
DK 1 - Die Kelders (Schweitzer 1979)

Data were not reported or were incompletely reported for the undernoted :

| | |
|---|---|
| EB Sampled Sites | - Bone assemblage (too fragmented) |
| BS | - All categories other than shellfish and rock lobsters |
| SM | - Bone assemblage |
| ROI | - Bone assemblage |

Site locations and place names appear in Figures 1.1, 1.2 and 1.3. Energy yields for species of shellfish which are not found at Eland's Bay and for which there are no specific determinations, have been extrapolated from Avery (1977: 106), Rebelo (1982) and Kilburn and Rippey (1982).

4.1.4 Uniform Methods of Analysis and Reporting

This overview and the extraction of data from site reports on shell middens have revealed that standardisation in analytical techniques and in reporting format would benefit future research. Among the important factors that are seldom quoted in these reports are the volumes of the samples, especially for shellfish and the weight and numbers of bone fragments. Scientific accuracy is beyond the reach of archaeological quantification and is precluded *inter alia* by the inevitable biological variability in consumer and consumed. This study may help towards outlining the comprehensive data required from every midden site; such data would facilitate the application of the expanding range of statistical techniques.

## 4.2 TABLES OF THE COMPOSITION OF FOODS

For a very few prehistoric foods, energy yields and more rarely nutritional values have been specifically determined. For other foods, archaeologists have to rely on published tables of the composition of foods which are compiled primarily for modern natural and processed foods to give guidance in health, diet and nutritional problems for specific regions. Data suitable for use on prehistoric food items are scarce.

A list of tables is attached (Table 4.2.1, p.115). Only McCance and Widdowson (1978: 3) specify their criteria for the acceptance of published and unpublished experimental results for incorporation in their tables. The values given in all tables are no more than averages but the error is certainly no more than 15% (Durnin and Passmore 1967: 8-9). The variations in values for the same items in different tables arise from variability in moisture content, lean to fat ratios in meat, season, age and environment, the percentage edible to inedible and other factors. These qualifications can seldom be taken into account in archaeological research.

The published energy values are calculated on the proximate constituents of protein, carbohydrate and fat and represent the net energy yield derived by a human consumer after allowance for incomplete digestion and absorption and incomplete oxidation of protein as energy. The specific determinations of energy yields for shellfish used in this study were done by bomb calorimetry, which gives the gross energy yield before consumption. The difference between the two methods is 2,5% to 7,5% (Davidson and Passmore 1967: 13) and has been ignored.

In order to arrive at energy yields for non-molluscan foods, it was necessary to search through such of these Tables of the Composition of Foods as were locally available for appropriate entries; the entries were then grouped into broad categories (Table 4.2.2, p.117). Each of these categories comprises a heterogeneous mixture of items, yet the standard deviations suggest that the mean values may have statistical significance and are sufficiently accurate for the purposes of this study. The range in energy yields and an appropriate mean value for each food category are discussed in more detail in paragraphs 4.3 to 4.12, which incidentally suggest that the same species from different continents tend to produce much the same energy yield. The notable similarity in the caloric content of many different phyla suggests a basic biochemical similarity (Griffiths 1977: 601). This aspect is illustrated further by the conclusion of Brand *et al*. (1983: 293-8) from their analysis of Australian Bush Foods - the energy yields of Australian wild plant and animal foods were found to be comparable with Western foods of the same type.

An important omission from these published tables is any reference to wild plant foods. Fox (1966: xi) states that "the wild plants of South Africa, although used extensively by Bantu, have been omitted since, apparently, they have never been analysed". His Tables 50 to 54 do give some data for plants of South Africa and Kenya, but whether his information could be usefully applied to the edible plants of the southwestern Cape would depend on the services of an experienced botanist. Brand *et al*. (1983) provide comparative data on the fruits, roots, tubers and seeds exploited by Australian Aborigines, and useful information on tubers eaten by the Hadza of northern Tanzania is provided by Vincent (1985).

## 4.3 LIMPETS

### 4.3.1 Energy Evaluation

To enable calculation of energy yields from limpet shell remains, a table of kilojoule yields for each mm size in each of the four species was first compiled from data in Rebelo (1982). Average shell weights were later added, based on weighing individual shells (N = 701); the listed weights apply to large samples but not to individual shells which can vary up to 35% from the average (Appendix K.1, p.326).

To evaluate total energy yields from limpet samples, differential methods were applied to each sample wherever possible to minimise the potential for gross errors. Fortunately, limpets from sites along the southwest coast exhibit a surprisingly narrow range of variability in two characteristics : the relative species frequencies and the mean size of shell within each species. By exploiting these features, a simple, quick and sufficiently accurate method of energy assessment is possible which avoids much of the tedium of sorting and analyses. The description of these methods (Table 4.3.1, pp.118/121) indicates the data required and the choices available, but modification may be necessary under different circumstances or situations.

4.3.2 Limpet Energy Yields From Other Sources

There is a marked scarcity of data on limpets from other continents. Although the Tables of the Composition of Foods give values for mussels, clams, oysters, abalone and other important food species, I found only one entry for limpet flesh, an Asian species Helcioniscus exaratus, with an energy yield of 380 kJ 100 $g^{-1}$ or slightly more than 400 kJ 100 $g^{-1}$ if calculated by bomb calorimetry which compares with 430 for Eland's Bay limpets. Bailey (1975: III, 7) had to estimate limpet energy yields by extrapolation from values for other molluscs and his analysis would appear to be based on 33 limpets from the beach at Brighton, England. However, his 324 kJ from every 100 grams of shell weight is close to the Eland's Bay value of 350 kJ 100 $g^{-1}$. Data from Bailey (1975: III) and from Eland's Bay have been compared (Table 4.3.2, p.122) and reveal that the mean weights per shell are almost identical, with a close correspondence in mean kJ yields and in the index of kJ per 100 g of shell. It seems unlikely, however, that limpets from Brighton beach would have produced more edible flesh per unit shell weight than limpets from the nutrient-rich upwelling waters of the South African west coast.

4.3.3 Limpets as Seasonal Indicators

Since sea temperatures along the Atlantic coast of South

Africa are variable with no clear distinction between summer and winter, the technique of seasonal determination by oxygen isotope analysis (Bailey et al. 1983) cannot be applied to west coast limpets. Microscopic investigation of thin shell sections is a potential but as yet unexplored field for seasonal determinations from South African molluscs but, similarly, the variability in environmental conditions may preclude positive results. Patrick (1984) failed to find seasonal indications from fish otoliths.

### 4.3.4 Limpet Exploitation - Past and Present

The gathering of limpets for food along the South African coastline appears to have had a long but intermittent history extending back for one hundred thousand years or more, but true shell middens as evidence of intensive exploitation do not appear in the archaeological record until about 10 000 to 9 000 years ago (Parkington 1976a: 85), and only in the late Holocene do substantial shell middens become ubiquitous in proximity to rocky stretches of the coastline (Avery 1977; Olivier 1978; Buchanan et al. 1978).

The earliest evidence comes from two sites : the south coast Klasies River Mouth Caves (KRM) (Voigt in Singer & Wyman 1982: 155-210) and the west coast Sea Harvest Midden (SHM) (Volman 1978: 911-2). Both may date to the last inter-glacial. The scanty data from the lowest levels that the shells derived from a natural rather than a human origin.

Generally, limpets seem to be ignored today worldwide, except for occasional gathering along some continental coastlines. The Encyclopedia of Marine Resources (Firth 1969) contains no reference to limpets. Even Meehan's modern Anbarra shellfish gatherers show a striking disregard for the abundance of gastropod flesh; gastropods contributed only 2% of the total gastropod/bivalve shell weight and were collected only incidentally (Meehan 1982: 69). In a recent study of Transkei shellfish gatherers, (Siegfried *et al*. n.d.), severe depletion of the available mussel numbers from N = 80 $m^{-2}$ to only N = 2 $m^{-2}$ resulted in an increase in limpet collections in energy terms from 7% in 1978 to 37% in 1984.

## 4.4 MUSSELS

### 4.4.1 Energy Evaluation - Choromytilus meridionalis

The energy yield from a black mussel *C. meridionalis* is calculable from the length of the shell (in mm) on the formula :

$$\text{kJ Yield} = 19{,}5 \times 1{,}251 \times 10^{-5} \times l^{2 \cdot 646}$$

(where l is length of shell in mm)

(Griffiths, R. 1981: 104) (Table 4.4.1, p.123). As the shell is fragile and fragments easily, few shells are recovered from middens sufficiently intact for the length of the shell to be measured. The hinge (umbo) is structurally the strongest part with consequently a high survival rate and provides a reliable count of MNI.

Methods for estimating total kJ yields from samples are described (Table 4.4.2, p.124) with supporting data and comparison of factors used by other authors (Table 4.4.3, p.126) and a comparison of data from Bailey (1975: III, 5) with data from Eland's Bay sites (Table 4.4.4, p.128).

### 4.4.2 Energy Evaluation - Aulacomya ater

Populations of this species seem to consist of two size groups : numerous newly settled groups of small animals and a few groups of much larger animals (Branch 1981: 78). Energy yields calculated by Griffiths' formula on the rare whole shells from EB samples suggest yields of 4 kJ and 16 kJ respectively and a mean of 10 kJ per shell when calculations can be based only on the MNI.

### 4.4.3 Mussel Exploitation - Past and Present

From his comprehensive worldwide survey of shellfoods, Bailey (1975: II, 13) concluded that bivalves, although potentially more abundant than limpets, make a relatively late appearance in the prehistoric record, since there is little, if any, evidence of collection in quantity until about 7 000 BP. He suggests this late appearance may be attributable to trends in subsistence behaviour, ecological change or differential preservation.

If the very early dates for KRM and SHM are accepted, then the first archaeological appearance of mussels is synchronous with limpets along the South African coast, but the problems of quantity and intensity of exploitation remain open. Although molluscs first appeared in the EBC sequence (Parkington 1976a) about 11 000 to 10 000 years ago, mussels are virtually absent until Layer 12 dated to 9600 BP, and contribute no more than 15% of shellfish energy yield. This percentage then increases up to mussel-domination which persists until the hiatus in occupation just after 8 000 BP. Disregarding KRM and SHM, the EBC evidence suggests a delayed availability of mussels compared with limpets.

Differential preservation may be an unlikely explanation for the late appearance of mussels, as there is no evidence in the EBC sequence of differential preservation (Parkington 1976a: 92). Loss of shell weight through leaching or other post-depositional processes has given rise to two opposed views : whereas Bailey (1975: VII, 17) concluded that such loss of weight could be disregarded for his

Australian Weipa midden, Shawcross (1967: 22) for a midden at Galatea Bay, New Zealand, had no doubt about the marked loss of weight estimated at 17% to 23% and suggested that this loss of weight over time could be used to indicate the age of the midden. Such potential weight loss through time could be important where energy yields are calculated on shell weight.

Edible mussels of the family Mytilidae occur all over the world and have great possibilities as a food source (Davies 1969). Bailey (1975) exploited modern commercial production data as an independent control on prehistoric predation of shellfish, but this technique is not available in South Africa as small scale commercial mussel production is a recent innovation and gathering along most of the coast is restricted to 25 animals per person per day. In contrast to the growing popularity of mussels, limpets appear to be largely neglected everywhere and are taken only where mussels are not available. Prehistoric limpet-dominated middens in coastal regions where mussels are also available present a phenomenon that requires investigation and explanation.

## 4.5 WHELKS

Whelks from the research area mainly comprise *Burnupena* species (cf. *B. cincta*, *B. limbosa*, *B. papyracae*, *B. pubescens* and *B. catarrhacta*) and *Argobuccinum argus*. These small tidal pool scavengers rarely exceed 10% of the M.N.I. of all species present in middens. Based on unpublished data from Smith (1981), a mean size of 45 mm has been assumed which gives a mean kilojoule yield of 7,5 kJ.

*Burnupena* species belong to the family *Buccinidae* which contains edible whelks "regarded as a delicacy in some parts of the world" (Kilburn & Rippey 1982: 93). Schweitzer (1979: 189) doubted the importance of *Burnupena* as a food source, despite the numbers present in his Die Kelders site, as whelk flesh is said to be bitter and unpalatable. Against this view is the unique phenomenon of the synchronous occurrence some 10 000 years ago in both Eland's Bay Cave (Parkington 1976a: 94) and Nelson Bay Cave (Klein 1972) of extraordinarily large numbers of whelks.

Possibly whelks gave an element of variety and piquancy to prehistoric shellfish consumption, and cannot be ignored as contributors to energy needs although only in a minor role.

## 4.6 CRUSTACEA : ROCK LOBSTERS

### 4.6.1 Introduction

The only crustacean for which evidence survives in south-west coast middens is the Cape Rock Lobster *Jasus lalandii*, popularly known as "crayfish". While the exoskeleton of the animal as a whole soon decays without trace, the highly calcified distal ends of the mandibles are preserved in middens and an MNI can be calculated on the greater number of left or right mandibles (Grindley 1967: 94). Crayfish mandibles were first recognised by Grindley from 358 fragments recovered during excavation of the Bonteberg Shelter in the Cape Peninsula (Maggs & Speed 1967); his analysis indicated that the mandibles were sub-fossil, with little, if any, mineralisation and uniformly well preserved over a period of some 4 000 years (Grindley *et al*. 1970: 24).

### 4.6.2 Energy Evaluation

Carapace length and tail weight can be calculated from mandible measurements from the linear relationship demonstrated between them (Grindley 1967, Fig. 2: 95). For the Bonteberg sample, Grindley determined the mean carapace length at 92 mm, giving a tail weight of 130 grams. If we assume that the Bonteberg Shelter occupants ate all the flesh, their edible portion might be taken at 150 grams. Body structure and internal organs of the rock lobster are illustrated in Branch (1981, Fig. 264: 188).

The growth rate of lobsters is related to the biomass of their prey organisms, mainly mussels, and differs between areas (Pollock & Beyers 1981: 388). Growth is faster at Eland's Bay than at Bonteberg (op.cit., Table 2: 389) and thus the average size of animals caught at Eland's Bay tends to be larger, which is evident in the archaeological data :

| | MNI | Mean Carapace Length (mm) |
|---|---|---|
| Bonteberg Shelter | 192 | 92 |
| Eland's Bay - Sampled Sites | 19 | 98 |
| - EBO, HSM & CLB (Horwitz 1979) | 290 | 104 |

The edible portion of the Eland's Bay lobsters would be heavier than for Bonteberg specimens and so might be taken at 200 grams which would also apply to lobsters from the sites of DE and PN to the south, where the environment and coastal geomorphology are similar to Eland's Bay.

Published energy yields for lobsters are listed (Table 4.6.1, p.129) and suggest 400 kJ 100 $g^{-1}$ as an appropriate value which, when applied to the assumed weights of edible flesh gives :

| | | |
|---|---|---|
| EB, DE and PN lobsters | : | 800 kJ each |
| Other sites | : | 600 kJ each |

4.6.3 Ecology of the Cape Rock Lobster Jasus lalandii

I am indebted to Dr David Pollock of the Division of Sea Fisheries for information and guidance on pertinent aspects of the ecology of rock lobsters. This animal is common along the west coast and lives under rock ledges, in caves and crevices and among kelp from low spring tide level to a depth of some 80 m. The animal is also known as the 'spiny' lobster and, when threatened, wedges itself into its retreat and is difficult to dislodge; it is the most important predator in the kelp beds and, although omnivorous, feeds largely on mussels. Little is yet known on its reproduction. 70% of the females reach sexual maturity on attaining a carapace length of 70 mm and 100% at 85 mm. After the peak moulting months of May/June, mature females are in berry from July to November. Males mature at 70 mm and moult during October/December. Rock lobsters do not feed during moulting and are not attracted to bait. The hard exoskeleton precludes continuous growth, which necessitates annual moulting during which the lobster is soft and helpless. Growth is slow and only after nine years does a lobster attain the modern minimum catchable size of 89 mm; thereafter, female growth is only one mm a year and males about two to four mm a year. A carapace length of 150 mm would represent an age of 30 to 50 years.

Commercial catching data indicate that populations are massed around Eland's Bay itself and up to one km to the south. Mussel Point some 2 km to the south, is thought to be too exposed to swell action to support large populations. Further, lobster mobility is limited and the calmer waters around the Bay would be necessary for moulting. A phenomenon of lobster mobility of importance to archaeological interpretation is that, during summer, there is a massive migration of lobsters into shallower waters. This phenomenon has been attributed to a deep, slow moving tongue of water beneath the Benguela current which drifts southwards and has characteristically very low levels of oxygen; its most spectacular effect is to drive lobsters before it into the shallows, where wave action maintains higher levels of oxygen concentration. Rock lobsters are infratidal animals and are not adapted to the stresses of the intertidal zone. The intertidal seabed around the Bay slopes gradually and uniformly without deep caves or crevices in which lobsters can shelter, and large areas are suddenly exposed at ebb tide. When lobsters are driven into the intertidal zone, they seem unable to orient themselves or to retreat with sufficient speed to escape as the tide ebbs, and mass strandings occur. Such strandings of millions of lobsters have periodically been recorded along the west coast and, in one instance at Eland's Bay, were piled over a metre high in places (Branch 1981: 19). A mass stranding is reported in Newman and Pollock (1974), when a 120 m stretch of the Eland's Bay intertidal zone was literally covered by thousands of lobsters, whose escape was hindered by the massing of lobsters immediately beyond them. The authors concluded that there was a well-defined seasonal pattern of lobster migration into shallow water, caused by the intrusion of the oxygen-deficient subsurface water. This inshore seasonal massing of lobsters was confirmed by local fishermen, and I have also witnessed some 50 lobsters struggling along the water's edge, which the villagers tell me happens every year. They confirmed that the strandings occur only along the shores of the Bay itself. Presumably the irregular rocky platforms, intersected by gulleys and crevices, at Baboon Point and the steeply shelving sandy shore to the south of the Bay do not entrap lobsters.

Analysis of annual commercial catches shows maximum production during November/December, a slight fall-off in January/February which is more evident in March, but recovery begins in April and continues to the end of the season on 30th June (Pollock, pers.comm.). These fluctuations are attributed partly to catching and partly to lobster migration closer inshore out of the range of the lobster boats. Modern commercial exploitation of lobsters at Eland's Bay is restricted to the period 1st November to

30th June and no lobsters in berry or of less than 89 mm carapace length may be taken. Some half a million lobsters are processed each year through the Eland's Bay factories, with an average carapace length of 96 mm. Random sampling (unrestricted) to establish population structure produced modal sizes of 82 mm for males and 72 mm for females (Pollock & Beyers 1981: 389), which suggests that pre-historic hunter-gatherers may have been able to select for size or that the population structure has been depressed by commercial exploitation.

Another periodic phenomenon, mainly of the summer months along the west coast, is the occurrence of massive planktonic blooms ('red tides'). Decay and disintegration of these blooms entails a high biological oxygen demand which can drastically reduce oxygen concentration in the sea and lead to mass mortalities of marine organisms.

### 4.6.4 Spatial Distribution of Rock Lobster Remains

The maximum density of lobster remains in Eland's Bay sites is found in sites adjacent to offshore areas where lobster populations are massed and to the beach where mass strandings occur (Table 4.6.2, p.130). During occupation of the Vlei sites, little attention seems to have been given to lobster catching and none at all at Mussel Point sites as expected from modern lobster distribution. The scarcity of mandibles from Vlei sites may correlate with the scarcity of lobsters around Mussel Point Sector 3; if so, most shellfish gathering from Vlei sites may have been oriented to Sector 3.

The spatial distribution among sites along the southwest coast reveals a prehistoric pattern which is consistent with modern conditions in that :

(1) Commercial exploitation is restricted to the west coast, with most processing factories clustered around the stretch of coast from Eland's Bay to PN; but, to the east of Cape Point, the lower abundance of rock lobsters has been attributed not so much to the higher sea temperature as to the wide variety of reef fish and sharks compared with the west coast where there are few predators on lobsters (Pollock & Beyers 1981: 397).

(2) While the summer inflow of oxygen-deficient subsurface water has been traced as far south as the Cape Peninsula, its regular annual incidence and consequent mass mortalities of lobsters seems to be primarily a phenomenon of the Eland's Bay to PN region.

(3) 'Red tides', which can also cause mass mortalities of marine fauna, are more frequent on the west coast than east of Cape Point.

## 4.6.5 Temporal Distribution of Rock Lobster Remains

Analysis of rock lobster remains from the whole sequence of EBC (Table 4.6.3, p.131), since the first appearance of seafood debris about 11 000 years ago, indicates a similarity in the intensity of exploitation during the pre-hiatus period (11 000 - 7800 BP) and the ceramic period (1800 - 300 BP), but a distinctly lower intensity during the post-hiatus pre-ceramic period (3800 - 1800 BP). During this unproductive middle phase, when sea levels were one to two metres above present (Flemming 1977), mass strandings may not have occurred as animals were able to escape back into the deeper water or, if the cave was occupied mostly during the lobster moulting months of winter/spring, returns would be low and would miss the bonus of summer strandings. Finally, foraging may have been directed to more dependable and less risky resources such as shell-fish. In contrast to EBC, the sequence at Bonteberg Shelter suggests increasing attention through time to lobster exploitation (Table 4.6.3), but there were long breaks in occupation and the increase may be an artifact of sampling.

The EBC sequence has revealed an inexplicable phenomenon. The records of pre-commercial catching of the late 1800's show a maximum carapace length of 170/180 mm (Pollock, pers.comm.), yet one lens of Layer 10 of EBC produced mandibles (N = 32) with a mean length of 214 ± 31 mm and a maximum of 253 mm, indicating an age of 50 years for a female or 150 years for a male. Lobster mandible density in Layer 10 is the second highest of any layer of the whole sequence and in its context a change from limpet to mussel domination is evident. Since mussels are the favourite prey of lobsters, there may be an environmental link between the increasing presence of mussels and the high density and large size of lobsters. A wind regime with more frequent southeasterlies, increased upwelling, better feeding and lower sea temperature is a possible explanation for the apparent higher biomass of both mussels and lobsters.

### 4.6.6 Rock Lobsters as Seasonal Indicators

The stratified shell middens of the southwest coast represent sequences of short-term occupations by small mobile bands. Shell lenses in these middens would accumulate rapidly and only a week or two would be required for one cubic metre of deposit to accumulate. On this assumption, which is discussed in more detail in Chapter 8, comparative densities of lobster minimum numbers per cubic metre of deposit (Table 4.6.2) can be examined. A low density of less than 20 as at ROI and PB/H suggests opportunistic catching whereas a density greater than 100 as at DE and PN implies that catches were supplemented by stranded animals. For Eland's Bay sites and for Bonteberg Shelter, densities of 30 - 70 per $m^3$ are indecisive but if, as suggested, there is an inherent bias towards underestimation, then some strandings may have been exploited, which could be done only during summer visits.

4.6.7 Technique of Catching Rock Lobsters

Catch rates, other than from strandings, are partly dependent on technique, but there is no evidence from Eland's Bay sites to suggest any technique of catching other than by hand from the intertidal zone. The prehistoric occupants of the area were probably San (Parkington 1976a), of pygmoid stature (Tobias 1978: 21-22) and probably non-swimmers in view of the absence from site debris of infra-tidal shellfish. The prevalence of rough seas and high waves along a rocky shore would have inhibited non-swimmers from venturing beyond knee-deep wading at low tide level.

Branch (1981: 124) and others have, however, reported that lobsters have been taken in knee-deep water along the south-west coast. At Eland's Bay, two factors militate against such easy catching of any significant numbers : the extensive gently-sloping intertidal rocky seabed and the virtual absence of black mussels, the major prey of lobsters, from the Sector 1 platform (Appendix S.1(a), p.347). Certainly lobsters have been taken in the gullies that intersect the platform and among the kelp beyond, but depths exceed one metre and catching in the deeper water would be risky for non-swimmers.

The problems of catching therefore tend to reinforce the argument for the supplementing of opportunistic catching by acquiring lobsters from strandings and consequently for some visits in summer.

### 4.6.8 Other Crustacea

The Crustacea are the most diverse of all marine animals in South African waters and are described by Branch (1981: 175-97). The crabs, shrimps and prawns of the shore and estuaries may have been exploited as food resources in prehistoric times, but no evidence survives. This omission may not be important as the energy yield from these mainly small species is unlikely to have justified the effort, except possibly for fishing bait.

The Class Crustacea includes the family Cirripedia or barnacles which are found in most middens. Barnacles are sessile; once settled, the animal cements itself for life to the substrate. This substrate may be the shell of a mollusc and hence the usual archaeological assumption that barnacles were brought to sites only incidentally and not as a source of food.

This assumption is well founded as the edible content is minimal and the yield per 100 grams of dry flesh is only 7 kJ (Field et al. 1980: 194). Barnacles accounted for only 1,7% of total weight of shells from the 32 sampled sites but site EC 5 in front of Eland's Bay Cave and close to the shore produced barnacles at 15% of total shell weight and included several large unattached specimens of 10 or more grams each. Presumably these were deliberately collected from the rocks for some purpose such as soup-making (Meighan 1969: 420).

## 4.7 FISH

### 4.7.1 Introduction

Research in South Africa into the energy and nutritional values of local fish is of recent origin and is concerned mainly with pelagic and benthic species of economic importance and only incidentally with the inshore and estuarine species which comprise most of those of archaeological interest. This analysis owes much to the guidance and information provided by Dr Simmonds of the Fishing Industry Research Institute and by Cedric Poggenpoel.

## 4.7.2 Energy Evaluation

The basic data required for energy evaluation comprise the MNI for each species, length, live weight, percentage edible and kilojoule yield per unit weight, together with an MNI for the unidentifiable residue.

### 4.7.2.1 Identifiable Species

Poggenpoel's analyses of fish bone assemblages for south-west coast sites have provided all the necessary MNI. Individual fish lengths could not be determined from fish remains but, instead, a mean length and live weight for each species was calculated from data accumulated by Poggenpoel over two decades from modern samples.

### 4.7.2.2 Percentage Edible

The edible portion for all species was taken at 70% of live weight calculated from data for hake *Merluccius capensis* (Simmonds & Tanner 1980). Shawcross (1967: 114) also adopted 70%, but Keene's percentage at 88% (1981: Table A 3.2) seems high by comparison, but relates to North American freshwater fish.

#### 4.7.2.3 kJ 100 $g^{-1}$ Wet Flesh

Values and sources for west coast species have been listed (Table 4.7.1, p.132). For unlisted species found only at sites to the east of Cape Point, values have been calculated from Smith (1965) with the help of Poggenpoel. Since the season of catching is unknown, no account can be taken of seasonal variation in fat content which, for mackerel *Scomber japonicus*, can vary from 3% in January to 18% in July (Simmonds & Tanner 1980: 53). The mean yield over all species from west coast sites emerges at 494 ± 105 kJ 100 $g^{-1}$ (Table 4.7.1), the large standard deviation being attributable mainly to the inclusion in one list of both fatty and non-fatty fish with kJ 100 $g^{-1}$ values of about 700 and 350 respectively (Table 4.2.2, p.117). Bailey (1975: VI, 26) used an identical mean value of 494 but derived it from doubling the yield from oysters.

#### 4.7.2.4 Unidentifiable Residue

Only the MNI for the residue is known. The mean kJ yield applied to this MNI was calculated for each sample separately on the numbers and yields of all identified species in the sample.

### 4.7.3 Reliability of MNI

An inherent bias towards underestimation of energy yields from fish remains can be assumed as a result of depositional and post-depositional processes, loss through sieves and other factors. An attempt was therefore made to estimate the potential shortfall by comparing the total number of fish vertebrae recovered from the EBC ceramic period Layers 1 to 6 against the original numbers of vertebrae in the live fish. A shortfall of 15% was found and the MNI for all samples has been increased accordingly. For mammal bones, Cook and Treganza (1947: 138) recommended a much higher percentage increase and their recommendations were adopted by Bailey (1975: 26) for fish bone assemblages. An increase of only 15% in MNI may thus be understated.

### 4.7.4 Spatial Distribution by Sites at Eland's Bay

Analysis of the fish remains by grouped sites (Table 4.7.2, p.133) demonstrates substantial numbers of fish caught from sites adjacent to Verloren Vlei but very few from sites around the Bay or at Baboon Point and none at all elsewhere. There is no archaeological evidence for the ceramic period to suggest techniques of fishing (Parkington 1976a: 101), nor have remains of fish traps been observed among the rocks. Most of the species caught are to be found both in estuaries and the open sea, but it is predominantly the younger and smaller fish which inhabit the estuaries, while the larger fish prefer the marine environment (Parkington 1976a: 102). Predictably, therefore, the Vlei sites reveal the catching of large numbers of comparatively small fish (Table 4.7.2) which may have been achieved by netting or trapping in contrast to the Bay and Baboon Point sites from which the few fish caught were much larger and may have been taken by line.

### 4.7.5 Spatial Distribution Among Southwest Coast Sites

In the coastal region east of Cape Point, reef fish are more diverse and abundant and include some much larger species (Smith 1965; Pollock & Beyers 1981: 397), which is evident from the comparative analysis of the archaeological fish bone assemblages (Table 4.7.3, p.134). Prehistoric fishing was clearly more productive than on the west coast, which may partly account for a lower dependence on shellfish.

## 4.8 TERRESTRIAL MAMMALS

### 4.8.1 Problems of Sampling

The problems and recent progress in zooarchaeological quantification are reviewed in Gilbert and Singer (1982: 21-40) and have been discussed more recently in Southern

Africa (Brain & Turner, G.P. 1984; Turner, A. 1984; Avery, G. 1984). Among the factors which have been ignored in this study for lack of information are environmental and other biases inherent in the results and inaccuracies attributable to the use of MNI (Lyman 1979: 536-546). The further assumption that, except for the very large African mammals, all edible parts of a carcase were consumed, is open to question (Lyman 1979; Stewart & Stahl 1977: 269). Further, the age, sex, season of killing and other factors that can affect the live mass of an animal, have also had to be ignored.

These factors may not be as important in this context as for bone assemblages from inland sites. We are here concerned only with coastal shell middens which represent short-term hunter-gatherer occupations, sometimes ephemeral or occasionally with long sequence deposits but brief occupation at any one time. Gilbert and Singer (1982: 29) have suggested that such simple transitory camps are rare examples of sites which preserve a high percentage of the kill-offs. In support of this view, there is a high proportion of animals of less than 50 kg live mass, which could be brought back whole to the sites; at EBC, only five out of a total of 58 exceeded 50 kg (8,6%) and at DK1 only 22 out of 414 (5,3%) (both analyses were done by Dr Richard Klein). Further reasons for bringing back these smaller animals whole to sites may be the secondary use of bone and skin. None of the site reports refers to biotic or abiotic agencies of accumulation or dispersal.

4.8.2 Energy Evaluation

Where remains are distributed fairly evenly through a midden, sample size is a problem of statistical adequacy. For bone assemblages, even distribution cannot be assumed and the only safeguard against gross error lies in very large samples from excavations. For EBC, with a total sample of 39,14 $m^3$ and DK 1 of 37,3 $m^3$, the assemblages may be reasonably representative, but for all the other samples analysed, there are potentially gross errors.

The most problematic energy evaluations arise from the very large African fauna with a live mass exceeding 500 kg, such as buffalo or hippo. One buffalo would provide enough food for a band of 20 eating only buffalo for two or three weeks, but in the temperate climate of the Western Cape, the generally humid atmosphere at the coast and the prevalence of coastal fogs, the meat would not keep fresh for more than a few days and drying for storage is unlikely to have been practicable for mobile bands. Van Zyl (1962) recorded the rate of loss of moisture from atmospheric drying of eland meat to make biltong and found that a month was the minimum period but complete dehydration took 74 days, and hunter-gatherers have the further problems of protecting the meat from direct sunlight and from predators. Even in the arid Kalahari, the G/wi do not seem to have practised the technique of drying meat for storage :

> "... the G/wi eat large but not gargantuan quantities of meat at irregular intervals finishing off a carcase in a day or so in hot weather. When the weather is cooler and meat does not spoil so rapidly, a large antelope may last as long as six days (by which time the last cuts are distinctly noisesome)"

(Silberbauer 1981: 206).

For very large mammals, I have applied an arbitrary maximum of one million kilojoules each, which represents a live mass of some 250 kg or about one-third of the live mass of a buffalo and one-sixth the mass of a hippo.

Three factors are used for estimating the energy yield per animal of each species :

Mean live mass derived from Smithers (1983) taking the average for males and females where both are given.

Percentage edible to live mass for animals up to 5 kg live mass 70% and for animals over 5 kg live mass 60%, derived from White (1953: 396), Van Zyl (1963), Van la Chevallerie (1970), Van Zyl *et al*. (1969), Binford (1978) and Keene

(1981: Table A 3.2).

kJ 100 $g^{-1}$ of raw edible portion : There is a total lack of data on energy yields from African terrestrial fauna and neither the Mammal Research Institute of the University of Pretoria nor mammologists elsewhere could provide estimates. The following were extracted from Tables of the Composition of Foods, expressed in kJ 100 $g^{-1}$ edible portion : boar 717, water buffalo 504, hares 570, reindeer 817, whales 655, seal meat 760. Croes, Huelsbeck and Stucki (n.d., Table 3: 8) quote blacktail deer at 847 and Roosevelt deer at 859, but animals of the high northern latitudes tend to have a higher fat content and energy yield than African fauna (Louw, pers.comm.). Finally, Brand et al. (1983: Table 4, Composition of Australian Aboriginal Bushfoods) determined the yield for only one mammal, the possum Trichosurus arnhemensis at 700 kJ 100 $g^{-1}$. The mean value of all these sources is 693 $\pm$ 125 kJ $100^{-1}$ and, therefore, until better determinations become available, a mean value of 700 kJ 100 $g^{-1}$ has been assumed (Table 4.8.1, p.135). Domesticates (cattle, sheep, goats and pigs) give an average yield of 1 290 kJ 100 $g^{-1}$ (Table 4.2.2, p.117) and, using this figure as a base, and allowing for the proportionately higher protein but lower fat content of wild animals, gives a result very close to 700 kJ 100 $g^{-1}$.

On these parameters the energy yields from terrestrial mammals identified at EB excavated sites (Table 4.8.2, p.136) and at southwest coast sites (Appendix H.4, p.318) have been estimated.

## 4.8.3 Comparative Abundance and Diversity of Species

A comparison is set out below of Eland's Bay data, representing the west coast, and DK 1 data, representing the coast east of Cape Point :

| | Eland's Bay | | DK 1 | |
|---|---|---|---|---|
| | | $Nm^{-3}$ | | $Nm^{-3}$ |
| Terrestrial Mammals | | | | |
| Total volume of samples | 39,14 $m^3$ | | 37,3 $m^3$ | |
| Number of species identified | 18 | | 28 | |
| Total MNI (excluding dune molerats) | 102 | 2,6 | 414 | 11,1 |
| Bovids | | | | |
| Grysbok/Steenbok | 28 | 0,72 | 284 | 7,6 |
| Other Bovids | 18 | 0,46 | 21 | 0,6 |
| Total MNI | 46 | 1,18 | 305 | 8,2 |
| Hyrax (Rock rabbits) which should be more plentiful in the EB area, being a more suitable habitat with hilly country around | 24 | 0,72 | 26 | 0,7 |

Evidently, during the last 2 000 years, terrestrial mammals were significantly lower in abundance and diversity around Eland's Bay than in the catchment of DK 1. The explanation may lie in soil deficiencies (Smith, pers.comm.) and low rainfall (150 - 250 mm a year) at Eland's Bay, with sparse vegetation affecting the higher trophic levels. Even the very large mammals seem to have avoided the area :

> "hippos do not seem to have been seen at Verloren Vlei although the area is frequently referred to as an ideal camping site for travellers and their trek-oxen nor were hippos encountered at Langvlei some 10 km to the north"

(Skead 1980: 410). Similarly, there are no historical records of elephants or rhino within about 100 km of Eland's Bay and, in fact, very scant records of mammals sighted there compared with other areas of the south-western Cape.

### 4.8.4 Notable Omissions from Faunal Inventories

In the inventories of terrestrial mammals for the south-west coastal sites, the following species of the larger African fauna are not represented, although their presence in the area has been documented in Skead's summary (1980) of the early historical records : Brown Hyena ('strand-wolf') *Hyaena brunnea*, Spotted Hyena *Crocuta crocuta*, Black Rhino *Diceros bicornis*, Elephant *Loxodonta africana*, Lion *Panthera leo* and Gemsbok *Oryx gazella*.

Other large African fauna not represented in these inventories but reported in the records mostly to the north of the area, in the mountainous interior or as occasional visitors into the fringes, include : Kudu *Tragelaphus strepsiceros*, Springbok *Antidorcas marsupialis*, Giraffe *Giraffa camelopardis*, Black Wildebeeste *Connochaetes gnu* and Zebra *Equus zebra* and *E. quagga* (extinct).

Lee (1979: 232-234) has commented that Kalahari ! Kung almost never hunted big cats or hyenas and elephant hunting probably required too many hunters for a co-ordinated single drive.

## 4.9 CETACEANS - WHALES AND DOLPHINS

In addition to the specific references quoted, information has been derived from Watson (1981), Best (1982), Smithers (1983) and Smith, A.B. (*pers.comm.*), supplemented by invaluable guidance and information from Dr Peter Best of the Marine Mammal Laboratory, Sea Fisheries Research Institute.

### 4.9.1 The Archaeological Evidence

The archaeological evidence is minimal from the Eland's Bay area : one cetacean identified in Layer 4 of EBC, the bones of 17 dolphins from the surface of two deflation hollows on the north side of Verloren Vlei about two to three kilometres from the sea (Horwitz 1979: 60), identified by Dr Graham Ross of the Port Elizabeth Museum as Dusky Dolphins Lagorhyncus obscurus and one decayed whale fin bone (?) from the surface of a small cave within 200 m of the beach. The last two finds may be, but are not necessarily, prehistoric. From other southwest coast sites, DK 1, Layers 1-12, produced MNI of eight cetaceans but not identified to species, and one dolphin was identified from the Pearly Beach/Hawston sites.

Two products from whales which might have been of use or interest to hunter-gatherers have never been found in South African middens : ambergris and whale 'ivory'. Ambergris is a dark coloured substance excreted by the Sperm Whale Physeter catodon which is a fairly abundant species in Cape waters. When weathered by sun, wind and sea, ambergris changes to a light colour and acquires a subtle fragrance and is occasionally washed up on continental beaches in pieces from 100 grams to over 40 kg. Ambergris has been traded for centuries for perfume making. Prior to the closing of the whaling factory at Donkergat on the west coast in 1967, Xhosa workers are reported to have been collectors of ambergris from processing carcases (Best, pers.comm.), but the practice is unknown to the senior ethnologist of the South African Museum, Miss E. Shaw. Whale 'ivory' derives from the teeth and appears in characteristics akin to elephant ivory but was presumably ignored by hunter-gatherers, despite its potential use as a raw material. The absence of these two whale products after millenia of exploiting marine resources suggests a low encounter rate or lack of interest.

### 4.9.2 Historical and Ethnographic Evidence

Skead (1980: 690-709) quotes *in extenso* the historical references to the exploitation of whales in Cape waters from the first sighting by Vasco da Gama's sailors in 1497 of Hottentots eating whalemeat at St Helena Bay up to the mid-nineteenth century from which the following have been selected as relevant to this enquiry.

> "... the Hottentots gather up whole handfuls of oil which the sun has rendered down from stranded whales and drink it. Some cut pieces from these and bury them in the sand." (Nieuhof 1654)

A similar observation was made by Ogilby (1670: 591). Paterson recorded (1790: 107) that the Hottentots, having settled where a whale has stranded,

> "subsist upon it as long as any part of it remains; and in this manner it sometimes affords them sustenance for half a year though in great measure decayed and putrified by the sun."

Backhouse (1844: 33) visited Port Nolloth and noted that the "Hottentots were preserving the flesh by burying it in the sand and live principally upon it for many weeks together". The storage of oil by Hottentots in the hollow trumpets (stems or stipes) of the giant kelp was recorded in Van Riebeek's Journal (Thom 1952: 1: 217).

Such accounts have to be treated with caution as inter alia, they may have little time depth. To sum up the historical evidence there are numerous references to whale sightings, especially to females during calving in favoured bays, but there is only scant mention of beached or stranded whales and no record of multiple strandings. The seasonal evidence is equivocal. No mention occurs of ambergris or whale 'ivory' or the local use of whale bone or, more significantly, of the drying of whalemeat. Rendering of whale oil by the indigenous people seems to have depended on the sun's action.

The only ethnographic observation of drying whalemeat relates to the Namibian Topnaar of the lower Kuiseb Valley (Budack 1977: 26). This area is hyperarid; the Kuiseb flows about once every seven years and its waters are stored in capped underground tanks. Drying is therefore practicable, in contrast to the southwestern Cape with its wet winters, coastal mists and sporadic rain in the other months. Burial in the sand seems the more likely method of storage but costly in energy expenditure in burying and unearthing; salt may have been used from the natural salt-pans to the south of Eland's Bay.

### 4.9.3 Energy Evaluation

The problem of assessing the energy yield derived from whales and dolphins by prehistoric coastal peoples appears, at first sight, to be insoluble on archaeological evidence. Nevertheless, we ought not to ignore the data accumulated by the Sea Fisheries Research Institute since 1963 on cetacean strandings (Tables 4.9.1, p.137 and 4.9.2, p.138), which supplemented by the following information given by Dr Best, enable a tentative estimate to be made :

Edible portion of live mass : Toothed whales 35% and Baleen whales 40%.

kJ 100 $g^{-1}$ raw edible portion : Toothed whales 350, Baleen whales 650.

The major difference in yield is attributable to fat content, which is 0,2% for Toothed whales and 7,5% for Baleen whales.

An economic range for the exploitation of cetaceans might be assumed at 50 km either way from Eland's Bay, which would comprise the coastline from the northern limit of Lambert's Bay to the southern extremity of St Helena Bay. Multiple strandings are taken as one stranding event on the assumption that a single band would not be able to exploit more than one animal from a multiple stranding. The stranding of one large baleen whale or multiple strandings may have attracted other bands to the area, but such aggregations would have been sporadic and unpredictable and, with such massive quantities of food available, much time could have been spent in non-economic activities such as ceremonial.

### 4.9.4 Prehistoric Incidence of Strandings

In addition to the record of modern strandings (Tables 4.9.1 and 4.9.2), the following is an analysis of the strandings during the same period along the Lambert's Bay - St Helena Bay coast :

| Single/Multiple | | | Area | Total No. of Animals | No. of Stranding Events | |
|---|---|---|---|---|---|---|
| | | | | | Toothed | Baleen |
| Single | - | 10 | St Helena Bay | 10 | 9 | 1 |
| Threes | - | 1 | Lambert's Bay | 3 | 1 | - |
| Fours | - | 1 | St Helena Bay | 4 | 1 | - |
| Mass | - | 1 | St Helena Bay | 65 | 1 | - |
| | | 13 | | 82 | 12 | 1 |

There were no strandings in Eland's Bay itself.

The Toothed whales account for 12 out of 13 strandings within range of Eland's Bay and 205 out of 225 along the entire coastline. It has never been economic for the whaling industry to exploit these smaller cetaceans with the single exception of the Sperm whale Physeter catodon, whose pre-exploitation numbers are estimated to have been reduced by about 50% and in the present context are treated along with Baleen whales. Only two Sperm whales stranded during the period covered by the records, but none within economic range of Eland's Bay. In the absence of evidence of commercial exploitation of Toothed whales or of any environmental changes that might have affected their population numbers over the last 2 000 years, it seems reasonable to extrapolate the modern incidence of Toothed whale strandings back into the prehistoric past.

During the 19 years of recorded strandings, there were 119 stranding events of Toothed whales (Table 4.9.1) over some 2 500 km of coastline or roughly one stranding event every four years per 100 km of coast, assuming an even distribution, but both the historical and modern records indicate that strandings tended to favour certain sandy bays, such as Table Bay and St Helena Bay. On the Lambert's Bay - St Helena Bay coast, there were 12 stranding events over the same period or about one every two years. Since it cannot be assumed that all prehistoric strandings were exploited, I have assumed a prehistoric incidence of one stranding event of Toothed whales every three years.

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A similar calculation for the 20 Baleen and two Sperm whales which stranded during the same period, gives a modern incidence of one stranding every 20 years over the whole coastline. Only one stranding has been recorded for the 100 km of coastline north and south of Eland's Bay over the past 20 years. Modern incidence, however, cannot be extrapolated into the prehistoric past in view of the drastic reduction in the populations of some species through commercial exploitation, but the consequences should not be overstated. Kenwisher and Ridgway (1983: 108-111) comment :

> "many species of cetaceans are commonly thought to be in imminent danger of extinction: this conclusion is based largely on a misperception of their current population levels ... in fact, most cetacean species exist in substantial numbers ... sperm whales were probably twice as numerous in the generations before modern whaling began, but even so their numbers are far from low ... human harvesting, being largely confined to a few highly productive species, has probably not affected the gross nutrient dynamics of most ocean areas."

Current information on exploitation is summarised in Table 4.9.3 (p.139) in the light of which the modern incidence of one stranding every 20 years might be increased to a prehistoric incidence of one stranding every 10 years, which would also allow for some unexploited strandings.

## 4.9.5 Energy Yields from Strandings

The following table provides a basis for estimating the potential energy yield from Toothed (*Ondotoceti*) whales (excluding the Sperm whale) in prehistoric times, and is based on strandings for the whole coastline from Namibia to west of Mossel Bay.

| Family | 1963 - 1981 (inclusive) | | | Estimations | |
|---|---|---|---|---|---|
| | No. of Events | Mean Live Mass (kg) | Total Live Mass (kg) | Mean Live Mass kg p.a. | Total kJ p.a. |
| *Ziphiidae* | 30 | 1 320 | 39 600 | 2 084 | 2 552 900 |
| *Physeteridae* | 34 | 324 | 11 016 | 580 | 710 500 |
| *Delphinidae* | 55 | 427 | 23 485 | 1 236 | 1 514 100 |
| | 109 | 523 | 74 101 | 3 900 | 4 777 500 |

Mean live mass has been calculated on the recorded species frequencies. Strandings over the whole coastline of 2 500 km give an annual yield of approximately five million kilojoules and thus, on a proportionate allocation, the annual yield for the 100 km range round Eland's Bay would be about 200 000 kJ, assuming an even distribution.

Strandings of Toothed whales would have provided a bonus about once every three years of enough food for a band of 20 for some three or four days.

Any attempt to estimate the prehistoric energy yield from the few heavily exploited species (Mysticeti - Baleen whales and the Sperm whale Physeter catodon) would be too speculative. An arbitrary maximum of 1,5 million kilojoules from each animal might be applied which would provide enough food for at least one week or more but, if the historic record is true of eating nothing but whale for weeks or even months, this estimate is understated. Since the prehistoric incidence of strandings of these exploited species has been estimated at one every 10 years, the annual yield would be in the region of 150 000 kJ.

For all species, therefore, the annual yields would be :

| | |
|---|---|
| Toothed whales | 200 000 kJ p.a. |
| Baleen and Sperm whales | 150 000 kJ p.a. |
| | 350 000 kJ p.a. |

Since other categories of archaeological food debris have been expressed in kJ $m^{-3}$ of deposit, the cetacean estimate requires conversion to this standard unit as follows :

All Eland's Bay Sites - Ceramic Period 1800 - 300 BP

| | |
|---|---|
| Aggregate Volume of Deposit (approximately) (As discussed in Chapter 8) | 2 500 $m^3$ |
| Time Span for Accumulation | 1 500 years |
| Total kJ from Cetaceans over this time span | 1 500 yrs x 350 000 kJ p.a. |
| | = 525 million kj |
| kJ $m^{-3}$ of deposit | $\frac{525 \text{ million kJ}}{2\ 500\ m^3}$ |
| | = 210 000 kJ $m^{-3}$ |

4.9.6 Why Do Whales Strand and How Often?

Best (1982) summarises the numerous but unsubstantiated hypotheses on why whales strand with the indication that live strandings may be the culmination of a sequence of events as yet unknown. Re-strandings after rescue have been recorded here as elsewhere. No symptoms of disease, injury, parasitism or other similar cause has yet been found, but stranded animals, mostly offshore species, appear to be only semi-conscious. St Helena Bay seems to be one of several 'whale traps' or favoured stranding areas.

Klinowska (n.d.) has analysed British Museum records on cetacean strandings since 1911 along the coast of Britain. When plotted on a map, 'wash-ups' are widely distributed along shorelines, whereas live strandings are concentrated at certain places ('whale traps'), which appear to share only the single common characteristic of local geomagnetic topography. Klinowska therefore predicates that cetaceans, like some fish species, use geomagnetic clues to orient themselves and, like fish, can make mistakes and so strand. Off-shore species, unaccustomed to coastal waters, show a much higher frequency of live stranding than inshore species. On this hypothesis, symptoms of shock on stranding are predicted but no signs of disease or injury.

Several features are common to the British and South African strandings, e.g. 'whale traps', the higher frequency of off-shore species, the shock on stranding of apparently healthy animals, re-strandings after rescue, and the reference by Klinowska to three species in the British records - *Pseudorcas crassidens*, *Delphinus delphis* and *Globicephala melaena* - which also appear in the South African records (Table 4.9.1).

Klinowska's conclusion, although based on British data, may have some relevance to this study :

> "live strandings are very rare events. In 70 years, only 137 incidents have been recorded for 14 000 km of coastline and in many of these, all or most of the animals escaped. In comparison with almost 3 000 strandings of all types, including animals which have been dead for some time when first washed up, live strandings are very rare indeed."

When a live whale strands, hunter-gatherers must see or hear about it and get to the animal without delay. If whales are not cut open within seven days of stranding, the flesh becomes liquified and unusable for any purpose (Best, pers.comm.).

### 4.9.7 Conclusions

Stranded whales and dolphins may have provided a sporadic and unpredictable food supply in vast quantities, but probably only for a short time at intervals of several years. The dietary reconstructions (Appendices G.1 to G.6, pp.309/314) point to an adequate supply of a range of fresh foods that, after a time, seems likely to have replaced a single fare diet of putrid whalemeat. The historical records may therefore have little relevance to pre-contact times, when the scenario may have been more akin to Meehan's account of the modern Anbarra (1982: 40) :

> "in the diet of the Gidjingali or for that matter any hunting group, it is the amount of protein animal or vegetable that each person gets each day that really regulates the health of its members not the massive quantities brought in irregularly in the form of a buffalo, a large salt-water turtle or a dugong, though such fleshfalls are the ones that cause greatest excitement, praise and grand periods of feasting in the camps. Because the aborigines have no technology

> for storing flesh, this feasting can continue for only a few days at the outside. Then the community returns to the more usual pattern of food consumption and shellfish once again take their place as a stable dependable and acceptable source of flesh."

In the dietary reconstructions (Appendices G.1 to G.6), no account has been taken of whales and dolphins except for the identified cetacean remains recorded from PB/H and DK 1. A more realistic assessment should include estimates for cetaceans and therefore for Eland's Bay sites, a revised table has been compiled (Appendix G.1A).

## 4.10 SEALS

### 4.10.1 Introduction

The seal problem was first defined by Parkington (1976a: 108-114). Seals have a brief pupping season from late November to early December. The ages of seals up to two years old can be determined from measurement of the mandible which thus gives the month of catching and virtually all the seal mandibles recovered from the Ceramic period of EBC (Layers 1 to 6) were derived from animals of eight to 10 months old and were therefore caught between July and September. Young seal mandibles appear to give indisputable evidence of season of occupation, but the unexplained phenomenon is the prehistoric selection of eight to 10 month old animals.

Seal species which have been caught, sighted or beached in South African waters have been listed (Table 4.10.1, p.140).

## 4.10.2 Historical Evidence of Seal Exploitation

In this instance, a review of the historical evidence is given first to provide a background to the subsequent discussion and is derived from Skead (1980: 661-689) who has compiled a record of seal exploitation from 1497 to the mid-nineteenth century.

As commercial hunting has always been by vessel to off-shore islands and operated mostly from Cape Town as far north as Saldanha Bay, the Eland's Bay area and any mainland colonies of seals would have escaped hunting pressure. The first observation of seals being caught, roasted and eaten by indigenous people was reported in Vasco da Gama's log book (Raven-Hart 1971: 3), when he called at St Helena Bay in 1497. Da Gama also recorded that

> "seals attack man and no spear whatever the force with which it is thrown can wound them",

which was said in another way by Van Spilbergen (1615) that "seals move so quickly they are almost as fast as a man. The beast is also very savage and bites so fiercely". Both the locals and the European sealers killed seals by clubbing on the head (the method still in use). During Van Riebeek's tenure as Governor of the Cape from 1652 to 1662, the lesson was learned that seals are ashore in large numbers only from November to March and hunting outside these months was unproductive. Their objectives were skins and oil and, to a lesser extent, meat, and hunting tended to concentrate on the younger animals which were easier to catch and had more valuable skins (Thom 1952, Van Riebeek's Journal 1: 137-199; Mentzel 1785, 2: 138). Hottentots used sealskins for domestic purposes, including use as tobacco pouches (Paterson 1790: 109), but drying the skins at the Cape, even at the height of summer, meant they would have to remain on pegs for 14 days and still be in danger of rotting (Liebbrandt 1901, 2: 83). On the edibility of sealmeat, Da Gama's sailors were disgusted at the way the Hottentots cooked it (Raven-Hart 1967: 3), whereas Sir James Lancaster was favourably impressed by the "good meate" (Raven-Hart 1967: 24). Sealmeat provided fresh food for ships' crews but ashore was mainly used as slave food. There are no records of washed up seals and only one reference to drying sealmeat (Alexander 1838, 1: 85), which relates to a pastoralist group in the arid area of Port Nolloth in the early nineteenth century.

### 4.10.3 Commercial Exploitation of Seals

Smithers (1983) has provided data which enable a comparison of modern with prehistoric seal populations in South African waters. Modern numbers have been estimated at 345 000, and culling is controlled by annual quota (Sea Birds and Sea Fisheries Act, 1973), but even the present small quota is only of academic interest, as in recent years the actual rate of culling has fallen short of it. The problem today arises not from culling but from over-fishing, which deprives seals of their main source of food. The annual catch in the seventeenth and eighteenth centuries was about 30 000 and, by the time of Morell's voyage of 1829/30, there appeared to be fewer colonies and fewer seals but, with the introduction of control measures in the nineteenth century, seal populations seem to have recovered. It is an odd coincidence that culling today is restricted to the seven to 10 month old seals, the same age group as has been found in the EB sites.

### 4.10.4 Ecology of the Cape Fur Seal

All archaeological identifications refer to the Cape Fur seal (*Arctocephalus pusillus*), except at DK 1 where one Elephant seal (*Mirounga leonina*) was identified. Species other than the Cape Fur seal appear to be rare visitors to the southwest coast and have been ignored (Table 4.10.1).

An understanding of the ecology and lifecycle of the Cape Fur seal is necessary for the interpretation of the archaeological evidence (Parkington 1976a: 108-110), and the following account has been summarised from Smithers (1983: 512-514).

Seal terrestrial haulouts occur on rocky islands above high tide level and on rocky promontories or sandy beaches tenable at low tide. Males start to arrive at breeding sites in mid-October and, having established a territory, do not move off for up to six weeks during which time they live off their food reserves. Females follow a few weeks later and give birth to single pups, mostly in late November to early December, with 90% born within a 34 day period. Impregnation of females usually occurs within seven days of parturition. Pups tend to form play groups and, with the lengthening absence of their mothers on foraging trips, are driven by hunger to explore the deeper waters. Suckling continues for most of their first year, but from July onwards, gradual weaning forces them to rely increasingly on their own foraging and they may stay away from land for three to four days at a time.

Zurstrassen (1971) has provided further information from many years of observation of a large mainland colony estimated to exceed 100 000 animals at the isolated Cape Cross on the Namibian coast. Seal rookeries during the non-breeding season, are temporary haulouts used by local seals and by strangers, mostly yearlings. Weaning causes pups to lose so much weight that they really seem to shrink. Only after the fighting and mating season, when the males have used up their food reserves, do some of them die and get washed up in significant numbers.

### 4.10.5 Energy Evaluation

Dr Jeremy David of the Marine Mammal Research Laboratory of the Sea Fisheries Research Institute has kindly supplied the required data :

| | Mean Mass (kg) | |
|---|---|---|
| | Males | Females |
| Yearlings | 21,5 | 18,8 |
| Second Year Seals | 25,0 | 25,9 |
| Adults (Sexually mature at 3 years; a harem may comprise up to 50 females) | Up to 250 | 57 (N=201) |
| Ratio of Edible to Live Mass | 55% | |
| kJ 100 $g^{-1}$ Edible (including viscera and some blubber) | 750 | |

For sealmeat only, Croes et al. (n.d. Table 3: 8) quote 635 kJ 100 $g^{-1}$ for the Harbour and Northern Fur seals. First and second year seals have overlapping ranges in weight and cannot be distinguished by appearance only. Mammalogists distinguish them by the canine teeth, which, like the mandible, continues growing during the early years.

## 4.10.6 Archaeological Evidence

Parkington (1976a) ascribed virtually all the seal bone in the EBC sequence to yearlings and the 21 seals identified by Horwitz (1979: 74) were also related to the same restricted age group. This phenomenon suggests that there were no prehistoric breeding sites in the vicinity of Eland's Bay as otherwise more adult wash-ups would have occurred. Seal bones for both young and mature animals have been recovered from Nelson Bay Cave (Klein 1972), where there is a modern seal colony in the vicinity. 'Black pups' of one to five months old from breeding colonies get drowned occasionally during heavy seas (Zurstrassen 1971) and wash up on shore, but no black pups have been identified at EB sites. Prehistoric foragers would have encountered the same problems as the early European sealers when raiding a colony or haulout and trying to select yearlings : the sealers were involved in much indiscriminate killing partly for self-protection, and the absence of archaeological evidence for such indiscriminate killing or wash-ups of adults or black pups suggests that there were no breeding colonies in the area to raid.

There is only one aspect of seal behaviour that might explain the phenomenon of yearlings only. "Young seals may form play groups on the beaches (my italics) above the high water mark" (Smithers 1983: 513), and these groups might all be yearlings and a continuance of the earlier play groups on the rocks. Presumably such groupings would be sporadic and short-lived while on the beaches and the encounter rate for hunter-gatherers would therefore be low and likely to be separated by many blank years. It is also possible that seals used the rocky promontories at Eland's Bay as temporary haulouts and that, as noted by Zurstrassen (op.cit.), such groups might include yearling strangers to the area, but this hypothesis leaves the problem of selection unresolved.

A low encounter rate can also be inferred from the EB evidence (Table 4.10.2, p.141). An MNI of 24 seals at EBC over a period of 1 500 years gives an incidence of only one seal every 60 years and for all sites in the area, one every 30 years. The rate of seal catches in the EBC sequence prior to 1800 BP is similarly low, with the single exception of Layer 12, dated to 9600 BP, which produced an MNI of 37. Seal abundance at this time may be linked to the supplanting of limpets by mussels and the presence of some phenomenally large rock lobsters in Layer 10, which is throught to be partly synchronous with Layer 12 (Parkington, pers.comm.).

## 4.10.7 Energy Evaluation

Energy yields have been calculated on the parameters provided by Dr David and on the assumption that the mean live mass per seal can be taken at 25 kg. Results on this basis for EB (Table 4.10.2) and for other southwestern coast sites (Appendix H.6, p.320) are given.

## 4.11 BIRDS

### 4.11.1 Energy Evaluation

I am indebted to Dr Richard Brook and Dr David Duthie of the Percy FitzPatrick Institute of African Ornithology for data and guidance to help calculate the energy yield from birds. Neither was aware of any research into the kilojoule yield from the edible portion of wild birds, but Dr Duthie suggested that, since the majority of wild bird remains found at coastal sites would be seabirds, the published figures for wild duck from the Tables of the Composition of Foods might be appropriate.

For the three species of wild birds listed in these Tables, the mean value is 611 $\pm$ 20 kJ 100 $g^{-1}$ (N=7) and for wild duck only 599 kJ 100 $g^{-1}$ (Table 4.2.2). The only other determination I have found is from Croes et al. (n.d. Table 3: 8), which gives a value of 520 kJ 100 $g^{-1}$ for waterfowl. A value of 600 has been assumed and the percentage edible to live mass taken at : Penguins 60% and all other species 75%, as suggested by Dr Duthie. For North American species, Keene (1981, Table A3.2) adopted 75% edible. Where archaeological identifications are to genus only, the live mass has been taken for the locally most common species of that genus.

On these parameters, the energy yield per bird for each species has been estimated (Table 4.11.1, p.142) and applied to the data for EB excavated sites (Table 4.11.2, p.143) and for all sites on the southwest coast (Appendix H.7, p. 321).

### 4.11.2 Species Frequencies

Analysis of species frequencies (Table 4.11.3, p.144) demonstrates the dominance of coastal birds, of which only a small proportion are oceanic and must have been scavenged from the beach. Species habitats have been distinguished by Avery (n.d. Table 1) into oceanic/nearshore and terrestrial/freshwater between which there is much overlapping. The classification in Table 4.11.3 is no more than an indication of the species taken within the catchment of a coastal site.

### 4.11.3 Birds as Seasonal Indicators

Seabirds washed up on the beach would appear to have been the main source of edible bird flesh, although some may have been caught, trapped or taken by baited line. From beach surveys, Avery has deduced a pattern of mortality at Eland's Bay which shows that 80% of overall modern seabird mortality occurs between November and April, and that a similar incidence applies to the Cape Cormorant Phalacrocorax capensis, which accounts for nearly two-thirds of the numbers of birds identified at the EB excavated sites. The area may, therefore, have been visited mainly in summer on this bird evidence but the hypothesis will be tested by Avery's current study of seasonal breeders by age and of the presence of medullary bone in females.

### 4.11.4 Non-Human Agents of Accumulation

Avery (n.d.) has expressed the view that non-human agents of accumulation may not be a serious problem in shell middens where rapid accumulation and concomitant contiguity of components can be assumed, which is supported by the archaeological evidence. Predators and non-human agents of accumulation would be more active in caves than on open sites, although the organic remains might have been equally attractive on both types of site. A comparison of the numbers of bird identifications (Table 4.11.4, p.145) indicates the reverse, even when DE and PN are excluded in view of the extraordinary high counts from these two sites which may be due to special circumstances such as mass mortalities. No species-specific bone modifications have been noted in site reports, nor is there any reference to accumulations of micro-mammalian bones such as was observed in a small rock shelter site in a gulley at EB.

### 4.11.5 Mean Energy Yield Per Bird

The consistency in mean kilojoule yield per bird reflects mainly the uniform methods applied in calculations and the similarity in species frequencies. Over all sites, the hunter-gatherers of the southwest coast derived about 7 000 kJ per bird consumed or about 1 200 grams of edible flesh, which would produce only a few mouthfuls if shared. The indigenous folk living in a temperate forest in North America did not fare any better (Keene 1981, Table 6.1) as their energy yield per bird was only 6 284 kJ.

## 4.12 TORTOISE

Studies of the common South African tortoise *Chersina ungulata* have been made by Dr W. Branch of the Port Elizabeth Museum, A. de Villiers of the Cape Provincial Administration Nature and Environmental Conservation Department and by John Greig, Editor of *African Wildlife*, but, unfortunately, none is aware of research into the live mass, edible portion or energy yield of any species of reptile.

### 4.12.1 Ecology of *Chersina ungulata*

Tortoises are fairly abundant today in the southwestern Cape, but population numbers would be sensitive to intensive predation even over only short spells. Tortoise do not hibernate in this area, but are active all the year round, September and October, after the winter rains, being the peak of activity and visibility (Greig, pers.comm.). Tortoise bones in deposits are therefore not seasonal indicators.

### 4.12.2 Energy Evaluation

Parkington (1976a, Table 5: 3) calculated MNI on the assumption that 100 grams of tortoise bone equals one tortoise. The average fresh bone weight for a tortoise is about 300 grams (Branch, pers.comm.) and, since the moisture content of most organic tissue is about 75% ± 10%, the Parkington assumption appears sufficiently accurate. The only determination of energy yield from reptiles that I have been able to trace is from Brand *et al*. (1983, Table 3), which gives 557 kJ 100 $g^{-1}$ for the Turtle *Chelodina rugosa*. This yield applied to the average edible content of 340 grams (Branch, pers.comm.), gives an energy yield of some 2 000 kJ per animal. On these parameters, the energy yields for EB excavated sites (Table 4.12.1, p.146) and for all southwest coast sites (Appendix H.8, p.322) have been calculated.

These results confirm Parkington's conclusion that tortoise were a minor item in the prehistoric diet of the late

Holocene. During the earlier period from 11 000 to 7800 BP, at EBC, tortoise numbers per cubic metre of deposit were at least ten times greater than in the late Holocene, which adds a terrestrial element to the evidence of more intensive exploitation of mussels, lobsters and seals during these times. The occupants of EBC may have been adapting to a new environment as a result of the post-glacial rise in sea level and developing the most efficient strategy for food procurement.

### 4.12.3 Other Reptiles

The bones of snakes and other reptiles are occasional finds in deposits, but may not represent food debris and, similarly, for micromammals. Both have therefore been ignored.

## 4.13 PLANT FOODS

The identified remains recovered from the whole EBC sequence of more than 10 000 years (Parkington 1976a: 87-88) comprise minimal evidence of three potentially edible species, the leaves of two species of doubtful food value, two species of seaweeds and one of estuarine grass. Although plant remains were present in all levels and preservation was good, plant foods were nowhere well represented and are inadequate as a basis for estimating energy yield. Cormbearing plants, a major food source of inland groups (Parkington 1976a) are extremely rare in coastal sites and are recorded only in Layers 1, 2 and 13. Seeds are similarly rare. Seaweeds have a high energy value of about 1 000 kJ 100 $g^{-1}$ (Table 4.2.2) and all are edible (South African Defence Force, Survival Handout), but the giant kelp Ecklonia maxima is very tough and is noted in Layers 1 and 2 only with another seaweed Gigartina striata only in Layer 13. Seaweeds are listed in the Tables of the Composition of Foods which implies their use as food in modern diets but the cave occupants appear to have ignored seaweeds as a food source. The estuarine grass Zostera capensis, ubiquitous throughout the deposit, was probably brought in as bedding material.

Analysis of the plant remains from the post-1976 excavations of EBC (Liengme, pers.comm.) has revealed a wider spectrum of species but none in any significant quantity. Research on coastal and inland edible plants is in progress.

The exploitation of plant foods is sometimes inferred from the presence in deposits of implements for collecting and preparing them, but the whole sequence at EBC failed to produce a single perforated stone or digging stick and only a few grindstones, mostly from the very early levels (Pettigrew 1977: 48; Sievers 1977: 23). The evidence from the other three excavated sites at EB proved likewise unhelpful.

Arbitrary estimates of energy yields from edible plants have been inserted in Appendix G.1(a) (p.309) and in Tables 5.5 (p.167) and 5.6 (p.168) of Chapter 5 to round off the totals.

# TABLE 4.2.1

## REFERENCES

## FOOD COMPOSITION TABLES


### United Kingdom

A.E. Bender (1979). Calories and Nutrition, 4th edition. London: Mitchell Beazley.

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W.R. Ackroyd and V.N. Patwardhan (1956). The Nutritive Value of Indian Foods. Indian Res. Fund Ass. Hlth. Bull. No. 23.

Australia

S. Thomas and M. Corden (1970). Tables of the Composition of Australian Foods. Canberra: Australian Government Publishing Section - Commonwealth Department of Health Nutrition Section Canberra.

International

Food Composition Tables for International Use (1949). Rome: Food and Agricultural Organisation of the United National Organisation - Nutritional Studies No. 3. Rome.

## TABLE 4.2.2

## ENERGY YIELDS PER 100 GRAMS OF RAW EDIBLE PORTION

| Category | | kJ 100g$^{-1}$ n | $\bar{x}$ | s |
|---|---|---|---|---|
| Nuts & Seeds | Almonds, Brazil, cashew and mongongo nuts, peanuts and walnuts | 22 | 2500 | 77 |
| Cereals | Barley, maize, rice, sorghum, wheat | 14 | 1429 | 80 |
| Meat (Domesticated) | Cattle, sheep, pig, goat | 9 | 1290 | 154 |
| Meat (Wild) | Boar, water buffalo, hare, rabbit, raindeer, venison | 9 | 588 | 94 |
| Honey | | 4 | 1203 | 75 |
| Seaweeds | *Gelidium*, *Porphyra*, *Lamminaria*, *Ecklonia*, *Ulva* spp. | 5 | 1037 | 156 |
| Fish (Fatty) | Herring, mackerel, mullet, salmon, stompnose, yellowtail | 17 | 711 | 137 |
| Fish (Other) | Seabass, carp, cod, haddock, hake | 17 | 350 | 63 |
| Whales & Dolphins | Whalemeat | 1 | 655 | |
| | Dolphin | 1 | 370 | |
| Birds (Wild) | Duck, pheasant, quail | 7 | 611 | 20 |
| Crustacea | Crayfish, lobster, prawns, shrimps | 9 | 394 | 16 |
| Molluscs | Albalone, clams, cockles, limpets, mussels, oysters, scallops, whelks | 29 | 327 | 66 |
| Fruit | Apples, figs, grapes, lemons, oranges, plums, prickly pears | 20 | 206 | 65 |

The only observed anomalies were acorns and chestnuts whose kJ 100 g$^{-1}$ were 202 and 770 against a mean of 2500 for the other nuts and seeds specified.

TABLE 4.3.1

LIMPETS - METHODS OF SAMPLE ANALYSIS & DETERMINATION OF TOTAL KILOJOULES FOR EACH SAMPLE

1. Analysis of Samples

(a) Segregate the shell remains into the four species and an unidentifiable residue;

(b) For each species :

(i) extract shells with a reasonably intact base, record the maximum width across the base of each shell and the overall weight of shell;

(ii) for the residue of broken shells, apices and fragments, count and record the number of apices and the overall weight of shell.

(c) For the unidentifiable residue, count and record the number of apices (M.N.I.) and the overall weight of shell; allocate the M.N.I. and shell weight to species on the undernoted percentages which have been derived from analyses of samples (N = 2144 and N = 9026) from west coast middens :

| | Allocation of | |
|---|---|---|
| | M.N.I. | Shell Weight |
| *P. granatina* | 64% | 67% |
| *P. granularis* | 30% | 17% |
| *P. argenvillei* | 4% | 11% |
| *P. barbara* | 2% | 5% |
| | 100% | 100% |

(d) Summarise the resultant data

| | P. granatina | | P. granularis | | P. argenvillei | | P. barbara | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | M.N.I. | Wt(g) | M.N.I. | Wt(g) | M.N.I. | Wt(g) | M.N.I. | Wt(g) | M.N.I. | Wt(g) |
| Measured Shells | | | | | | | | | | |
| Residues :<br>Identifiable<br>Unidentifiable | | | | | | | | | | |
| Sub-Total Residues | | | | | | | | | | |
| Total - Whole Sample | | | | | | | | | | |

## 2. Estimation of Kilojoule Yields

(a) Measured Shells : The kJ yield for each mm in size for each species is listed (Appendix K.1, p.326). Size is the maximum width across the base. The aggregate yield from measured shells is added in after the yield from the residues has been determined to give the total yield from the sample.

(b) Residues (Identifiable and Unidentifiable) : For these residues, different methods can be used or a combination of methods dependent on the time and data available.

Method 1 - on M.N.I. and mean weight per shell for each species : Division of shell weight by the M.N.I. (see 1(d) above produces a mean weight per shell, which can be translated into a mean kilojoule yield per shell by reference to the List of Kilojoule Yields by Size (Appendix K.1). Then

Mean kJ Yield x M.N.I. = Total Kilojoules.

Method 2 - by use of a factor to convert total shell weight directly into total kilojoules : The required factor is 100 grams of shell = 350 kJ and has been calculated from three independent sources.

| | kJ 100 $g^{-1}$ shell |
|---|---|
| Measured shells from sampled sites (Appendices L.1(a) - L.1(f)) (N=358; shell weight = 3027 g; total kJ on individual shell measurements = 10467 kJ) | 345,8 |
| *P. granatina* & *P. granularis* only (Rebelo (1982)) | 347,0 |
| Formulae for calculating the wet flesh weight of *P. granatina* & *P. granularis* (Branch (1974: 193)) | 369,0 |

Methods 3(a) and 3(b) - on assumed mean sizes and species frequencies : Method 1 is laborious and time-consuming and Method 2 is dependent on the availability of shell weights. Methods 3(a) and 3(b) are quicker and rely on assumptions, i.e. in Method 3(a), that the mean size of each species and consequently the equivalent mean kJ yield does not vary significantly from the consistent pattern for west coast middens as shown below :

| | N | Mean Size (mm) | Range | Assumed Mean Size (mm) | Equivalent Mean kJ Yield |
|---|---|---|---|---|---|
| *P. granatina* | 9049 | 51,6 | 49,8-56,7 | 52 | 28 |
| *P. granularis* | 9002 | 36,5 | 35,5-38,9 | 36 | 10 |
| *P. argenvillei* | 239 | 70,4 | 65,1-75,1 | 70 | 67 |
| *P. barbara* | 124 | 65,7 | 64,3-72,7 | 65 | 60 |

and in Method 3(b) that the mean kJ yield over all species does not vary significantly from 24 kJ which is derived from calculations by the other methods.

## 3. Comparison of Estimates of Total Kilojoules by Each of These Methods

| Method | M.N.I. | Total Kilojoules | Mean kJ Yield Per Shell |
|---|---|---|---|
| 1 | 3414 | 78812 | 23,1 |
| 2 | 3414 | 78659 | 23,0 |
| 3(a) | 3414 | 84636 | 24,8 |
| 3(b) | 3414 | 83302 | 24,4 |

The above totals include 358 measured shells at kJ values determined from their individual shell measurements which produced 10467 kJ in total or a mean yield of 29,2 per shell. Measurable shells tend to be the more robust and larger and if only their mean size is used to calculate total kilojoule yields for a whole sample, the results are likely to be over-stated by some 15% - 25%.

## TABLE 4.3.2

## COMPARISON OF DATA ON LIMPETS
## BAILEY (1975) WITH ELAND'S BAY SITES

| | Bailey (1975) | | Eland's Bay Sites | |
|---|---|---|---|---|
| Number | 33 | | 3414 | |
| Total Weights (g) of | | | | |
| Shell | 213 | | 22474 | |
| Meat | 241 | | 18388 | |
| Gross | 454 | | 40862 | |
| Mean Weights (g) of | | | | |
| Shell | 6,5 | 47,1% | 6,6 | 55% |
| Meat | 7,3 | 52,9% | 5,4 | 45% |
| Gross | 13,8 | | 12,0 | |
| Total kJ Yield | 690 | | 78812 | |
| Mean kJ Yield | 20,9 | | 23,1 | |
| kJ Per 100 Grams of | | | | |
| Shell | 324 | | 350 | |
| Meat | 286 | | 429 | |
| Gross | 152 | | 193 | |
| Ratio of Meat to Shell | 42 : 58* | | 45 : 55 | |
| | 45 : 55** | | | |
| | 53 : 47*** | | | |

* Paterson, (1839)
** Townsend, (1967) Bailey quotes all three of these ratios
*** Unstated

## TABLE 4.4.1

## DATA ON THE BLACK MUSSEL CHOROMYTILUS MERIDIONALIS

| | |
|---|---|
| Dry Flesh Mass | = $1{,}251 \times 10^{-5} \times$ Length of Shell$^{2.646}$ (mm) |
| kJ $g^{-1}$ Dry Flesh Mass | = 19,5 kJ |
| kJ $g^{-1}$ Dry Whole Shell | = 0,957 kJ |
| Composition of Dry Somatic Flesh | = Water - 82,12% Dry Flesh - 16,88% |

Parameters derived from the above data :

kJ per 100 grams of

| | |
|---|---|
| Wet Flesh | = 330 kJ |
| Shell Weight | = 150 kJ |
| Gross Weight | = 108 kJ |

(Taking the water content of the shell at 15% (Griffiths, pers.comm.)

| | |
|---|---|
| Ratio of Wet Flesh to Shell Weight | 31,3 : 68,7 |
| Dry Flesh Weight | = $\frac{\text{Total Kilojoules}}{19{,}5}$ |
| Wet Flesh Weight | = $\frac{\text{Dry Flesh Weight}}{16{,}88} \times 100$ |

Source : Griffiths (1981: 104)

## TABLE 4.4.2

## CHOROMYTILUS MERIDIONALIS - METHODS FOR ESTIMATING TOTAL kJ

Method 1 - On M.N.I. and Mean Weight per Shell

The technique is the same as Method 1 for Limpets and is illustrated below :

| | |
|---|---|
| N | 632 |
| Total Shell Weight | 11539 grams |
| Mean Weight per Shell | 18,3 grams |
| Equivalent Mean Length (Appendix K.2) | 82,7 mm |
| Equivalent Mean kJ Yield (Appendix K.2) | 28,9 kJ |
| Total kJ in Sample 632 x 28,9 kJ | 18264 kJ |

Total kJ from this sample calculated by Griffith's formula on individual shell measurements came to 18203 kJ, which gives a margin of error from the use of Method 1 of 0,3%.

Method 2 - An Index to Increase the Number of Shell Length Measurements

Along the interior margin of the shell is a blue/black band; the maximum width of this band on the anterior portion of the shell (which incorporates the hinge) is strongly correlated (r = 0,97) to the length of the shell at - band width (mm) x 10 = shell length (mm) (Buchanan 1985). Use of this index may increase the number of shell length measurements to statistical adequacy.

Method 3 - By Use of a Factor to Convert Total Shell Weight to Total Kilojoules

A conversion factor of 100 grams of shell weight = 150 kJ has been calculated on data from Eland's Bay sites and compared with factors used by other authors (Table 4.4.3).

Method 4 - On Assumed Mean Shell Length

A mean length of 78/82 mm and equivalent yield of about 28 kJ might be assumed for a sample of Black Mussels where the M.N.I. exceeds 100 and preferably 250. Archaeological specimens of Black Mussels can range from under 20 mm in shell length to over 150 mm with a corresponding range in kJ yield from under 1,0 kJ to over 120 kJ. There are therefore potentially significant differences in mean values for discrete samples from the same midden. Seven samples from Layers 1 to 6 of EBC produced mean yields from 16 to 35 kJ. As sample size increases, the mean size tends to focus on about 80/82 mm or about 28 kJ (Appendix M, pp.338/339).

# TABLE 4.4.3

## CHOROMYTILUS MERIDIONALIS - ANALYSIS OF DATA FROM ELAND'S BAY SITES

| | Sampled Sites | Tortoise Cave* Site TT2 | All Sites Measured Shells Only | All Sites All Shells |
|---|---|---|---|---|
| N | 36 | 93 | 632 | 2683 |
| Weight (g) of | | | | |
| Shell | 620 | 2679 | 11539 | 50253 |
| Wet Flesh | 287 | 1261 | 5530 | 23964 |
| Gross | 907 | 3940 | 17069 | 74217 |
| Mean Weights (g) of | | | | |
| Shell | 17,2 | 28,8 | 18,3 | 18,7 |
| Wet Flesh | 8,0 | 13,6 | 8,7 | 8,9 |
| Gross | 25,2 | 42,4 | 27,0 | 27,6 |
| Ratio | | | | |
| Wet Flesh/Shell | 46,3% | 47,1% | 47,9% | 47,7% |
| Wet Flesh/Gross | 31,6% | 32,0% | 32,4% | 32,3% |
| Mean Length (mm) | 75,1 | 95,3 | 82,7 | 83,2 |
| Total Kilojoules | 945 | 4156 | 18203 | 78802 |
| Mean kJ Yield | 26,3 | 44,7 | 28,8 | 29,4 |
| kJ per 100 Grams of | | | | |
| Shell | 152 | 155 | 158 | 157 |
| Wet Flesh | 329 | 330 | 329 | 329 |
| Gross | 104 | 105 | 107 | 106 |

*The sample from Tortoise Cave (Robey, 1984) was a localised concentration of large mussel shells found during excavation. Although very different in mean weights and mean length, kJ per 100 grams are the same as for the other samples.

Comparisons

| | | |
|---|---|---|
| Ratio : Wet Flesh/Gross | 35%-40% | (Davies 1969: 425, *M. edulis*) |
| | 33,4% | (Meehan 1982: 142, *Mytilidae*) |
| | 30,0% | (Cook 1946: 51, Californian sp.) Ratio adopted by Meighan (1958: 4) & Glassow (1967: 356) |
| | 31,3% | (Griffiths 1981: 104, *C. meridionalis*) |
| kJ 100 $g^{-1}$ Wet Flesh | 336 | (Bailey 1975: Table III: 2) Derived from McCance & Widdowson (1960) & Tresler & Lemon (1951) |
| | 336 | (Meehan 1982: 43) Derived from Shawcross (1967) & Thomas & Corden (1970) |
| | 330 | (Griffiths 1981: 104) |
| Ratio : Dry/Wet Flesh | 17,6% | (Davies 1969: 425, *M. edulis*) |
| | 16,9% | (Griffiths 1981: 104, *C. meridionalis*) |

## TABLE 4.4.4

## COMPARISON OF DATA FROM BAILEY AND FROM ELAND'S BAY SITES

| | Bailey (1975, II: 5) | | Eland's Bay Sites |
|---|---|---|---|
| Mean kJ Yield | Table III: 8 | *8,4 | 28 |
| Mean Weight (g) of | | | |
| Shell | - | - | 19 |
| Flesh | Table III: 8 | *3,0 | 9 |
| Gross | Table III: 9 | *8,0 | 28 |
| Ratio : Flesh/Shell Weight | Table III: 7 | *42:58 | 31,3:68,7 |
| | | **17:83 | |
| | | ***29:71 | |
| | | +25:75 | |
| Mean Value of Flesh/ Shell Weight Ratio | | 30:70 | |

Sources :
* Cook (1946)
** Bender (1968)
*** Davies (1969)
+ McCance & Widdowson (1960)

TABLE 4.6.1

PUBLISHED ENERGY VALUES FOR LOBSTERS

| kJ 100 $g^{-1}$ | Source | State |
|---|---|---|
| 352 | Field *et al.* (1980) up to 50 mm | Raw |
| 469 | Larger than 50 mm | Raw |
| 395 | Barton (1983: 32) | Raw |
| 329 | Bender (1979: 94) | Boiled |
| 498 | McCance & Widdowson (1978) | Raw |
| 380 | Watt & Merrill (1975) | Raw |
| 395 | Food Composition Tables, U.S. Dept. of Health/Food & Agricultural Organisation (1972) | Raw |
| 385 | Food Composition Tables/F.A.O. Nutritional Studies No. 3 (1949) | Raw |
| 380 | Australian Calorie Counter (1981) | Boiled |

Mean Value : kJ 100 $g^{-1}$ = $398 \pm 53$

TABLE 4.6.2

ROCK LOBSTERS - SPATIAL DISTRIBUTION AMONG ELAND'S BAY SITES

(Period 1800 - 300 BP)

| Sites by Area | M.N.I. | Volume of Samples ($m^3$) | N $m^{-3}$ | kJ $m^{-3}$ |
|---|---|---|---|---|
| Vlei | 5 | 0,2590 | 19 | 15444 |
| Bay | 385 | 11,2625 | 34 | 27347 |
| Baboon Point | 1079 | 28,1400 | 38 | 36675 |
| Mussel Point | Nil | | | |
| | 1469 | 39,6615 | 37 | 29631 |

ROCK LOBSTERS - SPATIAL DISTRIBUTION AMONG SITES ALONG THE SOUTHWEST COAST

Eland's Bay to Cape Point (West Coast)

| | | | | |
|---|---|---|---|---|
| All EB Sites (as above) | | | | |
| DE | 418 | 0,7807 | 535 | 428334 |
| PN | 335 | 2,7582 | 122 | 97200 |
| BS | 44 | 0,7696 | 65 | 38846 |
| HBC* | 3 | 1,3000 | 2 | 1440 |

Cape Point to Danger Point

| | | | | |
|---|---|---|---|---|
| SM | Nil | | | |
| ROI | 39 | 2,6000 | 15 | 9000 |
| PB/H | 22 | 1,3650 | 16 | 9670 |
| DK1 | Nil | | | |

*The steep coastal topography and south facing bay inhibit catching and stranding

## TABLE 4.6.3

## ROCK LOBSTERS

### Temporal Distribution at Eland's Bay Cave

(Period 11 000 - 300 BP)

| Layers | Period BP (Approx.) | M.N.I. | Volume of Sample ($m^3$) | N $m^{-3}$ | kJ $m^{-3}$ |
|---|---|---|---|---|---|
| 1/6 | 300- 1800 | 1079 | 28,14 | 38,3 | 39675 |
| 7/9 | 1800- 3800 | 148 | 12,92 | 11,5 | 9164 |
| 10/15 | 8000-11000 | 801 | 24,48 | 32,7 | 27176 |

### Temporal Distribution at Bonteberg Shelter

(Dates - 4105 and 1650 BP)

| Depth | Number of Fragments |
|---|---|
| 0" - 12" | 172 |
| 13" - 24" | 121 |
| 25" - 36" | 65 |

TABLE 4.7.1

CALCULATION OF MEAN KILOJOULE YIELD PER FISH

| | Mean Values | | Edible Portion | | Source | Mean kJ Yield |
|---|---|---|---|---|---|---|
| | Length | Live Weight | Weight 70% | kJ 100 $g^{-1}$ | (See Below) | per Fish |
| | (mm) | (g) | (g) | kJ | | kJ |
| Barbel *Tachysurus foliceps* | 300 | 286 | 200 | 440 | Estimate | 880 |
| Blacktail *Diplodus sargus* | 200 | 220 | 154 | 440 | Estimate | 678 |
| Catfish *Tachysurus* sp. | 240 | 264 | 185 | 440 | Estimate | 814 |
| Elf *Pomatomus saltatrix* | 400 | 352 | 246 | 531 | (b) | 1306 |
| Galjoen *Coracinus capensis* | 260 | 275 | 193 | 578 | (b) | 1116 |
| Harder *Mugilidae* sp. | 240 | 264 | 185 | 674 | (b) | 1247 |
| Hottentot *Pachymetopon blochii* | 200 | 220 | 154 | 430 | (b) | 662 |
| Kingklip *Xiphiurus capensis* | 900 | 2000 | 1400 | 322 | (a) & (b) | 4500 |
| Klipvis *Clinidae* sp. | 90 | 90 | 63 | 440 | Estimate | 277 |
| Kabeljou *Argyrosomus hololepidotus* | 500 | 935 | 655 | 374 | (a) & (b) | 2450 |
| Mullet *Mugil capensis* | 240 | 220 | 154 | 592 | (c) & (d) | 912 |
| Snoek *Thyrsites atun* | 900 | 2500 | 1750 | 660 | (a) & (b) | 1550 |
| White Steenbras *Lithognathus lithognathus* | 340 | 638 | 447 | 420 | (b) | 1877 |
| White Stumpnose *Rhabdosargus globiceps* | 240 | 264 | 185 | 471 | (b) | 871 |
| Yellowtail *Seriola lalandi* | 1000 | 5000 | 3500 | 603 | (b) | 21100 |
| Mean Value | 337 | 909 | 565 | 494 | | 3350 |
| Standard Deviation | 250 | 332 | 212 | 105 | | 5660 |

Sources :
(a) Simmonds & Tanner (1980) and Simmonds & Seaman (1981)
(b) Barton (1979)
(c) Bender (1979)
(d) Seafood Signal (1982)

TABLE 4.7.2

FISH - SPATIAL DISTRIBUTION BY SITES - ELAND'S BAY

| Area | No. of Sites | Volume of Sample ($m^3$) | N | N $m^{-3}$ | kJ $m^{-3}$ | Mean kJ Yield per Fish |
|---|---|---|---|---|---|---|
| Vlei | 11 | 0,2365 | 13 | 51,0 | 60038 | 1177 |
| Bay | 17 | 3,4813 | 16 | 4,0 | 6652 | 1663 |
| Baboon Point | 4 | 35,9740 | 261 | 7,0 | 10834 | 1548 |
| Other | 4 | 0,0485 | - | | - | - |
| | 36 | 39,7403 | 290 | 7,3 | 10901 | 1493 |

TABLE 4.7.3

FISH - SOUTHWEST COAST SITES

| | M.N.I. | Volume of Sample ($m^3$) | Total Kilojoules | N $m^{-3}$ | kJ $m^{-3}$ | Mean kJ/Fish |
|---|---|---|---|---|---|---|
| **West Coast Sites** | | | | | | |
| EB | 290 | 39,7403 | 433 209 | 7,3 | 10901 | 1493 |
| DE | 31 | 0,7807 | 27 239 | 39,7 | 34890 | 879 |
| DN | 83 | 2,7582 | 54 946 | 30,1 | 19921 | 662 |
| HBC | 112 | 1,3000 | 95 649 | 86,0 | 73576 | 854 |
| | 516 | 44,5792 | 611 043 | 11,6 | 11858 | 1184 |
| **Sites East of Cape Point** | | | | | | |
| SM | 438 | 12,5000 | 1 677 449 | 35,0 | 134196 | 3830 |
| ROOI | 596 | 2,6000 | 1 512 628 | 229,0 | 581780 | 2538 |
| PB/H | 115 | 1,3650 | 146 268 | 84,0 | 107157 | 1272 |
| | 1149 | 16,4650 | 3 336 345 | 69,8 | 202633 | 2904 |
| DK1 | 5282 | 37,3000 | 3 818 823 | 142,0 | 102381 | 723 |

West Coast Sites

HBC : The large numbers (86 N $m^{-3}$ compared with average of only 11,6 N $m^{-3}$) and the rather small average size of fish suggest netting or trapping in the estuary which flows into Hout Bay.

Sites East of Cape Point

DK1 : Results are anomalous in relation to other sites along the coast - a high rate of catch but mostly of small fish.

SM & ROOI : The areas round these sites are favoured by rock anglers today

TABLE 4.8.1

ENERGY YIELD OF TERRESTRIAL MAMMALS

| | Mean Live Mass (kg) | % Edible | Edible Mass (kg) | kJ Yield Per Animal |
|---|---|---|---|---|
| Baboon, Chacma *Papio ursinus* | 23,5 | 60 | 14,1 | 98700 |
| Blesbok *Damaliscus dorcas phillipsi* | 65,0 | 60 | 39,0 | 273000 |
| Blue Antelope *Hippotragus leucophaeus** | 167,0 | 60 | 100,0 | 700000 |
| Bovids (Unidentified) | | | | |
| Very small, up to 10 kg | 6,0 | 70 | 3,6 | 25000 |
| Small, 10 - 25 kg | 15,0 | 60 | 9,0 | 63000 |
| Small-Medium, 25 - 100 kg | 50,0 | 60 | 30,0 | 210000 |
| Large-Medium, 100 - 500 kg | 250,0 | 60 | 150,0 | 1050000 |
| Large, 500 - 1000 kg | 750,0 | 60 | 450,0 | 3150000 |
| Bontebok *Damaliscus dorcas* | 75,0 | 60 | 45,0 | 315000 |
| Buffalo *Syncerus caffer* | 750,0 | 60 | 450,0 | 3150000 |
| Bushbuck *Tragelaphus scriptus* | 35,0 | 60 | 21,0 | 147000 |
| Bushpig *Potomochoerus porcus* | 60,0 | 60 | 36,0 | 253890 |
| Caracal *Felis caracal* | 8,7 | 60 | 5,2 | 36540 |
| Cat, African Wild *Felis lybica* | 4,5 | 70 | 3,2 | 22050 |
| Cattle (Domesticated) *Bos* sp. | | | | |
| Small | | | | 2000000 |
| Large | | | | 3000000 |
| Duiker, Blue *Cephalophus monticola* | 4,7 | 70 | 3,3 | 23100 |
| Duiker, Grimm's *Sylvicapra grimmia* | 19,7 | 60 | 11,8 | 82740 |
| Eland *Taurotragus oryx* | 580,0 | 60 | 348,0 | 2436000 |
| Genet *Genetta genetta* | 1,9 | 70 | 1,3 | 9100 |
| Gerbil, Cape *Tatera afra* | 0,1 | 70 | 0,007 | 500 |
| Grysbok *Raphicerus melanotis* | 10,0 | 60 | 6,0 | 42000 |
| Hare *Lepus* sp. | 2,0 | 70 | 1,4 | 9800 |
| Hare *Pronolagus* sp. | 2,6 | 70 | 1,8 | 12740 |
| Hartebeest, Red *Alcelaphus caama* | 136,0 | 60 | 81,6 | 571200 |
| Hedgehog *Erinaceous* sp. | 0,35 | 70 | 0,25 | 1715 |
| Hippopotamus *Hippopotamus amphibius* | 1400,0 | 60 | 840,0 | 5880000 |
| Honeybadger *Mellivora capensis* | 11,6 | 60 | 7,0 | 48720 |
| Hyrax/Dassie *Procavia capensis* | 3,7 | 70 | 2,6 | 18130 |
| Jackal, Blackbacked *Canis mesomelas* | 7,5 | 60 | 4,5 | 31500 |
| Klipspringer *Oreotragus oreotragus* | 11,9 | 60 | 7,14 | 49940 |
| Kudu *Tragelaphus strepsiceros* | 225,0 | 60 | 135,0 | 945000 |
| Mole, Golden *Clorotalpa* sp. | 0,3 | 70 | 0,2 | 1400 |
| Molerat, Cape *Georhyncus capensis* | 0,3 | 70 | 0,2 | 1400 |
| Molerat, Dune *Bathyergus suillus* | 0,6 | 70 | 0,4 | 2800 |
| Mongoose, Cape Grey *Galerella pulverulenta* | 0,8 | 70 | 0,6 | 3920 |
| Polecat, Striped *Ictonyx striatus* | 0,9 | 70 | 0,63 | 4428 |
| Porcupine *Hystrix* sp. | 17,7 | 60 | 10,6 | 74340 |
| Rhebuck, Grey *Pelea capreolus* (Vaal ribbok) | 20,0 | 60 | 12,0 | 84000 |
| Rhinoceros *Diceros bicornis* | 868,0 | 60 | 520,0 | 3640000 |
| Serval *Felis serval* | 10,4 | 60 | 6,24 | 43680 |
| Sheep *Ovis* sp. (Adult) | 40,0 | 60 | 24,0 | 168000 |
| Sheep *Ovis* sp. (Immature) | 20,0 | 60 | 12,0 | 84000 |
| Steenbok *Raphicerus campestris* | 11,1 | 60 | 6,7 | 47000 |

*Extinct

TABLE 4.8.2

TERRESTRIAL MAMMALS - ALL EXCAVATED SITES - ELAND'S BAY

| Sites | N | Sample Volume ($m^3$) | N $m^3$ | Total kJ | kJ $m^{-3}$ |
|---|---|---|---|---|---|
| CLB | 12 | 2,80 | 4,3 | 625 778 | 223 492 |
| HSM | 4 | 0,40 | 10,0 | 86 990 | 217 475 |
| EBO | 33 | 7,80 | 4,2 | 2 163 880 | 277 420 |
| EBC | 58 | 28,14 | 2,0 | 4 662 705 | 165 697 |
| | 107 | 39,14 | 2,7 | 7 539 353 | 192 625 |

TABLE 4.9.1

CETACEANS - MEAN MASS & RECORD OF STRANDINGS, 1963/81

NAMIBIA TO WEST OF MOSSEL BAY

Area 1 : Whole coastline; Area 2 : Lambert's Bay to St Helena Bay

| | Mean Mass (kg) | No. of Animals Stranded Area 1 | Area 2 |
|---|---|---|---|
| ODONTOCETI - Toothed Whales | | | |
| Ziphiidae - Beaked Whales | | | |
| *Berardius arnouxi* | 6 400 | 1 | - |
| *Mesoplon mirus* | 800 | 7 | 1 |
| *M. layardii* | 800 | 15 | 6 |
| *M. densirostris* | 800 | 6 | 1 |
| *M. greyi* | 800 | 1 | - |
| *Z. cavirostris* | 2 600 | 4 | - |
| *Hyperodon planifrons* | 3 600 | 1 | - |
| Ziphiidae - Total | | 35 | 8 |
| Physeteridae - Sperm Whales | | | |
| *Kogia breviceps* - Pigmy Sperm Whale | 400 | 22 | - |
| *K. simus* - Dwarf Sperm Whale | 200 | 14 | - |
| *P. catodon* - Sperm Whale | 20 000 | 2 | - |
| Physeteridae Total | | 38 | - |
| Delphinidae - Dolphins; Pilot, Killer & False Killer Whales | | | |
| *Grampus griseus* - Risso's Dolphin | 300 | 7 | - |
| *Globiceps malaena* - Pilot Whale | 1 000 | 1 | - |
| *Orcinus orca* - Killer Whale | 4 200 | 3 | - |
| *Faresa attenuata* - Pigmy Killer Whale | 150 | 6 | - |
| *Pseudorcas crassidens* - False Killer Whale | 1 000 | 70 | 69 |
| *Delphinus delphis* - Common Dolphin | 100 | 13 | - |
| *Stenella coeruleoalba* - Striped Dolphin | 125 | 4 | - |
| *Tursiops truncata* - Bottlenosed Dolphin | 160 | 14 | 1 |
| *Popenocephala electra* - Melonhead Dolphin | 200 | 1 | - |
| *Lagorhyncus obscurus* - Dusky Dolphin | 100 | 10 | - |
| *Cepholorhyncus heavisidii* - Heaviside's Dolphin | 50 | 3 | 3 |
| Delphinidae Total | | 132 | 73 |
| Total Odontoceti (Toothed Whales) | | 205 | 81 |
| MYSTICETI - Baleen Whales | | | |
| Balaenidae - Right Whales | | | |
| *Caperea marginata* - Pigmy Right Whale | 2 700 | 1 | - |
| *Balaena glacialis* - Right Whale | 50 000 | 2 | - |
| Balaenopteridae - Rorquals | | | |
| *Megaptera novaeanglia* - Humpback Whale | 40 000 | 2 | - |
| *Balaenoptera acutorostrata* - Minke Whale | 7 500 | 8 | 1 |
| *Balaenoptera edeni* - Bryde's Whale | 11 000 | 7 | - |
| Total Mysticeti (Baleen Whales & Rorquals) | | 20 | 1 |
| Totals : Odontoceti | | 205 | 81 |
| Mysticeti | | 20 | 1 |
| | | 225 | 82 |
| Number of Stranding Events : Odontoceti | | 121 | 12 |
| Mysticeti | | 20 | 1 |
| Number of Stranding Events Odontoceti Excluding Sperm Whales *Physeter catodon* | | 119 | |

## TABLE 4.9.2

## INCIDENCE OF STRANDINGS BY AREA AND MONTH

| Area | J. | F. | M. | A. | M. | J. | J. | A. | S. | O. | N. | D. | Total | Events |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Namibia | 6 | 1 | - | - | 1 | 1 | 1 | 3 | - | 3 | 2 | - | 18 | 14 |
| Lambert's Bay/St Helena Bay | 3 | - | 3 | 2 | 1 | 5 | - | 65 | - | 1 | - | 2 | 82 | 13 |
| Saldanha Bay | - | - | - | 2 | 4 | - | - | - | 2 | - | - | 3 | 11 | 9 |
| Melkbos/Cape Point | 5 | 5 | 7 | 9 | 2 | - | 3 | 2 | 4 | - | 5 | 6 | 48 | 44 |
| False Bay | 4 | 4 | 1 | 1 | 1 | 2 | 6 | 2 | 2 | - | 2 | 2 | 27 | 27 |
| Walker Bay | 1 | 1 | - | 5 | 1 | - | 2 | 3 | 3 | 1 | 1 | 1 | 17 | 17 |
| W.B./Mossel Bay | - | 1 | 2 | 1 | - | - | 4 | - | - | 3 | 5 | 4 | 22 | 17 |
| | 19 | 12 | 13 | 20 | 10 | 8 | 16 | 75 | 11 | 8 | 15 | 18 | 225 | 141 |

### Seasonal Distribution on Number of Events

Spring : 36; Summer : 34; Autumn : 34; Winter : 37; Total : 141

### Single/Multiple Strandings

| | Total Number of Whales | Number of Events |
|---|---|---|
| Single Strandings | 130 | 130 |
| Pairs (2) | 10 | 5 |
| Threes (1) | 3 | 1 |
| Fours (3) | 12 | 3 |
| Fives (1) | 5 | 1 |
| Mass (1) | 65 | 1 |
| | 225 | 141 |

Although some species may be more likely to strand at certain times of the year, the seasonal distribution for all species would appear to be fairly even. The number of strandings by area seems to be correlated with modern population density; other strandings may have gone unnoticed on isolated beaches. Some species may have favoured beaches for stranding, e.g. St Helena Bay for *Pseudorcas crassidens* where 65 stranded in 1981 and 58 in 1936.

## TABLE 4.9.3

## COMMERCIAL EXPLOITATION OF BALEEN WHALES

### Species' Exploitation Details

*Caperea marginata* - Pigmy Right Whale
Unexploited; only 6 m in length

*Balaena glacialis* - Southern Right Whale
Universally protected from 1935; populations thought to be recovering; found mostly eastwards of False Bay where the number of sightings in 1984 confirms this recovery

*Megaptera novaeanglia* - Humpback Whale
Numbers reduced to under 10%

*Balaenoptera acutorostrata* - Minke Whale
Hunted in the southern oceans only within recent times

*Balaenoptera edeni* - Bryde's Whale
Regularly taken off the Cape coast until 1967 when whaling ceased

### Worldwide Strandings (Watson 1981)

| | Watson's Comment | No.* |
|---|---|---|
| Southern Right Whale | Rare | 2 |
| Humpback Whale | Rare | 2 |
| Minke Whale | Often | 8 |
| Bryde's Whale | Sometimes | 7 |

### Species Not Recorded in Table 4.9.1

| | |
|---|---|
| Fin Whale | Occasional |
| Blue Whale | Occasional |
| Sei Whale | Less often than Minke |

*From Table 4.9.1

## TABLE 4.10.1

## SEAL SPECIES CAUGHT, SIGHTED OR BEACHED IN SOUTH AFRICAN WATERS

Source : Smithers (1983: 511-528)

Otaridae - Fur Seals

Arctocephalus pusillus - Cape Fur Seal
Mass: Males 187,1 kg; Females 74,8 kg
Distribution : Confined to the islands and coasts of Southern Africa from Namibia to Algoa Bay.
Range : 160 km out to sea

Arctocephalus tropicalis - Antarctic Fur Seal
Mass : Males 117 - 165 kg; Females 50 - 54 kg
Distribution : Throughout sub-Antarctic waters; 23 strandings recorded between Cape Town and northern Natal; apparently seasonal visitors from May to September

Phocidae - True Seals

Mirounga leonina - Southern Elephant Seal
Mass : Males up to 350 kg; Females up to 346 kg
Distribution : Circumpolar; frequent visitor to South African coast; 28 recorded strandings mostly December to February from Namibia to Cape Agulhas

Lobodon carcinophagus - Crabeater Seal
Mass : Males up to 220 kg; Females up to 242 kg
Distribution : Circumpolar; 10 strandings recorded 1957 to 1978 mainly December to March from False Bay to East London

Hydurga leptonyx - Leopard Seal
Mass : Males 300 kg; Females 450 kg
Distribution : Two strandings recorded at East London in 1946 and one at Hout Bay in 1969.

## TABLE 4.10.2

### SEALS - ALL SITES - ELAND'S BAY

| Sites | M.N.I. | Volume of Sample ($m^3$) | N $m^{-3}$ | Total kJ | kJ $m^{-3}$ |
|---|---|---|---|---|---|
| **Excavated Sites** | | | | | |
| CLB | 1 | 2,8000 | 0,36 | 103 125 | 36 830 |
| HSM | 1 | 0,4000 | 2,50 | 103 125 | 257 813 |
| EBO | 21 | 7,8000 | 2,70 | 2 165 625 | 277 644 |
| EBC | 24 | 28,1400 | 0,85 | 2 475 000 | 87 953 |
| **Sampled Sites** | | | | | |
| (32 Sites) | 3 | 0,6003 | 5,00 | 309 375 | 515 367 |
| | 50 | 39,7403 | 1,30 | 5 156 250 | 129 748 |

## TABLE 4.11.1

## BIRDS - ENERGY YIELDS

| Genus/Species | Live Mass (g) | Edible (g) | Mean kJ Yield/Bird |
|---|---|---|---|
| *Phalacrocorax* (Cormorants) | | | |
| *P. carbo* - White-Breasted Cormorant | 2000 | 1500 | 9000 |
| *P. capensis* - Cape Cormorant | 1000 | 750 | 4500 |
| *P. neglectus* - Bank Cormorant | 2100 | 1575 | 9450 |
| *P. coronatus* - Crowned Cormorant | 500 | 375 | 2250 |
| *Spheniscus demersus* - Jackass Penguin | 3100 | 1860 | 11160 |
| *Morus capensis* - Cape Gannet | 2600 | 1950 | 11700 |
| *Diomedia* sp. - Albatross | 3500 | 2625 | 15750 |
| *Procellaria* sp. - Petrel | 1200 | 900 | 5400 |
| *Macronectes giganteus* - Giant Petrel | 4200 | 3150 | 18900 |
| *Larus dominicanus* - Blackbacked Gull | 1000 | 750 | 4500 |
| *Sternidae* - Tern | 120 | 90 | 540 |
| *Pelicanidae* - Pelican | 9400 | 7050 | 42300 |
| *Phoenicopterus ruber roseus* - Greater Flamingo | 2100 | 1575 | 9450 |
| *Phoeniconaias minor* - Lesser Flamingo | 1400 | 1050 | 6300 |
| *Anatidae* - Duck | 900 | 675 | 4050 |
| *Fulica cristata* - Red-knobbed Coot | 600 | 450 | 2700 |
| *Corvidae* - Raven | 1000 | 750 | 4500 |

## TABLE 4.11.2

### BIRDS - ENERGY YIELDS - ELAND'S BAY EXCAVATED SITES

| | kJ Yield | | EBC | | EBO | | HSM | | CLB |
|---|---|---|---|---|---|---|---|---|---|
| | Each | N | Total | N | Total | N | Total | N | Total |
| Cormorants | | | | | | | | | |
| Whitebreasted | 9000 | 10 | 900 000 | 5 | 45 000 | 1 | 9 000 | 1 | 9 000 |
| Cape | 4500 | 131 | 589 500 | 97 | 436 000 | 7 | 31 500 | 8 | 36 000 |
| Bank | 9450 | 5 | 47 250 | 5 | 47 250 | 1 | 9 450 | - | - |
| Crowned | 2250 | 1 | 2 250 | 2 | 4 500 | - | - | - | - |
| Penguins | 11160 | 37 | 412 920 | 9 | 100 440 | 1 | 11 160 | 2 | 22 320 |
| Gannets | 11700 | 5 | 58 500 | 2 | 23 400 | 1 | 11 700 | - | - |
| Albatross | 15750 | 4 | 63 000 | 1 | 15 750 | - | - | 1 | 15 750 |
| Petrels | 5400 | 5 | 27 000 | 2 | 10 800 | 1 | 5 400 | 1 | 5 400 |
| Giant Petrels | 18900 | 1 | 18 900 | | | | | | |
| Gulls | 4500 | 4 | 18 000 | 2 | 9 000 | | | | |
| Terns | 540 | 1 | 540 | | | | | | |
| Pelican | 42300 | 1 | 42 300 | 1 | 42 300 | | | | |
| Flamingo - Greater / Lesser } | 9450 | 5 | 40 500 | 5 | 47 250 | | | 1 | 9 450 |
| Duck | 4050 | 1 | 4 050 | 2 | 8 100 | | | | |
| Raptor (est.) | 5000 | | | 1 | 5 000 | | | | |
| Raven | 4500 | 1 | 4 500 | | | | | | |
| Red-Knobbed Coot | 2700 | 2 | 5 400 | 1 | 2 700 | | | | |
| Francolin (est.) | 2000 | | | 1 | 2 000 | | | | |
| Passerine (est.) | 600 | | | 1 | 600 | | | | |
| | | 214 | 1 424 610 | 137 | 800 590 | 12 | 78 210 | 14 | 97 920 |
| Mean kJ Yield per Bird | | | 6 657 | | 5 887 | | 6 518 | | 6 994 |
| Volume of Sample | | | 28,14 $m^3$ | | 7,8 $m^3$ | | 0,4 $m^3$ | | 2,8 $m^3$ |
| kJ $m^{-3}$ | | | 50 626 | | 102 640 | | 195 525 | | 34 971 |
| N $m^{-3}$ | | | 7,6 | | 17,6 | | 30,0 | | 5,0 |

Total Sample : 39,14 $m^{-3}$; N : 377; Total Kilojoules : 2 401 330 kJ; N $m^{-3}$ : 10;
kJ $m^{-3}$ : 61 352 kJ

## TABLE 4.11.3

### BIRDS - SPECIES FREQUENCIES BY SITES ON THE SOUTHWEST COAST

| | EBC EBO / HSM CLB | DE | PN | HBC | ROOI | PB/H | DK1 | Total |
|---|---|---|---|---|---|---|---|---|
| **Coastal** | | | | | | | | |
| Albatross | 6 | | | | 4 | | 3 | 13 |
| Petrels | 10 | | | 1 | 1 | | 4 | 16 |
| Shearwaters | | | | | 7 | | | 7 |
| Gannet | 8 | 1 | 1 | 1 | 19 | 2 | 23 | 55 |
| Terns | 1 | | 3 | | | | | 4 |
| Oystercatchers | | | 3 | | | | | 3 |
| Penguins | 49 | 36 | 27 | 9 | 23 | 3 | 8 | 155 |
| Gulls | 6 | | 2 | | | | 3 | 11 |
| White-Breasted Cormorant | 17 | 12 | 8 | 3 | 8 | | 3 | 51 |
| Cape Cormorant | 243 | 27 | 32 | 8 | 15 | 4 | 9 | 338 |
| Bank Cormorant | 11 | 11 | | 1 | | | 2 | 25 |
| Crowned Cormorant | 3 | | 3 | | | | | 6 |
| | 354 | 87 | 79 | 23 | 77 | 9 | 55 | 684 |
| **Vleis/Rivers** | | | | | | | | |
| Duck | 3 | | | | | 1 | 3 | 7 |
| Coot | 3 | | | | | 1 | 4 | 8 |
| Pelican | 2 | | | | | | | 2 |
| Flamingoes - Greater } Lesser | 11 | | | | 1 | | | 12 |
| | 19 | - | - | - | 1 | 2 | 7 | 29 |
| **Terrestrial** | | | | | | | | |
| Starlings | | | | 2 | | | 6 | 8 |
| Francolin | 1 | | | 1 | 1 | | 1 | 4 |
| Raven/Crow | 1 | | | 1 | 1 | | 1 | 4 |
| Raptors | 1 | | | | | | 3 | 4 |
| Passerine | 1 | 3 | | 1 | | 3 | | 8 |
| Owls | | | | | | | 1 | 1 |
| Bustard | | | | | | 1 | | 1 |
| | 4 | 3 | - | 5 | 2 | 4 | 12 | 30 |
| **Totals** | | | | | | | | |
| Coastal | 354 | 87 | 79 | 23 | 77 | 9 | 55 | 684 |
| Vleis/Rivers | 19 | - | - | - | 1 | 2 | 7 | 29 |
| Terrestrial | 4 | 3 | - | 5 | 2 | 4 | 12 | 30 |
| | 377 | 90 | 79 | 28 | 80 | 15 | 74 | 743 |
| Unidentified | - | 2 | 1 | 1 | - | 1 | - | 5 |
| | 377 | 92 | 80 | 29 | 80 | 16 | 74 | 748 |
| Volume of Sample ($m^3$) | 39,14 | 0,7807 | 2,7582 | 1,3 | 2,6 | 1,365 | 37,3 | 85,243 |
| N $m^{-3}$ | 9,6 | 117,8 | 29 | 22,3 | 15,4 | 11,7 | 2,0 | 8,77 |

### Species Frequencies by Habitat

| | | N | % | N | % |
|---|---|---|---|---|---|
| **Coastal** : | Oceanic | 36 | 5,3 | | |
| | Coastal | 648 | 94,7 | 684 | 92,1 |
| **Vleis/Rivers** | | | | 29 | 3,9 |
| **Terrestrial** | | | | 30 | 4,0 |
| | | | | 743 | 100,0 |
| Unidentified | | | | 5 | |
| | | | | 748 | 100,0 |

## TABLE 4.11.4

## BIRDS - DIFFERENTIATION BETWEEN CAVES & OPEN SITES ON THE SOUTHWEST COAST

| | N | Volume of Sample ($m^3$) | N $m^{-3}$ | kJ Yield/Bird |
|---|---|---|---|---|
| **Caves** | | | | |
| EBC | 214 | 28,14 | 7,6 | 6657 |
| HBC | 29 | 1,30 | 22,3 | 6462 |
| ROOI | 80 | 2,60 | 15,4 | 9659 |
| DK1 | 74 | 37,30 | 2,0 | 8132 |
| | 397 | 69,34 | 5,7 | 7523 |
| **Open Sites** | | | | |
| EBO | 137 | 7,8000 | 17,6 | 5887 |
| HSM | 12 | 0,4000 | 30,0 | 6518 |
| CLB | 14 | 2,8000 | 5,0 | 6994 |
| DE | 92 | 0,7807 | 117,8 | 7791 |
| PN | 80 | 2,7582 | 29,0 | 6359 |
| PB/H | 16 | 1,3650 | 11,7 | 7127 |
| | 351 | 15,9039 | 22,0 | 6616 |
| **Excluding DE & PN** | 179 | 12,3650 | 14,5 | 6128 |
| **All Sites** | 748 | 85,2439 | 8,8 | 7097 |

TABLE 4.12.1

TORTOISE - ENERGY YIELD - ELAND'S BAY EXCAVATED SITES

| Site | N | Volume of Sample ($m^3$) | N $m^{-3}$ | Total Kilojoules | kJ $m^{-3}$ |
|---|---|---|---|---|---|
| CLB | 6 | 2,80 | 2,1 | 12 000 | 4286 |
| HSM | 4 | 0,40 | 10,0 | 8 000 | 20000 |
| EBO | 75 | 7,80 | 9,6 | 150 000 | 19230 |
| EBC | 59 | 28,14 | 2,1 | 118 000 | 4193 |
| | 144 | 39,14 | 3,7 | 288 000 | 7358 |

on these aspects of prehistoric individuals or groups are seldom available. The early occupants of the Eland's Bay area are thought to have been San (Parkington 1976a). San lived all over Southern Africa prior to 300 years ago, were of pygmoid stature and similar in bodily characteristics to their present day relations in the Kalahari (Tobias 1978: 21-22). Lee (1979: 27) has provided mean weights for the Kalahari !Kung, who are San, at 46 kg for males and 41 kg for females and has commented that average kJ needs reveal a surprisingly narrow range. Data on human energy requirements from various sources have been collated (Table 5.1, pp.159/161) from which for this study a mean requirement of 9 000 kJ per person per day has been assumed, and this parameter is used in Chapter 8. Modern estimates, which usually refer to a 'reference' man of 65 kg and woman of 55 kg, would tend to overstate requirements for the San.

## 5.3 BASAL METABOLIC RATE

Basal metabolic rate (BMR) is the rate of resting metabolism and quantifies the energy expended simply to maintain bodily functions without any physical activity whatsoever. Appropriate rates for hunter-gatherers have been suggested at :

| Sex | Weight (kg) | BMR (kJ/day) | Source |
|---|---|---|---|
| Male | 46 | 5855 | Lee (1979: 271) from Taylor & Pye (1966: 45-48) |
| Female | 41 | 4607 | Lee (1979: 271) from Taylor & Pye (1966: 45-48) |
| Male | 53 | 6376 - 6691 | Speth & Spielman (1983) from FAO/UNO (1973: 108) and Payne (1972: 303) |
| Female | 46 | 5596 - 5648 | Speth & Spielman (1983) from FAO/UNO (1973: 108) and Payne (1972: 303) |

BMR accounts for about 60% of the total daily energy intake. If the total energy intake falls below the BMR for any significant time, undernourishment and even semi-starvation may ensue, as may have occurred with some of the Australian Aborigine groups of the far arid outback instanced by Meehan (1982: 57-58).

If eight hours each day are spent in sleeping at an assumed BMR of 5200 kJ per person per day, (i.e. 1733 kJ while sleeping) and the daily intake is 9000 kJ, the energy available for the other 16 hours (7267 kJ) would represent a rate of expenditure of 10 900 kJ per day. When related to empirical rates of energy expenditure per unit time for various activities (Durnin & Passmore 1967; Leslie *et al.* 1984), the 10 900 kJ would be adequate for all Eland's Bay hunter-gatherer activities other than possibly active game hunting.

## 5.4 FOOD WASTAGE

Modern practice in handling foodstuffs entails substantial losses in nutritional value as a result of transport, storage, processing and distribution, methods of preparation and cooking and plate wastage. In contrast, Meehan's study of the Anbarra (1982: 46-48) graphically illustrates how hunter-gatherers derive full nutritional value from their food :

> "... they eat almost everything contained inside the lightly cooked shells [of shell-fish]; there is no refinement of food, no storage, little waste and no leaching of vitamins or minerals in cooking water; fish are usually cooked whole in the ashes and most of the carcase consumed with the exception of the skeleton, the scales, the charred outer skin, gills and a small part of the gut; flesh from the head, including eyes and brain, are relished; birds are lightly cooked and feathers and skeleton discarded though all bones are sucked and if suitable broken to obtain the marrow; wallabies are cooked whole in the skin ... the only parts not eaten being the skin, the gall bladder, parts of the gut and the skeleton though long bones are cracked for marrow. The liver and kidney are especially valued. Wild honey is eaten entire - wax, bees and all ...".

Modern standards contain substantial safety margins and may not take full account of food waste.

## 5.5 COMPONENTS OF DIET

The components of diet comprise proteins, fats, carbohydrates, vitamins and minerals. Some fibre is now generally included though of little or no food value. Fats and carbohydrates are the body's main fuels; proteins are essential for growth, renewal, repair and reproduction.

### 5.5.1 Proteins

Proteins are composed of some 20 amino acids of which 12 can be synthesised by the body but the other eight are classified as 'essential' since they can only be acquired directly from food consumed. Proteins of animal origin are mostly 'biologically complete' and not only have a higher nutritive value than plant proteins but also contain most or all of the essential amino acids. Plant proteins are 'biologically incomplete' and therefore a mix of several kinds of plant foods is necessary to ensure an adequate supply of the essential amino acids.

A high protein diet can be tolerated without ill effects (Davidson & Passmore 1966: 75), but, if fats and carbohydrates are virtually absent, semi-starvation may ensue as the conversion of more protein for energy produces so much waste heat that hunger is never satisfied (Passmore *et al*. 1974: 19; Speth & Spielman 1983). Some proteins are, however, strictly glycoproteins, since they contain carbohydrate in the form of attached polysaccharides which can be converted to energy more efficiently.

Modern estimates of the minimum daily protein requirement per person range from 30 to 60 grams, but 45 is most frequently quoted. The one-time simple Masai diet of mostly milk and blood of cattle was adequate in protein (Durnin & Passmore 1967: 75); and the G/wi of the Central Kalahari in early summer had an average daily protein intake per person of only 15 grams but did not develop any of the classic malnutrition symptoms (Silberbauer 1981: 274-5). The minimum daily protein need is thus comparatively small - 200 grams of meat per person would suffice - and any excess is metabolised for energy.

### 5.5.2 Fats

Fats play many roles in diet. Each gram of fat consumed produces 37,7 kJ compared with only 16,7 kJ per gram of protein or carbohydrate. Fats are intimately associated with taste, flavour and aroma; they slow digestion, promote satiety, supply essential fatty acids which cannot be synthesised in the body and promote the absorption of the fat-soluble vitamins so that adequate levels of these vitamins are maintained.

Hunter-gatherers show a marked preference for animals that yield the most fat (Jochim 1976: 19-20). The eland is the only African game animal that accumulates fat (Van Zyl 1962: 35), which may partly explain why the eland features so prominently in the rock art of Southern Africa (Vinnicombe 1976).

### 5.5.3 Carbohydrates

Carbohydrates produce most of the energy from modern diets but do not appear to be essential to health (Davidson & Passmore 1966: 52). Carbohydrates are often bulky and ingestion is eased by fat (butter on bread).

### 5.5.4 Vitamins

The nutritionally important vitamins, their sources, the symptoms and consequences of deficiency and the recommended daily intake (RDI) have been listed (Table 5.2, pp.162/3). Other vitamins are unlikely to be short in any diet (Bender 1979: 8). Dairy products as a source of vitamins have been omitted from this table.

### 5.5.5 Minerals

A similar list has been compiled for essential minerals (Table 5.3, pp.164/5).

## 5.6 ASSESSMENT OF PREHISTORIC DIETS

The relative proportions of proteins, fats and carbohydrates in prehistoric diets were first assessed. A method for doing so is described below for shellfish for which independent controls are available.

100 grams of an equal mix of limpet and mussel flesh will comprise 15,6 grams of protein, 2,0 grams of fat and 2,6 grams of carbohydrate (Table 5.4, p.166). The balance of about 70%/80% is moisture content. Each gram of protein or carbohydrate will produce 16,7 kJ and of fat 37,7 kJ (Passmore *et al*. 1974: 7). The 100 grams of limpet/mussel flesh will thus produce :

| | | | |
|---|---|---|---|
| Protein | 15,6 g x 16,7 kJ $g^{-1}$ | = | 261 kJ |
| Fat | 2,0 g x 37,7 kJ $g^{-1}$ | = | 75 kJ |
| Carbohydrate | 2,6 g x 16,7 kJ $g^{-1}$ | = | 43 kJ |
| kJ 100 $g^{-1}$ wet flesh | | | 379 kJ |

This estimate can now be compared with estimates from other sources :

| | | kJ 100 $g^{-1}$ |
|---|---|---|
| (a) | Limpets (Table 4.3.2, p.122) | 429 |
| | Mussels (Table 4.4.1, p.123) | 330 |
| | An equal mix of mussel/limpet flesh would produce | 379 |
| (b) | 100 grams of an equal mix of west coast limpet/mussel flesh comprises 81 grams of moisture content and 19 grams of dry flesh (Griffiths 1981: 104; Branch, *pers.comm.*) | |
| | One gram of dry flesh produces (Table 2.3, p.30) | 20 kJ |
| | 19 grams of dry flesh will produce | 380 kJ |
| | Thus 100 grams of edible wet flesh produces | 380 kJ |

Although there must be an element of coincidence in the exact agreement of these estimates, there is justification in applying the proportions of the major constituents from the Tables of the Composition of Foods (Table 5.4) to other food categories even though independent controls are not available.

The following example, based on the kJ $m^{-3}$ of 350 000 for shellfish at Eland's Bay (Appendix G.1), illustrates how the proportionate contributions of protein, fat and carbohydrate to the total of 350 000 are calculated :

<u>Weight of Constituent</u> (in this example protein)

$$= \frac{\text{Percentage of protein in limpet/mussel wet flesh (Table 5.4, p.166)}}{\text{kJ per 100 grams of edible wet flesh of limpets \& mussels (p.155)}} \times 350\ 000$$

$$= \frac{15,6}{380} \times 350\ 000$$

= 14 368 grams

<u>kJ Yield from Protein</u>

One gram protein = 16,7 kJ

14 368 grams of protein = 239 946 kJ

With similar calculations for fats and carbohydrates, the results are :

| Constituent | Weight Grams | % | kJ $g^{-1}$ | Total kJ kJ | % |
|---|---|---|---|---|---|
| Protein | 14 368 | 77,2 | 16,7 | 239 953 | 68,7 |
| Fat | 1 842 | 9,9 | 37,7 | 69 447 | 19,9 |
| Carbohydrate | 2 395 | 12,8 | 16,7 | 39 997 | 11,4 |
| | 18 605 | | | 349 397 | |

The proportionate contributions of the three main constituents in prehistoric diet have been calculated by this method for the Eland's Bay sites (Table 5.5, p.167) and for all coastal sites (Table 5.6, p.168). The results are compared below with an average modern western diet (from Bender 1979: 7) :

| Constituent | Prehistoric Diet | | Modern Diet |
|---|---|---|---|
| | EB | All Coastal Sites | |
| | % | % | % |
| Protein | 65,6 | 60,8 | 10 |
| Fat | 29,6 | 35,2 | 40 |
| Carbohydrate | 4,8 | 4,0 | 50 |

If the speculative values assumed for plant foods, honey and other prehistoric dietary items with a substantial carbohydrate component are too low, then the percentage of protein will be overstated; but a high protein diet is characteristic of most hunter-gatherer groups and is a safeguard against the protein deficiency diseases which are endemic among some modern communities where food intake comprises mainly carbohydrates. The striking contrast between prehistoric and modern diets mostly originated from the introduction of agriculture.

In this context we must bear in mind the caveat expressed by Walker (1985: 548) that "... the setting out of quantitative needs of nutrients - and more particularly the interpretations and the significance of optimal intakes and of shortfalls - these have remained fields of controversy wherein much remains that is still unresolved".

## 5.7 CONCLUSIONS

The hunting-gathering lifestyle has been referred to as the most successful and persistent of human adaptations and the diet as 'ideal' (Yudkin 1969: 547). In his search for food, man has evolved adaptive mechanisms and bodily reserves to tide him over periods of shortage (Weiner 1964: 417; Passmore *et al*. 1974: 3).

> "... the human species has spent more than 90% of its existence leading the life of the hunter-gatherer ... in their genes people today are still hunter-gatherers; 'civilisation' is too recent to have made any appreciable impact on the human genetic make-up" (Short 1984: 24).

It is not surprising, therefore, that nutritionally related pathologies are strikingly absent in contemporary foraging societies and palaeopathological studies suggest that prehistoric hunter-gatherers were relatively free of nutritionally related diseases as well (Keene 1981: 31). This conclusion is confirmed from the reconstruction and analyses of the diet of the prehistoric peoples of the southwestern Cape who exploited a range of natural foods to provide a balanced diet of protein, fat and carbohydrate. Shellfish supplemented by other seafoods would have met all their needs in essential vitamins and minerals (Bailey 1975: III, 8; Branch, pers.comm.). The quality of their diet was thus satisfactory. From the abundance of marine, estuarine and to a lesser extent terrestrial resources in the area, which could be taken by hand or with simple technology, and the virtually unlimited supply of shellfish on the shores, we can assume that the quantity was there for the taking. It would be difficult to explain otherwise why these groups continued to visit the area over thousands of years; it has, however, been suggested (Prof. Dowdle, pers.comm.) that an excessive intake of fluoride or vitamins to which 'strandlopers' might be exposed (see discussion in Chapter 9) may have produced the high incidence of osteoporosis and dental caries reported by Rawlinson (1982).

## TABLE 5.1

## HUMAN DAILY ENERGY REQUIREMENT

| Source | kJ Intake/Person per Day |
| --- | --- |
| A frequent assumption by Archaeologists (2 000 kcals) | 8360 |
| Shawcross (1981: 595) | 8925 |
| Bailey (1975, III: 2) based on McArthur (1960) | 8950 |
| FAO/UNO (1973); Global minimum standard | 8990 |
| Keene (1981, Appendix 2) based on Nutrition Canada (1975) for a hypothetical group of 25 individuals in the Late Archaic period | 9008 |
| Meehan (1982: 152-5, Tables 29-32) based on four months' observations of Anbarra total food intake | 9045 |
| Passmore *et al*. (1974); average of male (55 kg) and female (45 kg), both aged 25 years | 9050 |
| Fox (1966) based on South African National Nutrition Council Standards (1956) and calculated for a group of 25 of similar age composition to Keene's | 9234 |
| Endicott (1983): Batek of Malaysia, modern hunter-gatherers | 9645 |
| Mean kJ Intake/Person/day on above data | 9023 ± 333 |

| Modern Averages for Men & Women (65 kg & 55 kg respectively) | |
| --- | --- |
| Australian kilojoule and calorie counter (1981: 10) | 9825 |
| Bender (1979: 14) | 10425 |
| Passmore *et al*. (1974, Table I) | 10850 |
| Durnin & Passmore (1967: 115) for a mixed group of clerks, students, housewives, factory workers & farmers | 11364 |

Modern Kalahari !Kung (Lee 1979: 271)

Lee quotes the following estimates : males - 9420 kJ and females - 7326 kJ, which allows for an activity regime from light moderate to severe exercise with an hour of nut cracking per day and 32 km of subsistence travel per week. Mean daily energy requirement for a group of 31 consisting of 30% adult males, 35% adult females and 35% children under 15 years is 8267 kJ. The per capita yield of all foods consumed (Table 9.9) is 9858 kJ giving an apparent excess over estimated energy required of 1590 kJ, which Lee thinks might be attributed to feeding the camp's dogs, building up bodily reserves against the lean season and the energy expended in ceremonial such as trance-dancing involving everyone in strenuous day/night activity. Lee's estimate for adult women at 7326 kJ per day may not take fully into account their higher energy requirements during pregnancy and lactation as a mean birth interval of 4,1 years for these !Kung women has been attributed to prolonged lactation (Short 1984: 24).

Leslie et al.'s (1984) study presents a model for computer application by anthropologists and human ecologists to determine caloric needs and requires account to be taken of variability in physical activity and of anthropometric, demographic and environmental variables. However, there are some aspects of interest to archaeologists. For the ambient temperatures that prevail at Eland's Bay, estimates of BMR should be increased by 4% and for activity by 2%; such minor adjustments can be ignored in this study. From quoted data (Consolazio 1963), moderate activity in a temperate climate requires a daily energy intake of between 8665 to 10013 kJ for a 46 kg male and from 7723 to 8925 kJ for a 41 kg female, which give support to the overall mean of 9000 kJ assumed. Finally, from four ethnographic studies of groups living in the Peruvian Andes, New Guinea and the Kalahari, energy needs as estimated by the ethnographers, by application of the model and by FAO/UNO standards are compared, and their data have been combined below to give an overall result :

| Source of Estimate | N | Males kJ/Person/Day | N | Females kJ/Person/Day |
|---|---|---|---|---|
| Ethnographers | 5 | 9042 ± 1503 | 5 | 7740 ± 1281 |
| By Model | 5 | 8405 ± 2196 | 5 | 7238 ± 1737 |
| By FAO/UNO Standards | 5 | 10532 ± 1900 | 5 | 8585 ± 1160 |
| Mean Value - All Three Methods | 15 | 9326 ± 2118 | 15 | 7854 ± 1432 |
| Overall - Males & Females (N = 30) | | 8590 ± 1927 | | |

Postscript

Peoples' Republic of China (Smil 1985: 104-112)

| | Average or Range |
|---|---|
| Average per capita daily energy requirement based on age/sex distribution and occupation from 1982 census and average weights of men (60 kg) and women (50 kg) | 2200-2400 Kcals (9200-10 000 kJ) |
| Estimate by Food & Agricultural Organisation per capita | 2360 Kcals (9880 kJ) |

Average daily food energy available per person :

| | Kcals | kJ |
|---|---|---|
| 1950 | 1800 | 7500 |
| 1957 | 2100 | 8800 |
| 1960 (The Great Famine) | 1500 | 6300 |
| 1965 | 2000 | 8400 |
| 1977 | 2100 | 8800 |

## TABLE 5.2

## VITAMINS

Retinol (A) : RDI = 750 micrograms

Source : Foods of animal origin particularly liver, but can be synthesised in the body from plant carotenes.

Symptoms of Deficiency : Night and permanent blindness; skin eruptions; bone malformations; deranged tooth forms.

Thiamin ($B_1$) : RDI = 1,2 mg

Source : All unrefined plant and animal foods, particularly animal organs.

Symptoms of Deficiency : Beriberi (vitamin lost in refining).

Niacin (B) : RDI = 19,8 mg

Source : Widely distributed, mostly in small amounts in plant and animal foods. Rich sources include liver, kidney and fish.

Symptoms of Deficiency : Pellagra (skin lesions on exposure to light; damage to digestive system and brain).

Riboflavin (B) : RDI = 1,8 mg

Source : Most foods, especially meat and fish.

Symptoms of Deficiency : Skin and oral lesions; eye disorders.

Cyanocobalamin ($B_{12}$) : RDI=2 micrograms

Source : Small amounts in all animal tissues especially liver. Plants do not make or utilise this vitamin.

Symptoms of Deficiency : Addisonian (pernicious) anaemia which stems not from deficiency but from failure of the stomach to secrete an 'intrinsic factor' essential for the absorption of this vitamin.

Ascorbic Acid (C) : RDI = 30 mg

Source : Plants, freshly killed raw meat, fish, liver and other organs and glands, fish roe.

Symptoms of Deficiency : Scurvy, defective formation of new bone collagen, delayed healing of wounds, (body's supply can last for two to six months).

Cholecalciferol ($D_3$) : RDI = 2,5 micrograms

Source : Animal and fish livers; none in plant foods; can be synthesised in the skin when exposed to sunlight; promotes absorption of calcium and mineralisation of bone.

Symptoms of Deficiency : Rickets (bone malformations in the young).

## TABLE 5.3

## MINERALS

Iron : RDI = 5 mg to 9 mg

Source : A range of foods especially meat, liver, offal and fish. The rate of absorption differs according to the source, e.g. meat 30%, fish 15%, plants 10%. Most diets provide more iron than is needed.

Symptoms of Deficiency : A mild iron deficiency anaemia is present in all populations symptomised by weakness, ill health and substandard performance, but may be related more to rate of absorption than to insufficient intake.

Calcium : RDI = 0,4 grams to 0,5 grams

Source : All raw foods especially fish. All diets appear to provide calcium in excess of RDI. The rate of calcium absorption is precisely regulated and the control mechanism is thought to depend on Vitamin D which can be synthesised in the skin on exposure to sunlight.

Symptoms of Deficiency : Osteomalacia (softening of bones) and osteoporosis. Growth and atrophy of bone seem to proceed at rates which are independent of calcium intake. Bone pathology would appear to be attributable to a lack of Vitamin D or a lack of exposure of the skin to sunlight to synthesise this vitamin.

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Iodine : RDI = 0,14 mg

Source : Seafoods comprise the only rich source.

Symptom of Deficiency : Goitre.

Fluorine : RDI = 0,25 mg to 0,30 mg

Source : Widely but unevenly distributed in nature. Seafoods are a significant source.

Symptom of Deficiency : Dental caries.

Zinc : RDI = 22 mg

Source : Animal foods, especially fish and seafoods.

Symptom of Deficiency : Growth failure reported.

Magnesium : RDI = 200 mg to 300 mg

Source : Rich sources include meat, viscera. Widely distributed in plants.

Copper : RDI = 30 micrograms

Source : Rich sources include liver, kidney and shellfish.

Other essential minerals which are rarely if ever in short supply in any diet include phosphate, sulphate, chloride, sodium, potassium, cobalt, molybdenum and chromium.

Sources : Passmore *et al.* (1974: 49-65 Table 1); Bender (1979: 13).

## TABLE 5.4

### ENERGY VALUE & PERCENTAGE CONSTITUENTS PER 100 GRAMS RAW EDIBLE PORTION

| Description of Food | kJ 100 $g^{-1}$ | Protein % | Fat % | Carbohydrate % |
|---|---|---|---|---|
| Shellfish (Limpets and Mussels) | 380 | 15,6 | 2,0 | 2,6 |
| Rock Lobster | 400 | 18,7 | 1,9 | 1,0 |
| Fish | 500 | 19,1 | 2,1 | - |
| Terrestrial Mammals | 700 | 24,4 | 7,8 | - |
| Cetaceans | | | | |
| Toothed | 350 | 20,5 | 0,2 | - |
| Baleen | 650 | 21,4 | 7,8 | - |
| Seals | 750 | 20,6 | 10,8 | - |
| Birds | 600 | 23,8 | 5,4 | - |
| Tortoise | 550 | 20,0 | 5,7 | - |
| Plants (geophytes) | 300 | 3,5 | 0,5 | 17,0 |
| (other) | 1250 | 10,0 | 2,0 | 60,0 |

*The balance comprises roughly :*

| | | |
|---|---|---|
| Moisture content | - | 70/80% |
| Ash | - | 1/5% |
| Fibre (plants) | - | 5/10% |

Source : Derived from Tables of the Composition of Foods and estimates for geophytes calculated from Vincent (1985, Table 5: 141)

## TABLE 5.6

## SOUTHWEST COAST SITES - PROPORTIONS OF PROTEINS, FATS & CARBOHYDRATES IN PREHISTORIC DIET

| Category | $kJ\ m^{-3}$ (Appendix J) | $kJ\ m^{-3}$ Protein | Fat | Carbohydrate | Total |
|---|---|---|---|---|---|
| Shellfish | 341 768 | 234 309 | 67 814 | 39 051 | 341 174 |
| Rock Lobsters | 36 711 | 28 661 | 6 574 | 1 533 | 36 768 |
| Fish | 78 970 | 62 973 | 15 630 | - | 78 603 |
| Mammals | 661 204 | 384 896 | 277 762 | - | 662 658 |
| Cetaceans | 52 809 | - | - | - | - |
| Toothed | 30 177 | 29 517 | 650 | - | 30 167 |
| Baleen | 22 632 | 12 443 | 10 239 | - | 22 682 |
| Seals | 214 692 | 98 478 | 116 552 | - | 215 030 |
| Birds | 75 054 | 49 718 | 25 466 | - | 75 184 |
| Tortoise | 13 891 | 8 436 | 5 427 | - | 13 863 |
| Plants (Estimate) | 24 901 | 3 327 | 1 502 | 19 961 | 24 790 |
| | 1 500 000 | 912 758 | 527 616 | 60 545 | 1 500 919 |

| | | |
|---|---|---|
| Protein | 912 758 $kJ\ m^{-3}$ | 60,8% |
| Fat | 527 616 $kJ\ m^{-3}$ | 35,2% |
| Carbohydrate | 60 545 $kJ\ m^{-3}$ | 4,0% |
| | 1 500 919 $kJ\ m^{-3}$ | 100,0% |

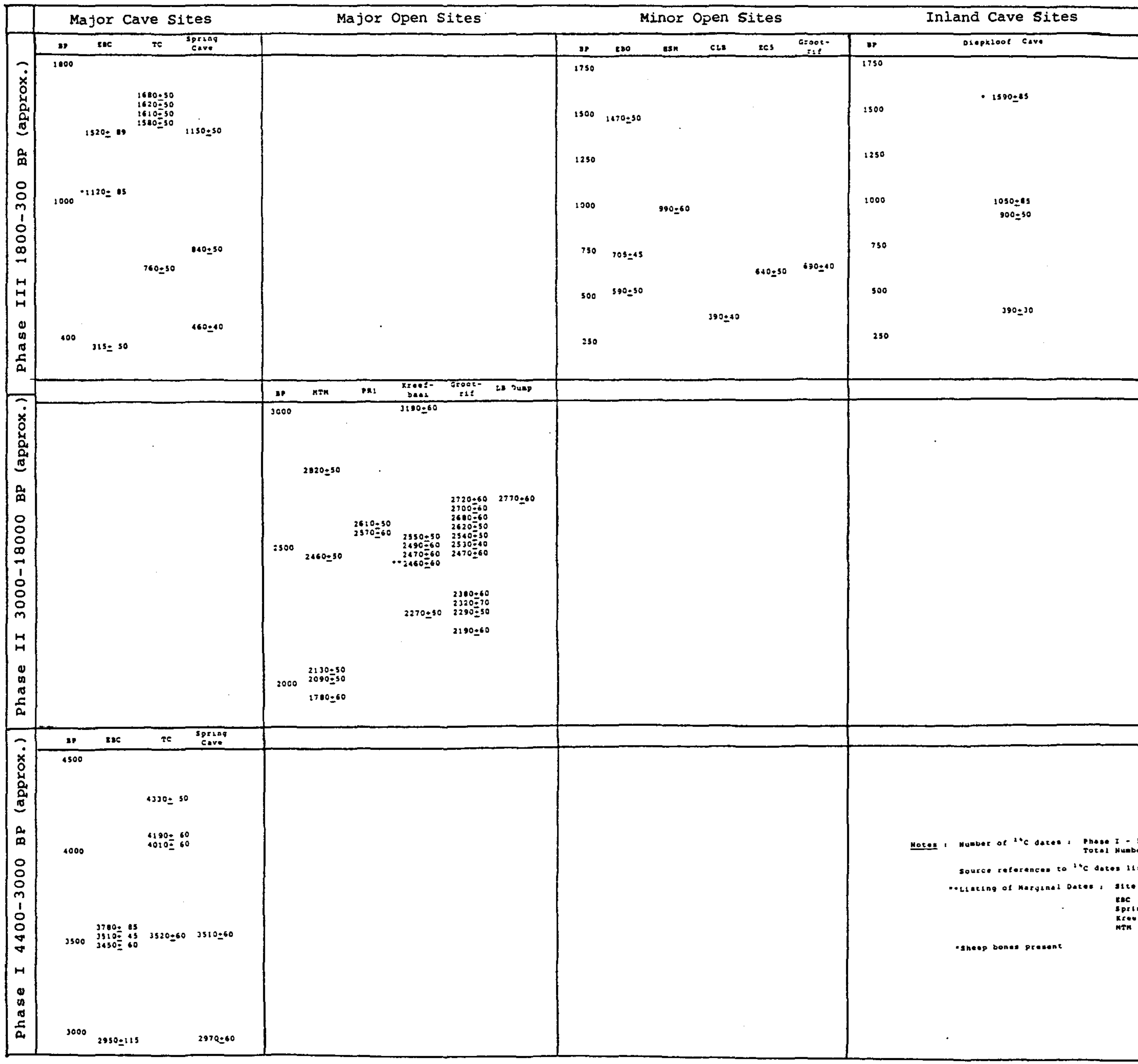
# CHAPTER 6

## POST-HIATUS $^{14}C$ DATES & SETTLEMENT PATTERNS

The $^{14}C$ dates for coastal sites from Eland's Bay to Lambert's Bay, which have been listed (Table 6.1), and shown chronologically by sites (Figure 6.1), reveal three distinct phases of occupation which coincide with changes in settlement patterns (Figure 6.2). The pattern is not an artefact of sampling.

### 6.1 DESCRIPTION OF SITES TO THE NORTH OF ELAND'S BAY

The Kreefbaai midden is built up to a height of some 2 m above ground level and, after allowing for substantial removals for surfacing of farm roads, its original volume must have been greater than 10 000 $m^3$ (Parkington, *pers. comm.*). The Lambert's Bay Dump has been so severely eroded and disturbed that estimation of its original volume would be speculative. An investigation is in progress into the very large middens and the numerous small sites along this coast, but preliminary indications suggest a repetition of the pattern at Eland's Bay : pre-pottery megamiddens of thousands




**Notes** : Number of $^{14}C$ dates : Phase I - 10; Phase II - 26; Phase III - 22; Total Number of Dates - 58.

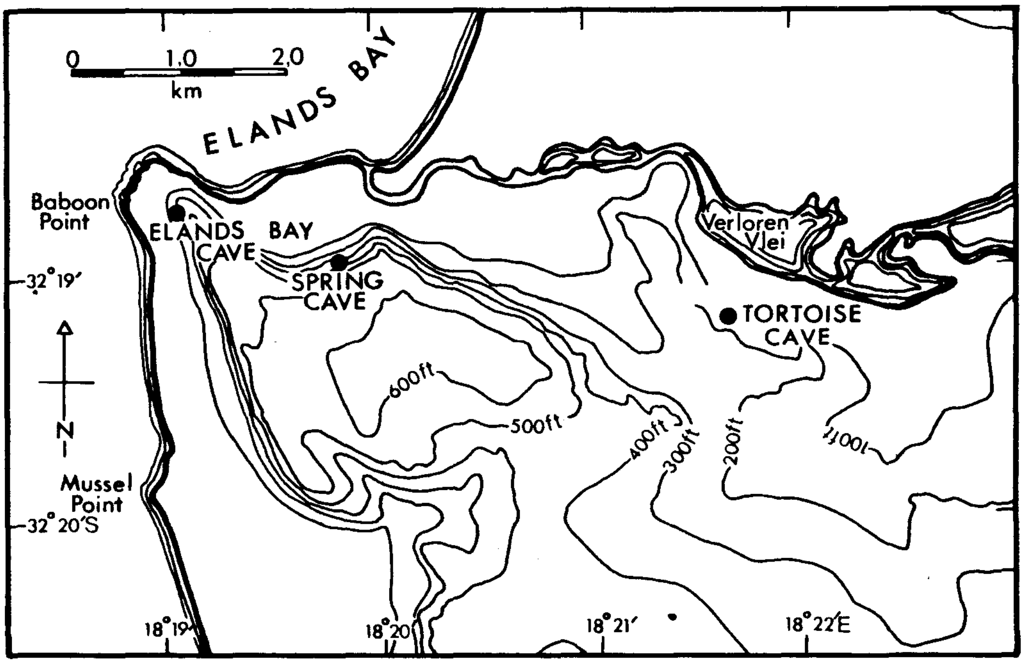
Source references to $^{14}C$ dates listed in Table 6.1.

**Listing of Marginal Dates :

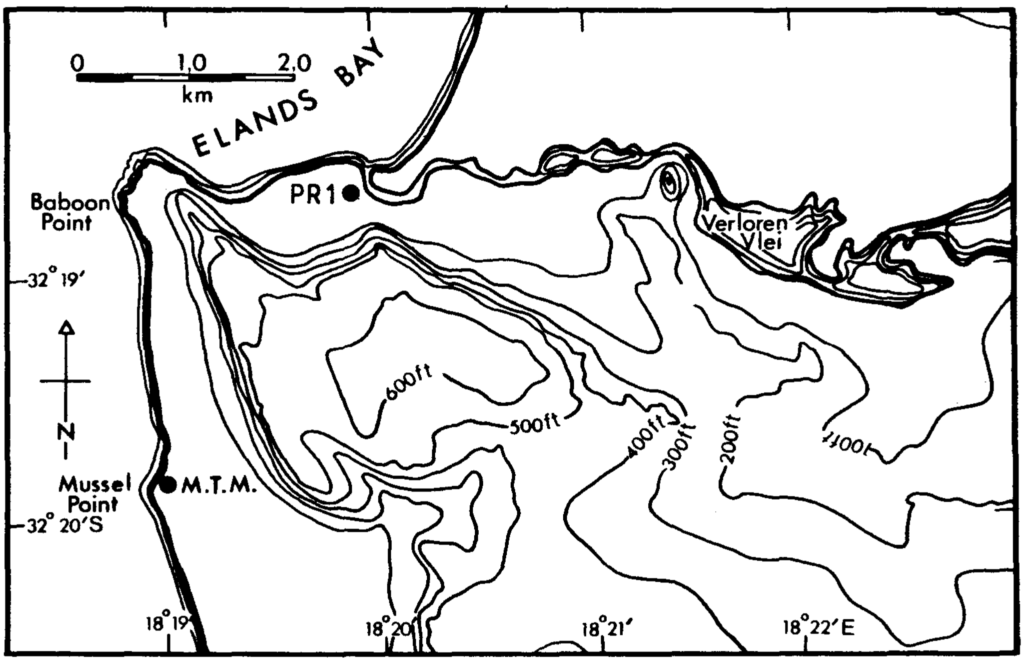
| Site | Reference | Date BP | Phase |
|---|---|---|---|
| EBC | GaK 4339 | 2950±115 | I |
| Spring Cave | Pta 4033 | 2970± 60 | I |
| Kreefbaai | Pta 4045 | 3190± 60 | II |
| MTM | Pta 3640 | 1780± 60 | II |

*Sheep bones present

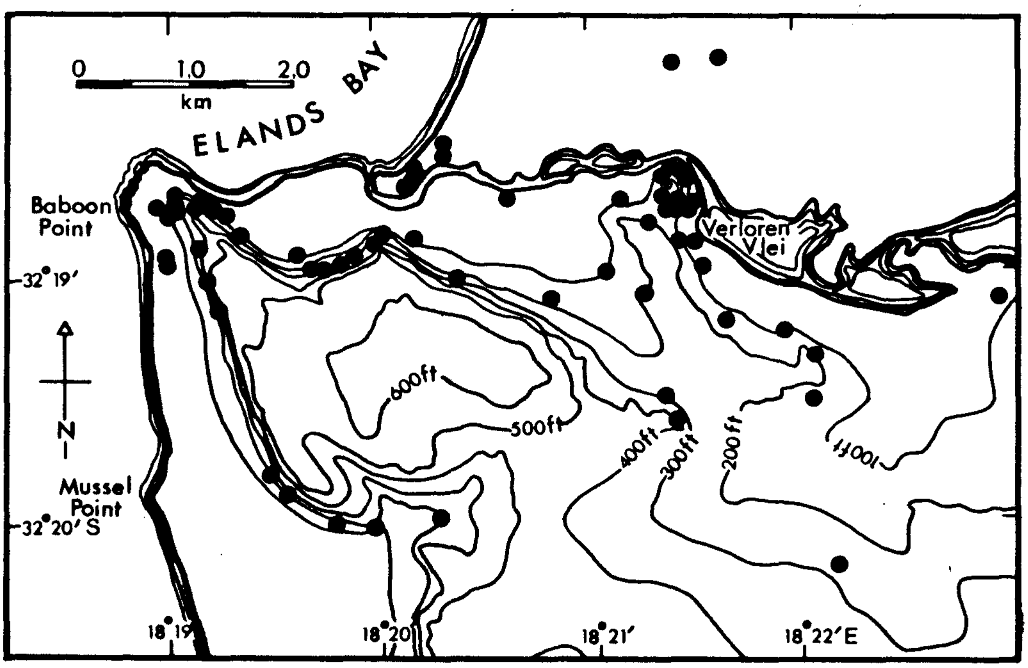
DISTRIBUTION OF POST-HIATUS $^{14}C$ DATES (Eland's Bay to Lambert's Bay) (Figs 1.2 & 1.3)




SITES DATED 4400 - 3000 B.P.




SITES DATED 3000 - 1800 B.P.




SITES DATED 1800 - 300 B.P.

Figure 6.2

of cubic metres of deposit like MTM and more numerous but small pottery sites (Yates, pers.comm.). Other similarities may be discovered from analyses of samples taken from these sites, particularly in changes in species frequencies of shellfish.

## 6.2 GEOMORPHOLOGY AND CHANGING SEA LEVELS

The submarine topography of the Eland's Bay/Lambert's Bay coast is a rather flattish rocky seabed (Pollock & Beyers 1981: 382) and, being relatively unsheltered, can be expected to support substantial mussel colonies. Minor changes in sea level could thus affect the accessibility of these shellfish beds as at Mussel Point (Figure 3.2, p.35).

Flemming (1977: 143-144) has proposed from evidence at Langebaan Lagoon (80 km south of EB, Figure 1.2, p.3) that there is strong evidence for a high stand of the sea during the mid- to Late Holocene, which he estimates at a maximum of +3,0 m ca. 5500 BP receding to +1,5 m ca. 3500 BP and to modern shortly after 2000 BP. There is support for this hypothesis from Cape Hangklip (Mabutt 1955), the southern Cape coast (Martin 1962 & 1968; Butzer & Helgren 1972) and more recently from Verloren Vlei (Miller n.d.).

During the high stand of the sea at +3,0 m, the Bay rocks of Sector 1 and the Mussel Point rocks of Sector 3 would have been totally submerged at low tide (Figure 3.2), and their shellfish populations out of reach of prehistoric intertidal waders. By about 3000 BP, the upshore Balanoid zone at least should have become accessible at low tide and might have met all the requirements of the gatherers without their venturing further downshore (Appendices S.1 and S.2, pp.147/150). The earliest date for MTM at 2820 ± 50 BP fits this scenario of an emergent Mussel Point and the opening up of its abundant mussel colonies to wader-gatherers, but, in contrast, the limpet populations of the Bay itself, in Sector 1, which were being exposed at the same time by the receding sea, were neglected. The rocks at Baboon Point, Sector 2, extend well above the present high tide mark (Figure 3.2), and at the maximum marine transgression would still be partly exposed. Sector 2 does not, however, today support prolific shellfish populations and accounts for only 5,8% of the total shellfish biomass along the Eland's Bay shore (Appendix S.2). The earliest dates for the return to the EB area after the hiatus (4330 ± 50 BP at TC and 3780 ± 85 BP at EBC) suggest that only then had sea levels fallen sufficiently to warrant a return to gather shellfish from Sector 2, if shellfish was a major attraction. TC has produced three dates from 4330 to 4020 BP which indicate the re-use of this cave some centuries before EBC if this is not an artifact of sampling. TC is better situated than EBC for exploiting terrestrial and vlei resources, which may explain its priority in re-occupation and implies that shellfish availability did not become a determinant in site location until some time after 4000 BP.

At EB there would appear to be a correlation between falling sea levels, emergent shellfish-bearing rocks and the sequence in the first use of the sites TC, EBC and MTM.

For sites between EB and Lambert's Bay, the close grouping of the $^{14}C$ dates for the large middens at Kreefbaai, Grootrif and Lambert's Bay and their correlation with MTM suggest that the same sequence of events took place all along this coast at the same time.

These sites may be linked by 'strandloping' or be disparate segments of coastal/inland rounds. Further research is required, specifically for more sites and on sampling and analysis of midden contents and of modern shellfish populations.

## 6.3 SETTLEMENT PATTERNS

The post-hiatus period is clearly differentiated (Figures 6.1 and 6.2) into three distinct phases (with dates in rounded figures) :

Phase I 4400 - 3000 BP with dated deposits only from TC, EBC and BR5, although a few other sites may also have been in use then. Shellfish gathering was restricted to Baboon Point, Sector 2, but other marine and terrestrial resources were also exploited.

Phase II 3000 - 1800 BP : shellfish gathering was concentrated on Mussel Point, Sector 3, and mussels contributed most of the diet certainly at MTM, while cave sites and other resources were largely neglected.

Phase III 1800 - 300 BP when MTM was abandoned as a shellfish eating station and replaced by a proliferation of sites, mostly representing ephemeral occupations and situated in the open or in caves and shelters previously ignored and often oriented on or near the hills and many of them with a panoramic view. Gathering shellfish at Mussel Point may have continued during this phase but for consumption elsewhere.

The allocation of undated sites to phases is by no means secure, particularly for Phase III, where finds of pottery on the surface or in samples, site location and the shallowness of deposits have been assumed to be characteristics of sites of this period on the analogy of dated sites. Phase III sites are also notable for the return to limpet gathering; limpets introduce the sequence of shellfish gathering some 11 000 years ago but were not intensively gathered again until the start of Phase III.

An environmental explanation has been offered for the change in foraging and settlement from Phase I to Phase II, but there is no evidence to support a similar explanation for the more radical change from Phase II to Phase III. The determinant of site location in Phase II seems to have been shellfish availability, particularly mussels, and little attention was given to other resources; in contrast, the numerous Phase III sites were occupied for only brief periods, as their volumes of deposit are insignificant in comparison with MTM and their site contents reveal a change from intensive shellfish gathering to the extensive exploitation of a range of marine and terrestrial resources (Appendices G.1 to G.6, pp.309/314).

The general assumption that the first appearance of pottery and sheep can be associated with the incursions of alien pastoralists and the consequent potential for territorial competition and conflict provides the only tenable explanation on the available evidence for these drastic changes in settlement and foraging when both procurement system and social structure may have suffered disruption. A similar situation may have arisen in the Eastern Cape. Deacon (1972: 37-39) has suggested that the correlation between the appearance of pottery and the 'death' of the Wilton cultural system is perhaps significant and that the social and economic changes noted in the Wilton-type site may correlate with new culture contacts, implying territorial competition along the southern coast. Post-climax Wilton and Pottery Wilton are perhaps least well represented at the larger sites; there is an apparent trend for the most recent phases to be better represented in smaller shelters and short sequence deposits, which, if confirmed, would imply a significant change in social terms.

TABLE 6.1

RADIOCARBON DATES : POST-HIATUS

C = cave; O = major open site; o = Minor open site.
*First sheep bones at EBC; **First sheep bones at Diepkloof

| Site: Name | Prefix | Type | Dates BP | Reference |
|---|---|---|---|---|
| Eland's Bay Research Area | | | | |
| Eland's Bay South | ES1 | O | | |
| Mike Taylor's Midden | MTM | | 1780 ± 60 | Pta 3640 |
| | | | 2090 ± 50 | Pta 3659 |
| | | | 2130 ± 50 | Pta 3641 |
| | | | 2460 ± 50 | Pta 3207 |
| | | | 2820 ± 50 | Pta 3720 |
| Borrow Pit | EC4 | o | 640 ± 50 | Pta 4023 |
| Eland's Bay Cave | EC5 | C | 315 ± 50 | Pta 1815 |
| | | * | 1120 ± 85 | GaK 4335 |
| | | | 1520 ± 80 | GaK 4337 |
| | | | 2950 ± 115 | GaK 4339 |
| | | | 3450 ± 60 | Pta 841 |
| | | | 3510 ± 45 | Pta 687 |
| | | | 3780 ± 85 | Pta 1816 |
| Eland's Bay Open | EC2 | o | 590 ± 50 | Pta 2460 |
| | | | 705 ± 45 | Pta 2465 |
| | | | 1470 ± 50 | Pta 2469 |
| Hail Stone Midden | JT2 | o | 990 ± 60 | Pta 4018 |
| Spring Cave | BR5 | C | 460 ± 40 | Pta 4062 |
| | | | 840 ± 50 | Pta 4042 |
| | | | 1150 ± 50 | Pta 4035 |
| | | | 2970 ± 60 | Pta 4033 |
| | | | 3510 ± 60 | Pta 4027 |
| Public Resort | PR1 | o | 2570 ± 60 | Pta 4022 |
| | | | 2610 ± 50 | Pta 4030 |
| Connie's Limpet Bar | CLB/EV2 | o | 390 ± 40 | Pta 4020 |
| Tortoise Cave | TC/TT2 | C | 760 ± 50 | Pta 3600 |
| | | | 1580 ± 50 | Pta 3309 |
| | | | 1610 ± 50 | Pta 3311 |
| | | | 1620 ± 50 | Pta 3310 |
| | | | 1680 ± 50 | Pta 3312 |
| | | | 3520 ± 60 | Pta 3604 |
| | | | 4020 ± 60 | Pta 3595 |
| | | | 4190 ± 60 | Pta 3608 |
| | | | 4330 ± 50 | Pta 3605 |
| Eland's Bay/Lambert's Bay | | | | |
| Kreefbaai | - | O | 2270 ± 50 | Pta 4032 |
| | | | 2460 ± 60 | Pta 3314 |
| | | | 2460 ± 60 | Pta 4047 |
| | | | 2470 ± 60 | Pta 3313 |
| | | | 2490 ± 60 | Pta 3589 |
| | | | 2550 ± 50 | Pta 4046 |
| | | | 3190 ± 60 | Pta 4045 |
| Grootrif | - | O | 690 ± 40 | Pta 4070 |
| | | | 2190 ± 60 | Pta 4081 |
| | | | 2290 ± 50 | Pta 4075 |
| | | | 2320 ± 70 | Pta 4098 |
| | | | 2380 ± 60 | Pta 4055 |
| | | | 2470 ± 60 | Pta 4085 |
| | | | 2530 ± 40 | Pta 4059 |
| | | | 2540 ± 50 | Pta 4083 |
| | | | 2620 ± 50 | Pta 4067 |
| | | | 2680 ± 60 | Pta 4060 |
| | | | 2700 ± 60 | Pta 4068 |
| | | | 2720 ± 60 | Pta 4063 |
| Lambert's Bay Dump | - | O | 2770 ± 60 | Pta 3207 |
| Inland Sites | | | | |
| Diepkloof | - | C | 390 ± 30 | Pta 1055 |
| | | | 900 ± 50 | Pta 1056 |
| | | | 1050 ± 85 | GaK 4597 |
| | | ** | 1590 ± 85 | GaK 4595 |

# CHAPTER 7

## MIKE TAYLOR'S MIDDEN (MTM)

Brief references have been made to this site (inset Figure 1.3, p.4) in earlier chapters but no date given as it is first necessary to decide whether this megamidden ranks as an archaeological site and is not a natural accumulation as suggested by Rebelo (1982). Relevant data and a brief account of excavations on this site are given (Table 7.1, p.191/2).

### 7.1 THE EVIDENCE

#### 7.1.1 Faunal Remains

Identifications include bovids, dassies, birds, fish and tortoises, but quantification awaits completion of faunal analyses. The bird and fish remains could well have had a non-human origin, but this is unlikely for the other remains. The density of remains per cubic metre of deposit is very low but may be attributable to the use of the site mainly as a shellfish eating station.

#### 7.1.2 Stone Tools

These are very scarce, but this is not unusual for sites in close proximity to shell beds. Mussels which comprise 95% of the shellfish contents of the site can easily be gathered by hand without the use of tools.

### 7.1.3 Pottery

Test Hole E4 (Figure 1.3) produced one potsherd at a depth of 20 cm and three conjoinable pieces at 30 cm. The total excavated volume from five discrete excavations was 10,5 $m^3$ (Table 7.1). These few finds from near the surface of one hole only imply that the site was abandoned about the time of the first appearance of pottery, which is confirmed by the final $^{14}C$ date for the site of 1780 ± 60 BP.

### 7.1.4 Sea Levels

The higher sea level hypothesis for the mid- to Late Holocene was discussed in Chapter 6. We need to relate the following data : tidal range 1,8 m (Rüther, pers.comm.), sea level ca. 3000 BP +1,5 m (Flemming 1977), base of MTM above present mean sea level not less than 7 m, and the earliest $^{14}C$ data for MTM 2820 ± 50. Deposition of this shell accumulation by wave action even during stormy spring tides and oscillations in the marine regression seem improbable; washed-up shells tend to disintegrate on beaches and become incorporated in beach sands (Miller, *pers.comm.*). Kilburn and Rippey (1982: 9) have commented on shell collecting from the beaches that

> "the same beach which one week is 'ankle-deep' in shells may be as barren as the lunar landscape by the next; overnight high seas and storms may sweep the beach clean of shells".

### 7.1.5 Configurations of Shell Mounds

Despite severe disturbance of the site, there remain discrete mounds on the surface ranging from one to 30 metres in extent and this pattern of shell heaps was found to be repeated in the sections of test holes. In contrast, the observed deposition of shells by wave action on this coast follows the contours of the substrate and, although patchy, is not noticeably heaped in sizable mounds on the beach. The human tendency is to create mounds of shells near but never out of the way of activity areas, which prevents feet being cut (Bigalke 1973: 164; Siegfried *et al*. n.d.).

These surface and subsurface configurations therefore are more indicative of a cultural than a natural origin.

### 7.1.6 Radiocarbon Dates - Megamiddens (Table 6.1)

The earliest dates are MTM 2820 ± 50, Kreefbaai 3190 ± 60, Grootrif 2720 ± 60 and Lambert's Bay 2770 ± 60. The Kreefbaai date appears anomalous against the dates for the other three sites; but this small range and the tight clustering of all the dates for both Kreefbaai (N = 7) and Grootrif (N = 11) around 2500 BP might be spread wider if calibration were possible. (The Grootrif date of 690 ± 40 relates to a small ceramic period midden Phase III 1800-300 BP.)

These megamiddens all appear to be beyond the range of marine deposition during Holocene higher sea levels which in conjunction with the array of dates seems to favour a human origin.

### 7.1.7 Analysis of Sand Samples

Both test holes E4 and E5 revealed an almost sterile sandy layer at a depth of 70 - 80 cm, but sufficient charcoal was recovered from E4 to give a date of 2090 ± 50 BP. Sand samples from these layers in E4 and E5 and from the nearby beach were kindly analysed by Dr Borg Flemming, who also provided Figure 7.1 to illustrate the difference between Eland's Bay river, beach and dune sand grain size frequencies and the effects of aeolian transport. His analysis of the MTM samples showed slight modification from beach to dune but too slight to be conclusive. The midden samples also differed from the beach sample in the inclusion of some very

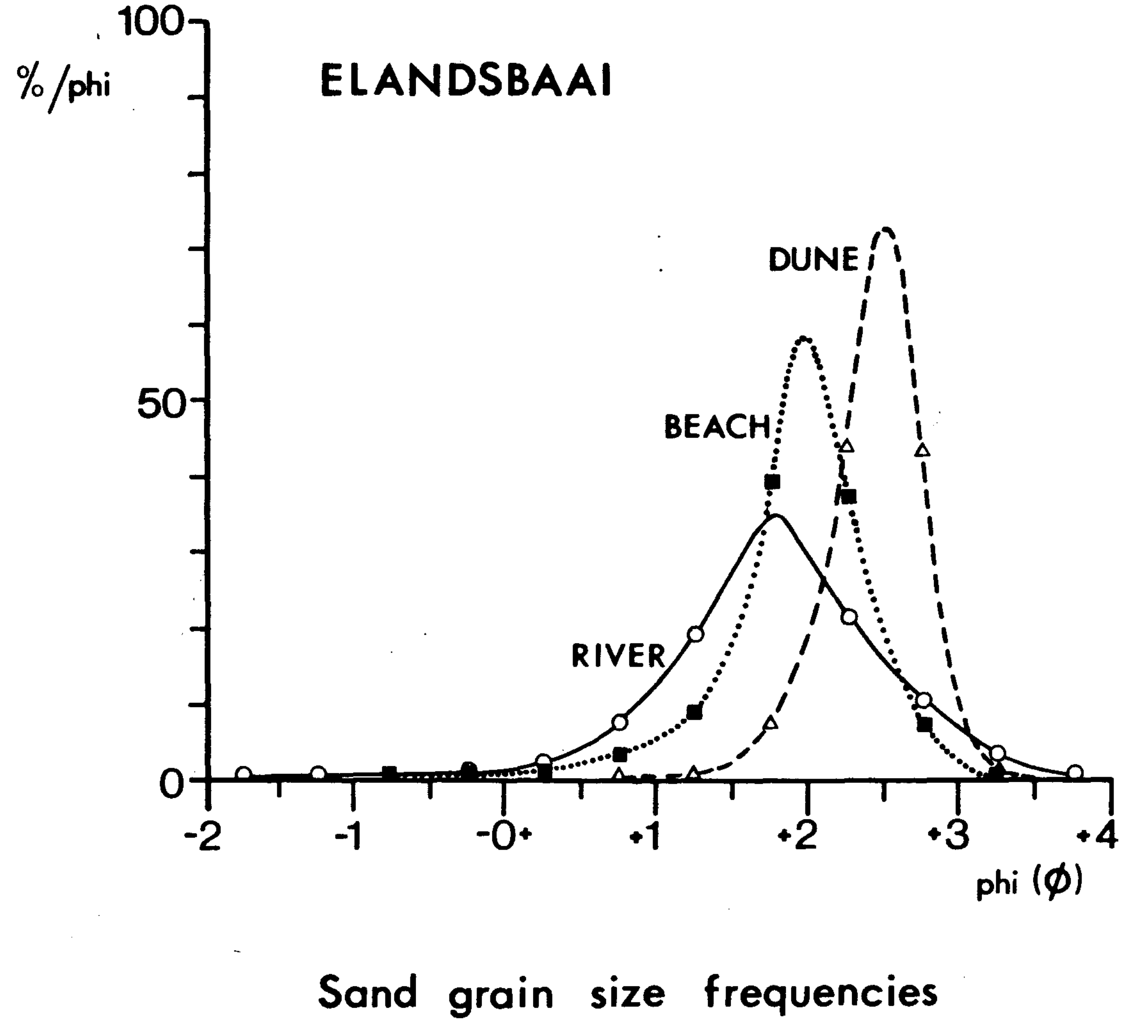
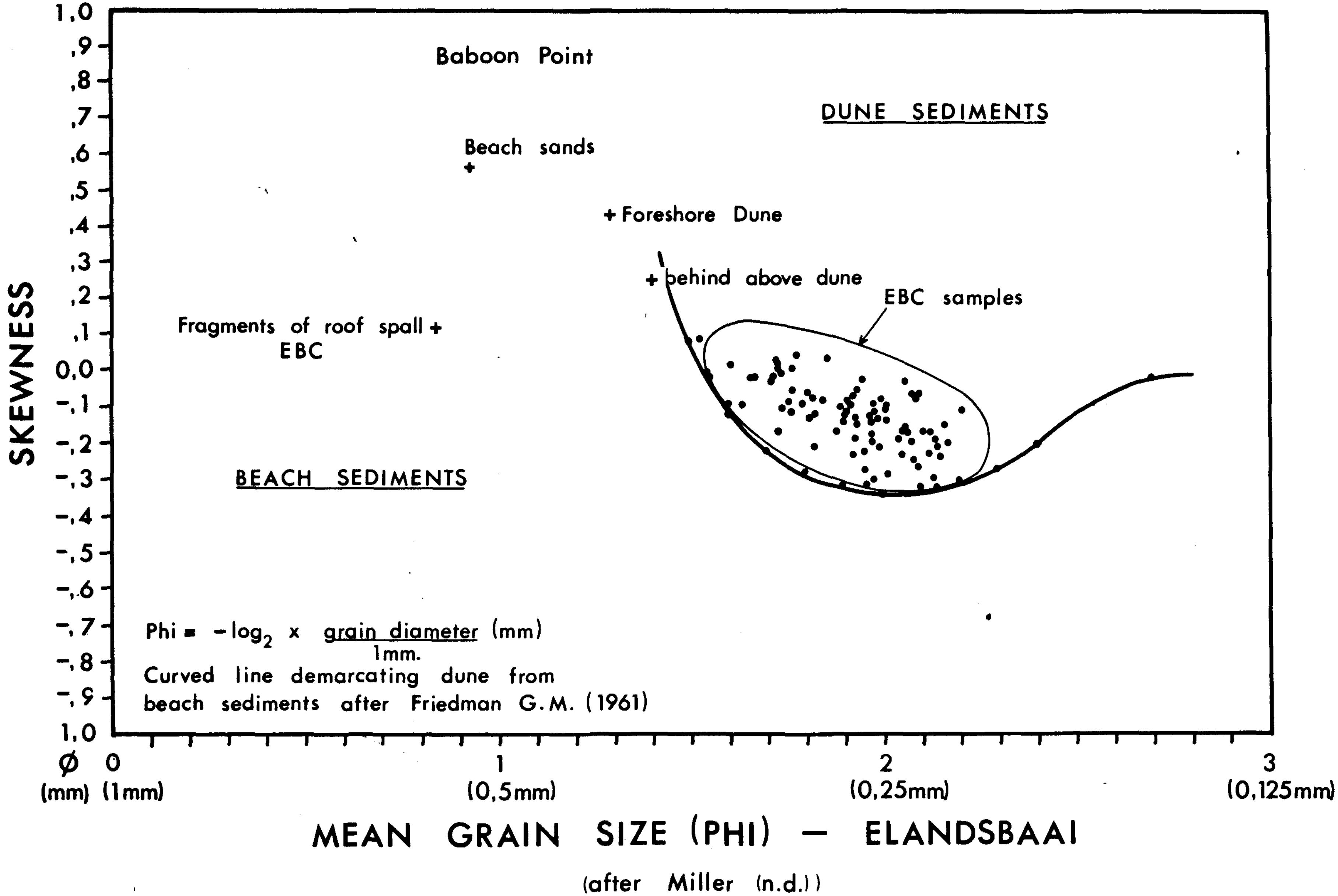

100
%/phi
ELANDSBAAI
DUNE
50
BEACH
RIVER
0
-2
-1
-0+
+1
+2
+3
+4
phi (ϕ)
Sand grain size frequencies

Figure 7.1



SKEWNESS
1,0
,9
,8
,7
,6
,5
,4
,3
,2
,1
0,0
-,1
-,2
-,3
-,4
-,5
-,6
-,7
-,8
-,9
1,0
Baboon Point
DUNE SEDIMENTS
Beach sands
+ Foreshore Dune
+ behind above dune
EBC samples
Fragments of roof spall +
EBC
BEACH SEDIMENTS
Phi = -log2 x grain diameter (mm) / 1mm.
Curved line demarcating dune from
beach sediments after Friedman G.M. (1961)
Ø 0 1 2 3
(mm) (1mm) (0,5mm) (0,25mm) (0,125mm)
MEAN GRAIN SIZE (PHI) — ELANDSBAAI
(after Miller (n.d.))




Figure 7.2

fine grains that may have originated in mud or silt. At best, this evidence tends to favour deposition by wind rather than by sea, although the distance between them is no more than 100 m, but effects begin to show even over short distances (Figure 7.2). Small sea-worm pebbles or shingle were not found in MTM.

### 7.1.8 Available Shellfish Biomass

The shellfish biomass available on the adjacent Mussel Point has been estimated at a total of 158 million kJ or 13 188 kJ $m^{-2}$ (Appendix S.1(c)). The nine sites other than MTM round the hills in the vicinity of MTM can be ignored as insignificant in this context. The hypothesis that MTM is a natural accumulation therefore implies that for centuries and even for millenia, hunter-gatherers paid scant, if any, attention to this super-abundant supply of easily accessible food, which they certainly favoured elsewhere and at other times. Coastal surveys have invariably found middens wherever there are outcrops of shellfish-bearing rocks (Avery 1977: Figure 5; Olivier 1977; Buchanan et al. 1978).

### 7.1.9 Conclusions

From the accumulated evidence there can be little doubt that MTM ranks as an archaeological site. If that were not so, we should have another problem : there is so little evidence of occupation for the time period of about 3000 to 1800 BP apart from MTM, that we should have to consider why the area was virtually abandoned.

## 7.2 DISTRIBUTION OF CHARCOAL

The final argument in support of this conclusion may lie in the ubiquity and distribution of charcoal and its implications.

All charcoal recovered from the 3 mm mesh sieves from test holes E3, E4 and E5 was bagged by 10 cm spits and subsequently weighed. Figure 7.3 illustrates the results and $^{14}C$ dates have been inserted. Unfortunately, time ran out on the excavation of E5 at Spit 5 and a subsequent visit to complete the excavation and put down more test holes was washed out by recurrent rainstorms.

While no ash lenses or hearths were discovered, fine-grained charcoal was recovered from every spit. Bush fires are an unlikely source of this charcoal as they are relatively infrequent in the sandveld (Van Wilgen 1984: 360) and the ubiquity of thinly spread charcoal rather suggests 'one-shot' cooking fires.

The horizontal and vertical distribution of the charcoal may be indicative of the spread and intensity of cooking activity over the site. The mean weights of charcoal per unit volume for E3, E4 and E5 at 516, 390 and 406 grams respectively suggest a fairly even horizontal spread of activity and no localised concentrations. Vertically,

# MTM. DISTRIBUTION AND $^{14}C$ DATING OF CHARCOAL
## Test Holes E3, E4 and E5

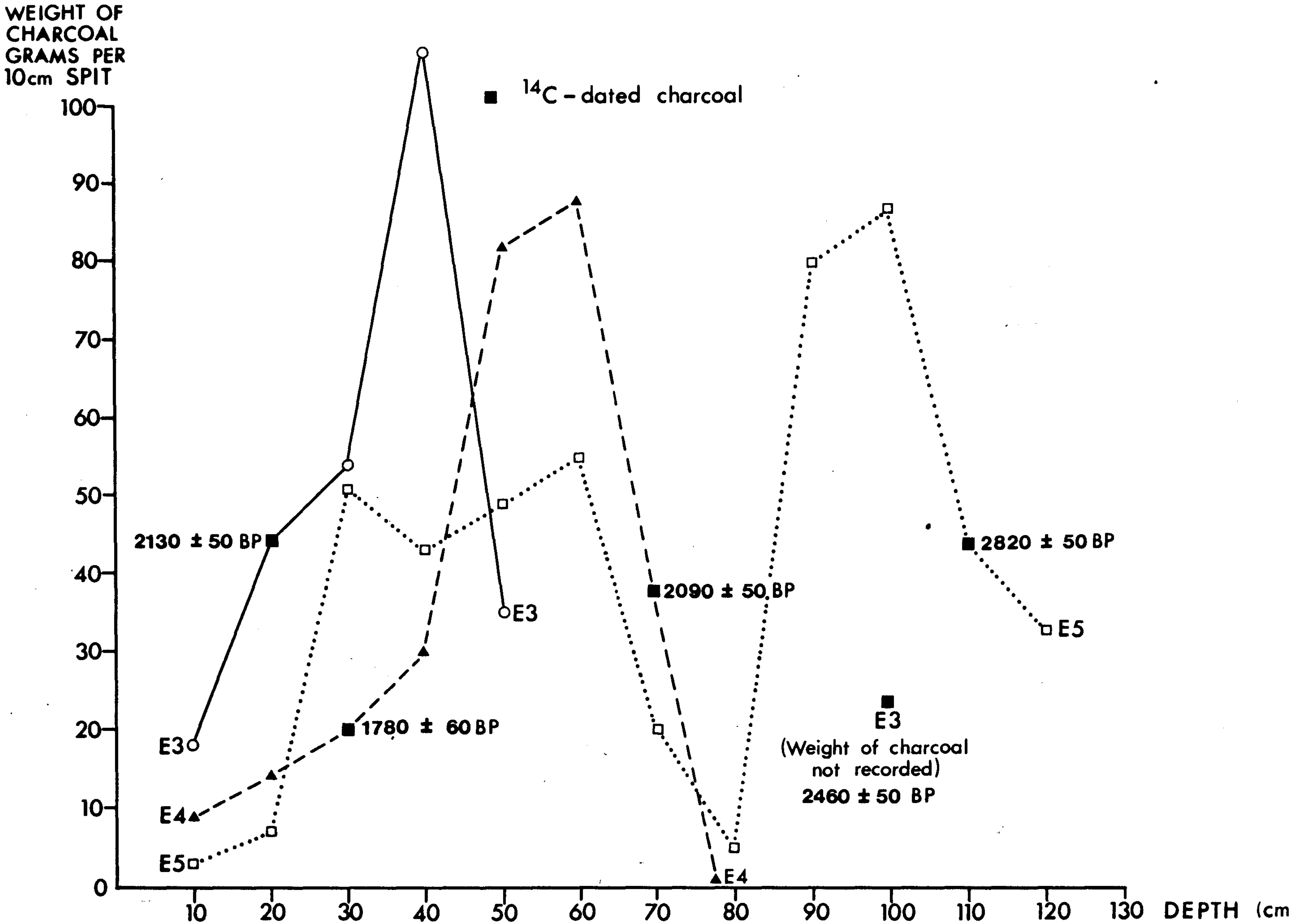



Figure 7.3

E4 and E5 each show a sharp decrease in charcoal density at 70 - 80 cm depth, where the sandy layer occurs; E3 shows a similar decrease at 50 cm, although there was no sandy layer; there is no mention of a sandy layer in the E1 or E2 reports and none is visible today. A possible inference is, therefore, that the vertical buildup of the midden was uneven and that, in particular, the northern portion was out of use for a time when the sandy layer built up, but no such interruption occurred to the south. After the episode of sand deposition, charcoal density peaks in all three test holes at 40 - 60 cm deep and then declines to negligible amounts at the surface. No similar patterning has yet been observed in the apparent densities of shellfish or other debris, but analyses have still to be completed.

## 7.3 IMPACT OF HUMAN GATHERING ON SHELLFISH BIOMASS

The rocks adjacent to MTM support a mussel population estimated at some 133 million kJ (Appendix S.1(c), p.349). A hunter-gatherer band of 30 individuals who stayed in the area for 60 days and ate nothing but mussels would consume about 16 million kJ, or about 12% of the available mussel biomass. The effective rate would probably be less than 10% when allowance is made for the rapid growth and reproduction of the black mussel, which would be stimulated by hand picking of the larger animals (Tregoning & Van der Elst n.d.) and by the consequent reduction in competition for space. The hunter-gatherer impact on this biomass may therefore have been of little consequence when compared with mass mortalities from environmental causes.

## 7.4 MTM AS A CENTRE FOR PERIODIC AGGREGATIONS

Periodic aggregations of mobile foraging bands is a generally recognised practice of the hunter-gatherer life-style to provide opportunities for more intense social contact, for exchanges, ceremonial, marriage-brokering and similar purposes. During times of aggregations, foraging must provide for everyone and yet leave enough time for non-subsistence activities which are the real purposes of the gathering. An aggregation site should, therefore, be recognisable by the ready availability of food in quantity and water.

The research area from Eland's Bay to the Olifants River valley from which Parkington (1976a) derived his seasonal mobility hypothesis, has so far failed to produce a site that might meet these needs. Manhire et al. (1983: 30-31) have suggested that the groups of more than 15 people, either all male or all female, depicted in rock art in the area, imply 'parent groups' of 40 or more during episodes of aggregation, but paintings of aggregations, co-operative activities or conflict situations are restricted to the inland area and none has been found at the coast.

Nevertheless, MTM would have been a potentially suitable site; the food supply was adequate for a large gathering and easily and readily available with a minimum of effort and feeding mainly on mussels would explain the scarcity of non-molluscan faunal debris.

MTM - Excavation History (continued)

| Year | No. | | Depth (m) | Volume Excavated ($m^3$) |
|---|---|---|---|---|
| 1982 | E3A | 1 $m^2$ test hole dug in 10 cm spits, adjoining E3, but excavation stopped at Spit 5 | - | 0,5 |
| | E4 | 1 $m^2$ test hole dug in 10 cm spits to sterile bottom | 0,8 | 0,8 |
| | E5 | 1 $m^2$ test hole dug as for E4 | 1,2 | 1,2 |
| | | Total Excavated Volume | | 10,5 $m^3$ |

All excavations and test holes struck a bottom level of bright yellow sand, which was tested down to a further 0,5 m.

## Mussel Point

(See Appendix S.1(c), p.349)

### Survey Data

| | | |
|---|---|---|
| Superficial Area - | Balanoid Zone | 6 800 $m^2$ |
| | A - C Zone | 5 180 $m^2$ |
| | Total | 11 980 $m^2$ |

### Beach Transects (Rebelo 1982)

| | |
|---|---|
| Species Frequencies (kJ) | |
| Mussels | 83,9% |
| All Other Species | 16,1% |

### Biomass

| | | |
|---|---|---|
| *Choromytilus meridionalis* - | Balanoid Zone | 6 120 kJ $m^{-2}$ |
| | A - C Zone | 17 570 kJ $m^{-2}$ |
| All Species of Shellfish - | Balanoid Zone | 7 191 kJ $m^{-2}$ |
| | A - C Zone | 20 660 kJ $m^{-2}$ |

# CHAPTER 8

## SHELLFISH - INSIGHTS & INFERENCES

Against the background of the preceding chapters, the prehistoric role of shellfish can now be examined in more detail, both spatially and temporally.

### 8.1 SPECIES FREQUENCIES

Comparison of beach transects with archaeological data (Table 8.1, p.231) reveals that pottery period sites of Phase III 1800 - 300 BP close by the shore tend to reflect the species composition of the adjacent shell beds and that a prehistoric preference for mussels is increasingly evident with increasing distance from shore to site. The only sites known as yet with dates in Phase II 3000 - 1800 BP are MTM and PR1 (Figure 6.2) both of which are dominated overwhelmingly by mussels (95% and 85% respectively). The abundance of mussels in PR1 appears anomalous in relation to its situation; it is surrounded by Phase III pottery period sites all of which are limpet-dominated being situated adjacent to the extensive limpet beds on the Sector 1 Bay rocks where mussels are scarce and where the sheltered habitats are not favoured by mussels.

# TABLE 5.5

## ELAND'S BAY SITES - PROPORTIONS OF PROTEINS, FATS & CARBOHYDRATES IN PREHISTORIC DIET

| Category | kJ m$^{-3}$ Appendix G.1(A) | kJ m$^{-3}$ Protein | Fat | Carbohydrate | Total |
|---|---|---|---|---|---|
| Shellfish | 350 000 | 239 953 | 69 447 | 39 997 | 349 397 |
| Rock Lobsters | 29 572 | 23 079 | 5 278 | 1 236 | 29 593 |
| Fish | 10 901 | 8 701 | 2 149 | - | 10 850 |
| Mammals | 192 625 | 112 124 | 80 904 | - | 193 028 |
| Cetaceans (Estimates) | | | | | |
| Toothed | 120 000 | 117 377 | 2 585 | - | 119 962 |
| Baleen | 90 000 | 49 483 | 40 716 | - | 90 199 |
| Seals | 129 748 | 58 519 | 70 424 | - | 128 943 |
| Birds | 61 352 | 40 648 | 20 810 | - | 61 458 |
| Tortoise | 7 358 | 4 476 | 2 865 | - | 7 341 |
| Plants (Estimates) | 8 444 | 1 128 | 509 | 6 769 | 8 406 |
| | 1 000 000 | 655 488 | 295 687 | 48 002 | 999 177 |

| | | |
|---|---|---|
| Protein | 655 488 kJ m$^{-3}$ | 65,6% |
| Fat | 295 687 kJ m$^{-3}$ | 29,6% |
| Carbohydrate | 48 002 kJ m$^{-3}$ | 4,8% |
| | 999 177 kJ m$^{-3}$ | 100,0% |

During Phase II the limpets of Sector 1, the Bay itself, would have been as accessible as the mussels of Sector 3 Mussel Point. Yet limpets were practically ignored during this phase while mussels were gathered intensively. During the higher sea level of Phase I 4400 - 3000 BP, both Sector 1 and Sector 3 rock platforms would have been submerged even at low tide leaving only a limited supply of accessible shellfish on the upper reaches of Sector 2 (Baboon Point). This promontory is comparatively unproductive with limpets and mussels contributing in roughly equal proportions to total shellfish biomass (Appendices S.1(b) and S.2, pp.348 and 350). The middens of Phase I appear to reflect this species frequency although some horizons are strongly mussel-oriented but overall mussel dominance is much less pronounced than in Phase II.

## 8.2 LIMPETS - SPECIES SELECTION & TIDAL CYCLE

Table 8.2 (p.232) gives a comparison of the collated archaeological data (Appendices L to R, pp.328/346) with the available biomass by species in Sectors 1 and 2 of the shore (Appendices S.1(a) and S.1(b), pp.347/8). Sector 3 has been omitted from this comparison in view of the overwhelming predominance of mussels on the rocks and in sites. The upshore and downshore distribution of limpet biomass by species (Appendix S.2, p.350) for all three sectors and a comparison of transect and archaeological data by kJ yield for each species are also provided (Table 8.3, p.237).

Factors that may have influenced prehistoric selection of limpet species include the mean kJ yield per animal, the available biomass, the effects of tides on accessibility and the number of shells that have to be collected for a given kJ yield and their weight.

The foraging strategy implied in these tables is indicative of intensive collection of the larger higher-yielding down-shore species P. argenvillei and P. barbara during the limited search time and having regard to their relative scarcity. Thereafter, gathering concentrated on P. granatina in preference to P. granularis which is smaller, more numerous and mostly upshore (Appendix S.3, p.351). Since subtidal species of limpets such as P. compressa and P. miniata are rare or absent from archaeological samples, gathering was evidently restricted to the inter-tidal zone.

Comparing shell weights and numbers to be collected of each species (Table 8.4, p.234), the inferred strategy appears efficient. For a given kJ yield, only one P. argenvillei/ barbara has to be gathered for every two P. granatina or six P. granularis. Selecting the largest available animals makes economic sense as energy yields increase exponentially to increase in size. A 40 mm P. granatina yields 8,6 kJ, whereas an animal of twice that size yields more than ten times as much (Appendix K.1, p.326); to Transkei Africans, the larger animals tasted better (Bigalke 1973: 166).

Table 8.5 (p.235) implies, tentatively in view of the small sample of the larger species, that these higher yielding limpets were preferred for carrying to distant sites despite their heavier weight.

The habitats of all four species of limpet gathered in prehistoric times at EB are restricted to the intertidal zone except for *P. barbara* which is also subtidal, from which we can assume that the gatherers did not venture beyond wading depth and that the tidal cycle would therefore be of crucial importance to the times of gathering. Since the fortnightly occurrence of low spring tides during the phases of new and full moon expose more of the low shore and for longer periods, the larger and more rewarding down-shore species would then be more accessible in contrast to neap tides when the moon is waxing or waning and the tidal range is less marked. Modern shellfish gathering by indigenous peoples along the South African coast is concentrated on one to three days either side of spring tides with only incidental collecting at other times (Voigt & Bigalke 1973: 4; Bigalke 1973: 160; Tregoning & Van der Elst n.d.; Siegfried *et al*. n.d.). Gathering during inclement weather or during neap tides usually entailed collection of more of the smaller upshore species. Since the interval between tides is about 12 hours 25 minutes, tides occur later each day; in summer low tides may thus occur occasionally about dawn and dusk on the same day but there is no record of gathering twice on the same day.

These modern coastal communities exploit shellfish as a supplementary food mainly for the protein content :

> "the incidence of kwashiorkor, a disease typical of a protein-deficient diet, is far less prevalent amongst coastal dwellers than among the people living inland in Transkei"

(Siegfried *et al.* n.d.). The pattern of shellfish predation of the Anbarra hunter-gatherers of northwestern Australia, however (Meehan 1982: 64-66), might be more relevant to prehistoric practice at EB. Over the year of her observ-ations, Meehan recorded that the number of days per month spent gathering shellfish during spring and neap tides did not differ significantly but, by weight of shell, collections were twice as productive during spring tides than neap tides as spring lows gave access to the larger downshore species, whereas neap lows restricted collection mostly to the smaller upshore species.

A feature of the EB shellfish analyses is the remarkable uniformity in limpet species frequencies which indicates a consistency in gathering tactics and timing. Departures from this pattern are rare; from the single instance of an exceptionally high concentration of the small low-yielding upshore *P. granularis* which occurs in one layer of EBC, we can infer that that collection was badly timed or inhibited by stormy seas to the upshore zone, and from the occasional pockets of the large downshore species *P. argenvillei* in the EBC deposit and of the mainly infratidal large Aulacomya ater at TC, neither of which occur at other sites, we might infer that gatherers were fortunate to catch very low spring tides at a time of calm seas. The early prehistoric groups at EB would certainly have been aware, like the Anbarra, that gathering at spring low tides was more productive than at other states of the tide; shellfish may therefore have been not only an important food source but possibly also influenced the scheduling of visits to the area.

## 8.3 MUSSELS - FORAGING PATTERNS

Unlike limpets, there is no clear foraging pattern in the data for the Black Mussel Choromytilus meridionalis, other than selection for size (Appendix S.3). Only minimal presence is indicated on the Sector 1 rocks of the Bay itself (Appendix S.1(a)) which lie in the lee of Baboon Point and lack the exposure required for optimal feeding of mussels. At Baboon Point, Sector 2, (Appendix S.1(b)), mussel colonies are mainly in the rough water of the down-shore zone where gathering must have been risky as days of calm seas along this coast are infrequent. At Mussel Point, Sector 3 (Appendix S.1(c)), the massive mussel colonies in the upshore zone, although only one-third of the biomass of the downshore zone, may have been adequate for the daily needs of the prehistoric gatherers.

## 8.4 MUSSEL POISONING

### 8.4.1 Introduction

Mussel poisoning, or paralytic shellfish poisoning (PSP) has been the subject of intensive research since the association of the mussel Mytilus californiansis with the toxic dinoflagellate Gonjaulax catenella was first established by Sommer and Meyer (1937). The toxin was isolated in 1962 and named "saxitoxin" (STX) after the Butter Clam Saxidomus. Even as late as 1970, STX was regarded as a rather exotic and unknown marine biotoxin. The biogenesis of the toxin is still unknown, although other species of STX-producing organisms have since been identified. Along the Atlantic coast of the Cape Province, 14 species of dinoflagellates have been identified, but only G. catenella has been confirmed as toxic, the toxicity of G. grindleyi being still uncertain, but treated as toxic for the purposes of this analysis.

The major class of STX-producing organisms are unicellular dinoflagellates which may be present in 'red tides' caused by massive overproduction or 'blooms' of marine phyto-planktons with resultant discolouration of the sea : red, yellow, green, brown, blue or purple dependent on species, depth and concentration. Three species are known to be bioluminescent - the nontoxic Noctiluca miliaris and

*G. polygramma* and the toxic *G. catenella* (Horstman 1981: 76-77). Red water outbreaks have been reported in most of the oceans and PSP epidemics have a similar near-world-wide distribution (Dale & Yentsch 1978: 43; Halstead 1965; Prakash 1975; Grindley & Nel 1970; McCullum *et al.* 1968).

STX is one of the most lethal biological substances known (Sapeika 1974: 16). Symptoms of poisoning appear within half an hour of ingestion and the progressive stages have been documented by Dale and Yentsch (1978) and by Bower *et al*. (1981: 835). The initial stage produces tingling, numbness and burning around lips, mouth and face spreading to the extremities and even only a few milligrams can lead to the final stage of muscular paralysis and death from asphyxia within two to 24 hours. Survival after this time gives a rapid and complete recovery. There are no known specific antidotes, nor has any effective curative or preventative medication yet been found and, as STX is not antigenic, immunity cannot be acquired (Bower *et al*. 1981: 836). Cooking has little if any effect on the toxin.

The danger in modern mussel consumption entails both a serious public health problem and a restraint on lucrative commercial exploitation and along extensive stretches of the American coastline, shellfish are regularly monitored or shellfish collection is banned temporarily or permanently.

Toxic dinoflagellates have already been the subject of two international conferences (Lo Cicero 1975; Taylor & Seliger 1979) and a third is projected. The undernoted local newspaper headlines, instigated by the Sea Fisheries Research Institute, highlight the danger :

Cape Times

| | |
|---|---|
| 14 January 1982 | BEWARE THE RED TIDE |
| 12 April 1984 | RED TIDE WIDESPREAD : NEW DANGER WARNING. |

## 8.4.2 Ethnographic Evidence

There is only scant evidence that the dangers of PSP were known to prehistoric shellfish gatherers (or even to archaeologists outside of South Africa). The Indians of the Pacific coast of North America were known to have suffered from mussel poisoning centuries before the White settlers arrived (Dragovich 1969: 175), to have recognised by the mid-eighteenth century the association of a discoloured sea with mussel poisoning (McCullum et al. 1968), and Dale and Yentsch (1978: 4) quote instances of their taboos on mussel eating. The massive quantities of mussel remains on sites along the Atlantic coast of South Africa with the absence of any archaeological, historical or ethnographic records of mass mortalities, support an assumption that these early peoples must have recognised the danger and the link with red water outbreaks.

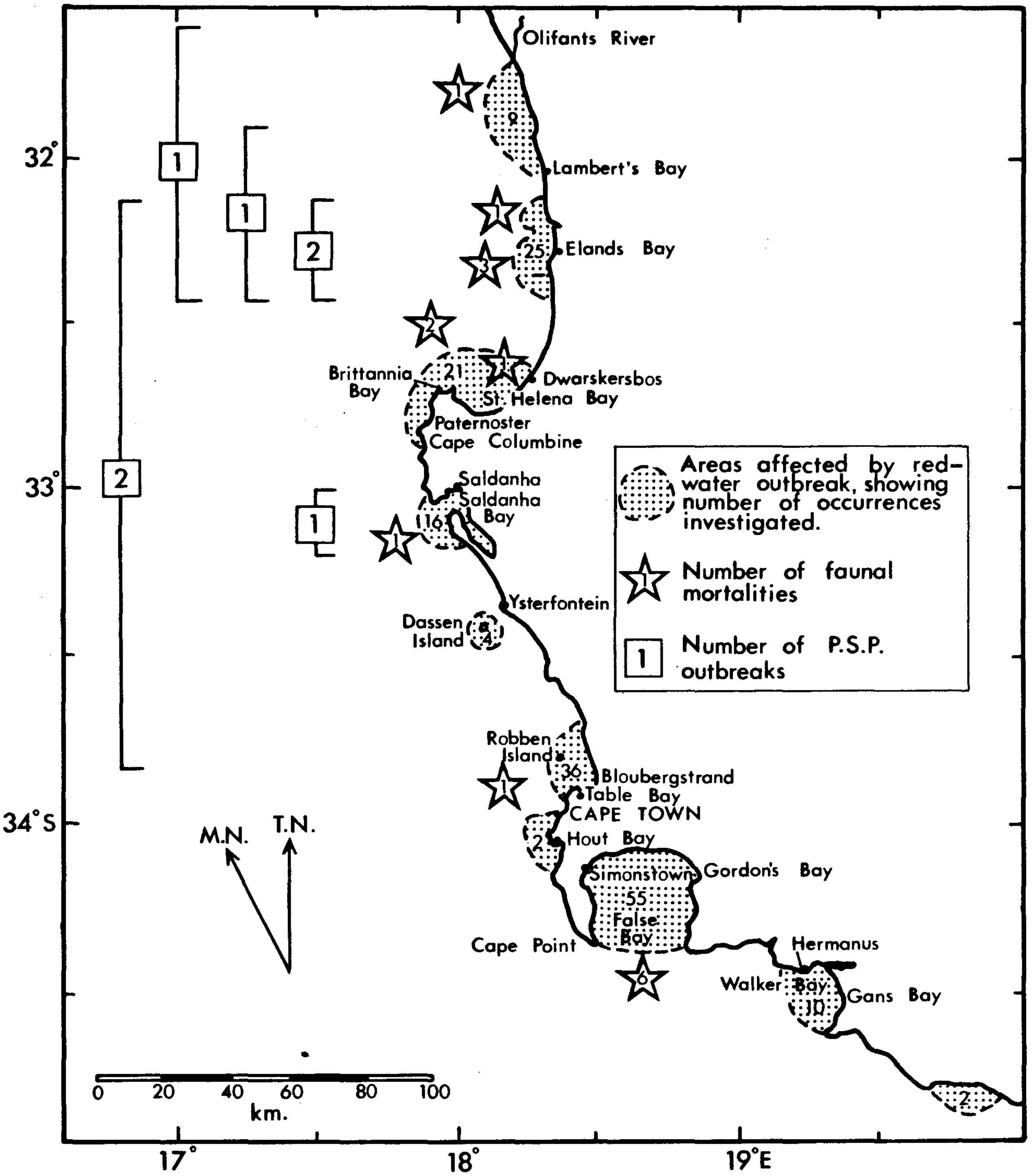
### 8.4.3 Assessment of the Risks of Mussel Poisoning at Eland's Bay

The data in Horstman's study (1981) enable an attempt to gauge the extent of the danger at Eland's Bay and to speculate on potential avoidance strategy. The attached Tables 8.6(a), 8.6(b) and 8.7 (pp.236/8) and Figure 8.1 relating to the period 1959 - 1983 suggest that :

(1) Over the whole period of 24 years, red water outbreaks occur irregularly and do not reveal cyclic or periodic patterning but at Eland's Bay tend to occur every year.

(2) Of the seven toxic outbreaks, six included Eland's Bay and of these six, two were limited to the Eland's Bay area of the coast, three extended from Eland's Bay to the north and one to the south. On average, therefore, Eland's Bay gets about one toxic outbreak every four years.

(3) All toxic outbreaks occurred between December and May with the single exception of the September 1974 episode involving *G. grindleyi* whose toxicity is still uncertain.




INCIDENCE OF RED WATER OUTBREAKS, FAUNAL MORTALITIES AND P.S.P. 1959 - 1983

(after Horstman (1981), updated to 1983)

Figure 8.1

(1978) have demonstrated for *G. excavata*. The substrate along the southwest coast is to be tested for the presence of resting cysts which, if confirmed, might explain the repeated toxic episodes at Eland's Bay. Resting cysts for *G. excavata* have been found to be ten to 1 000 times more toxic than the motile cell (Dale & Yentsch 1978).

Filter-feeding bivalves such as the Black Mussel *Choromytilus meridionalis* and the White Sand Mussel *Donax serra* - there is no mention of the Ribbed Mussel *Aulacomya ater*, possibly for the reason that this species mostly inhabits the deeper waters (Field *et al*. 1980) -

> "accumulate the poison in their digestive glands but may not die as a result; suffering paralysis, many are washed up on to the beaches where they die from exposure but death does not necessarily occur if the mussels remain submerged"

(Horstmen 1981: 85). Washing ashore is unusual along other continental coasts but may be due to the heavy surf action over most of the year along the Cape southwest coast. Mass mortalities of mussels, for instance the five million White Sand Mussels washed ashore on the Eland's Bay beach during the episode of March 1980, cause a drastic change in population structure and many years may pass before there is a return to normal, but this forecast is based on De Villiers' reports (1975 & 1979) of the White Sand

Mussel only. A more rapid recovery for the Black Mussel can be assumed (Horstman, pers.comm.).

Rock lobsters washed up on to the beach or intertidal rocks after a red tide are usually alive but moribund. Tests of toxicity have discovered significant quantities in the digestive glands, possibly derived from their favourite prey, the Black Mussel, but the flesh and particularly the tail which form the edible portions are unaffected (Horstman 1981: 84).

### 8.4.4 Prehistoric Mussel Avoidance

Prehistoric awareness of the dangers may have included recognition of the dangerous months, the predisposing climatic conditions, the association with discolouration of the sea and bioluminescence at night and the washing up on the shores of dead and dying marine fauna in addition to the symptoms of poisoning already described.

Since red water outbreaks can extend for hundreds of kilometres along the coast, a rapid inter-band exchange of early warning would be of mutual benefit. Reactions to an outbreak might have been to avoid mussels and turn to limpets and whelks which are not affected by toxic red tides, to treat all or most seafoods as suspect and direct subsistence activities to terrestrial resources, or even to move inland and stay away from the coast for some months.

### 8.4.5 Toxicity Levels

An attempt has been made in Table 8.8 (p.239), based on reported toxicity levels, to assess the dangers for prehistoric mussel eaters. Clearly, the only safe way would be to avoid mussels altogether for six months after any red water episode, but a few might be taken from the intertidal rocks with little risk since toxicity levels are lowest there, or, alternatively, to collect mussels only during the months of June to November when the incidence of red tides is at its lowest and toxic episodes occur rarely or perhaps not at all, but mussels contaminated during a toxic outbreak in late autumn might remain dangerous throughout the winter, although at a reducing level of toxicity.

These conditions suggest that massive mussel accumulations in middens such as MTM are indicative of occupations primarily in winter.

## 8.5 RATES OF PREDATION

Attempts to assess rates of predation and the consequences for natural populations have proved futile. Limpet studies give rates of growth, reproduction, longevity and mortality in age-group cohorts (Branch 1974a, 1974b) which cannot be reliably related to archaeological distributions based on size only. The respective population structures are not meaningfully comparable except in a general way. Zoological sampling aims to reconstruct the whole population irrespective of size, whereas archaeological samples are biased towards the larger animals and there is a striking difference between the two in the numbers of the small animals under 20 mm.

Limpet populations are not subject to mass mortalities and are relatively stable in time although major variations in structure can take place over a few metres of shoreline (Branch 1984: 61). Such localised variations should not affect an archaeological investigation concerned with the long time periods between $^{14}C$ dates and with extensive stretches of intertidal rocks where overall species frequencies are primarily dependent on the availability of species-specific habitats related to the geomorphology of the coastline (Branch 1981). Modern data on limpets can therefore be extrapolated back into the late Holocene and possibly even beyond.

The only sign of limpet over-exploitation relates to P. granatina. Animals over 80 mm accounted for 12,5% of total kilojoules on the shore but only 0,1% from sites; in other words, the largest animals are virtually absent from archaeological samples but the mean size of all shells of this species shows a remarkable consistency with only minimal variation from 52 mm. Reduction in size of shellfish as a result of intensive predation has been reported by several authors : for a New Zealand midden, Anderson (1981) attributed size reduction to predation over four centuries; Branch (1975) demonstrated a dramatic reduction in maximum size of two limpet species as a consequence of heavy predation by the indigenous people of the Transkei during a period of drought and crop failure from 1967 to 1973; and, on the same coast, intensive gathering of the mussel *Perna perna* over the period 1978 to 1984 led to a significant reduction in both numbers and mean size (Siegfried *et al*. n.d.). In the other direction, Robertshaw (1977) assumed a break in occupation from the recovery in mean size of limpets clearly evident in the data from his PN site.

From Eland's Bay sites, there is only one instance suggestive of over-exploitation. A grab sample from HSM (Horwitz 1979) produced 118 measurable *P. granatina* shells ranging from 50 mm to 90 mm with a mean size of 70 mm, compared with the usual 52 mm and, of these, 13 measured from 80 mm to 90 mm. An environmental explanation is improbable for this unique appearance of large shells in the grab sample and, as at PN, the more likely explanation is a break in exploitation which allowed some shells to grow to maturity. Presumably, at some undocumented time, human gathering nearly eliminated the large animals over 80 mm and regular concentration on the middle range animals allied to normal mortality and non-human predation precluded any significant number from reaching their full lifespan. P. granatina is sexually mature at 30 mm to 35 mm, after only one year's growth (Branch 1974b: 57) and, although a major contribution to reproduction is derived from the largest animals, populations below 80 mm must have survived and reproduced in sufficient numbers to withstand the inroads of the prehistoric gatherers without noticeable effects. No similar phenomenon has been observed for the other three species from the Eland's Bay data, which tends to support a cultural rather than an environmental explanation.

If the unique appearance of large P. granatina in the HSM grab sample is not controverted in future excavations and if the assumption of a break in occupation is valid, then we can infer that prehistoric foragers must have visited the area to gather shellfish every year or nearly so.

In contrast to limpets, mussel populations are highly susceptible to mass mortalities from environmental causes (Griffiths 1981: 111-112). Branch (1984) has reported on mass mortalities of subtidal populations at five localities on the west coast from Eland's Bay to Melkbosstrand during the Benguela 'warm event' of December 1982/ January 1983, although a causative link was not clearly established. Limpets were not affected.

The mussel biomass available to the Eland's Bay gatherers was evidently subject to far more drastic fluctuations than limpets and mussel gathering may even have been restricted for a time as a result of environmental causes, but the rapid rate of mussel reproduction and recolonisation should have limited periods of non-availability. Environmental agencies, other than red tides, might not have affected populations along the whole Eland's Bay coastline and, for most of the time, the abundance of mussel biomass would have precluded any noticeable impact from prehistoric predation.

## 8.6 ECONOMIC RANGE

The maximum economic range for the regular use of shellfish as food emerges from this study at about 6 km against 8 km for modern Transkei gatherers (Voigt & Bigalke 1973: 5), although up to 10 km is also quoted by Bigalke (1973: 61) and up to 15 km with an overnight stay on the beach by Tregoning and Van der Elst (n.d.) for Kwazulu people. Bailey (1975: V, 15) adopted 10 km or two hours' walking time as a reasonable guide to the maximum radius of habitual exploitation around a site, while accepting that distances of up to 16 km are not uncommon for hunter-gatherers and forays beyond that are still possible.

The Eland's Bay area offers the advantages of an ecotone with land, sea and vlei resources underwritten by the dependable, abundant and easily accessible shellfish, and there would be little need or incentive to go beyond the 10 km range; all the food debris identified in sites derive from resources that could have been taken within this radius. Hunting forays may on occasion have gone further afield, since prestige and other non-economic motives may overrule strict time/distance and cost/benefit factors, but scarcity of hunting toolkits in coastal middens (with the possible exception of TC) suggests that hunting was not a major activity while at or near the sea. The occasional very large mammal however or washed-up seal, whale or dolphin might justifiably have entailed much longer trips.

## 8.7 LIMPETS vs MUSSELS

Shellfish gathering is generally regarded as a task for women (Voigt & Bigalke 1973: 3; Bigalke 1973: 159; Tregoning & Van der Elst n.d.; Siegfried et al. n.d.; Shawcross 1970: 283). The only exception I have found related to the Topnaar of the Walvis Bay area in Namibia (Budack 1977: 36) where all collecting is done by men while women and children only help with the carrying.

If we assume that for the early Eland's Bay people, women did most of the shellfish gathering and that, of the individuals in a band, 35% were women, based on Lee (1979: 271-272), we can then relate these assumptions to two parameters already discussed, i.e. human daily energy requirement (Table 5.1, p.159) at 9 000 kJ and percentage contribution of shellfish to diet at the coast (Appendix G.1(a), p.309) at 35%, and attempt to estimate the time each woman would have had to spend each day gathering shellfish.

Tregoning and Van der Elst (n.d.) have provided a useful guide which has the unique advantage over other evidence in that the results are based on 1 519 samples from six months' monitoring of shellfish collecting and comprised 230 collectors' samples. The average harvest per collector weighed 4 kg to 6 kg which was "the limit of unshelled food that those women can physically remove from the beach in one trip". Since two-thirds of the Eland's Bay bands are assumed not to have participated in shellfish gathering to any significant extent, each woman would have to gather only three times her own daily energy requirement for shellfish, i.e. about 9 000 kJ in all to meet the needs of everyone, which would entail the daily collection of some 360 limpets or 320 mussels or 340 limpets/mussels in equal proportions with approximate gross weights of 4,3 kg if limpets only, 8,9 kg for mussels only or 6,8 kg for the mix. With children helping in the carrying, there should have been no problem about weight other than the distance of shore to site.

The following comparison of search times emphasises the major attraction of mussels.

Sector 1, Eland's Bay, where collection concentrated on limpets (Appendix S.1(a))

| Zone | Intertidal |
|---|---|
| Total Limpet Biomass | |
| N (thousands) | 1 789 |
| kJ (thousands) | 45 977 |
| Area of Rocks ($m^2$) | 58 170 |
| Limpets per $m^2$ | |
| N | 31 |
| kJ | 802 |

On the above data, the search area per woman would be about 12 $m^2$ to collect 9 000 kJ. Since the distribution of limpets is patchy and selection for species and size takes time, the search area in practice would be greater, but the time spent collecting should not have exceeded about two to three hours depending on conditions and other commitments. Gathering limpets at a rate of 75 - 100 an hour allows ample time for other activities during gathering (gossip, child watching, etc. as related by Meehan 1982).

<u>Sector 3, Mussel Point</u>, where collecting concentrated on mussels (Appendix S.1(c))

| Zone | Balanoid | A-C |
|---|---|---|
| Total Mussel Biomass | | |
| N (thousands) | 2 587 | 5 768 |
| kJ (thousands) | 41 614 | 91 014 |
| Area of Rocks ($m^2$) | 6 800 | 5 180 |
| Mussels per $m^2$ | | |
| N | 380 | 1 114 |
| kJ | 6 120 | 17 570 |

Mussels can be scraped off the rocks in masses as they tend to be attached more firmly to each other by the byssus than to the substrate (Griffiths, *pers.comm.*), whereas limpets must be individually knocked off the rocks by the initial sharp blow. Mussel mean length from both zones was 66 mm (16 kJ) compared with 78 mm - 83 mm (28 kJ) from archaeological samples, which supports an assumption of selection from the colonies of the largest animals (Appendix S.3).

From the high kJ yield per $m^2$, only a very short time would be required to produce 9 000 kJ - one square metre of the downshore A-C zone should have been more than enough. Mussels are fairly evenly distributed over the whole area.

The prehistoric selection for mussels over limpets can be related to easier and quicker collection, higher energy yield per animal, smaller numbers to be gathered and perhaps easier digestibility and better flavour, but offset by heavier gross weight and, more significantly, by the risks of mussel poisoning. Modern coastal communities show a similar preference for mussels over limpets where both are available (Voigt & Bigalke 1973; Siegfried *et al.* n.d.).

The Vlei sites (Table 8.1, p.231) are all mussel-dominated. Since mussels are scarce in the intertidal zone of Sector 1, plentiful on the downshore zone of Sector 2 and superabundant on Sector 3 rocks, shellfish gathering from Vlei sites was oriented mostly to Sector 2 and probably in the main to Sector 3.

## 8.8 CHANGES IN SHELLFISH PREDATION PATTERNS THROUGH TIME

### 8.8.1 Pre-Hiatus

The shellfish sequence at EBC starts at Layer 15 with traces of limpets only, but the first true shell midden does not appear until Layer 12 at about 9600 BP with limpet/mussel kJ ratio at 86%/14%. Thereafter, the proportion of mussels increases up to mussel-domination which continues until the start of the hiatus (Parkington 1981). The post-glacial rise in sea level brought shellfish within economic range of EBC by about 11 000 years ago, but we cannot assume that this heralds the start of reliance on marine resources as there may be sites now submerged on the continental shelf.

The change from limpets to mussels may be behavioural or environmental. The early evidence for Pleistocene mussel exploitation along the west coast at SHM is problematic and the change may be related to seasonal scheduling from summer to winter to avoid the dangers of mussel poisoning. Since mussels seem to have been late arrivals on the archaeological scene worldwide (Bailey 1975) compared with limpets, an environmental explanation seems the more likely.

At Eland's Bay, pre-Holocene coastal geomorphology and wind regimes may not have provided the rocky platforms, exposure to surging seas and mean sea temperature that mussels need to thrive; or the wind regime may have failed to stimulate upwelling and the mixing of the cold sub-surface waters with the warm upper layers with the result that the sea temperature variability was less and mean temperature higher than today, possibly comparable to the Benguela 'warm event' of 1982/1983 during which mass mortalities of mussels occurred; and rising sea levels with continually changing coastline may have inhibited mussel growth and reproduction.

We need more evidence before a reliable explanation can be formulated for the pre-hiatus change in shellfish gathering strategy from limpets to mussels.

8.8.2 Post-Hiatus

The hiatus in occupation has been attributed to a period of hyperaridity (Parkington 1980) which may have been reinforced by the submergence of most of the shellfish-bearing rocks as a result of rising sea levels which, on Flemming's hypothesis (1977), reached a maximum of +3,0 m at about 5500 BP. As sea level receded thereafter, occupation was resumed about 4400 BP with the earliest $^{14}C$ dates of 4330 ± 50 BP Pta 3605 from TC and 3780 ± 85 BP Pta 1816 from EBC.

Despite this break in occupation of several thousand years, the marked preference for mussels re-appears unchanged (Table 8.9, p.241) and there is at present little evidence for the exploitation of other species of shellfish or other marine or terrestrial resources until 1800 BP. From about 1800 BP, the predominantly mussel diet changes to a much wider spectrum of land, sea and vlei resources (Appendices G.1 to G.6, pp.309/314) in which shellfish consumption marginally favours mussels and the proportionate contribution of shellfish to the overall food intake is substantially less.

MTM - 2820 - 1780 BP

| | |
|---|---|
| Volume of deposit (Chapter 7, Table 7.1, p.191) | 11 360 $m^3$ |
| Less Estimated volume related to the pottery period post-1800 BP | 300 |
| Amended Total approximately | 11 000 $m^3$ |

| | |
|---|---|
| Elapsed time from first to last $^{14}C$ dates (Chapter 6, Figure 6.1) approximately | 1 200 years |
| Rate of accumulation of deposit | 9 $m^3$ p.a. |

This rate, which is four to five times greater than during the pottery period, implies larger bands or longer or more frequent visits and as suggested earlier, perhaps use as a site for periodic aggregations or combinations of these variants.

EBC and TC - 11 000 - 300 BP

Total deposits at EBC and TC are of the order of 150 $m^3$ and 400 $m^3$ respectively, but the EBC sequence extends over a period of nearly 5000/6000 years of occupation and the TC sequence about half of that. Annual rates of accumulation would thus be very small which implies very short or very irregular visits or both.

## 8.10 ESTIMATION OF GROUP NUMBERS & TIME SPENT IN THE AREA EACH YEAR

### 8.10.1 The Problem

The two factors of group numbers and time spent in the area each year are interdependent variables that seesaw on the fulcrum of total quantified food intake. Neither can be determined directly from the archaeological evidence but if group numbers can be estimated by other means the time spent can then be calculated. The justification for this attempt is that such phrases as "small mobile bands" and "short-term visits" may be more meaningful if expressed in numbers within a potential range of variation. Further research with a broader data base and more refined techniques should lead to more reliable results, and a better understanding of the ecology of these prehistoric people.

### 8.10.2 First Estimates

A sequence of calculations is set out below :

| | |
|---|---|
| Rate of Accumulation of Deposit (para. 8.9) | 1,33 $m^3$ p.a. |
| kJ $m^{-3}$ from all food intake (Appendix G.1(a), p.309) | 1 million kJ |
| Food intake p.a. (1,33 x 1) | 1,33 million kJ |
| Daily kJ requirement/person (Table 5.1.1, p.159) | 9 000 kJ |

Food intake p.a. represents $\frac{1,33 \text{ million kJ}}{9\ 000}$ = 150 person/days

| Source | Applicable To | EBC Estimated Group Numbers |
|---|---|---|
| Cook & Treganza (1950) | Shell mounds | 13,4 |
| Naroll (1962) | Structures | 15,0 |
| Le Blanc (1971) | Structures | 16,3 |
| Johnson (1983: 677) | Per capita modern living space in USSR | 21,0 |

Sleeping hollows were excavated at EBC but at different stratigraphic levels and thus are unhelpful. The lack of use of a large cave at the same altitude and only 100 m to the south of EBC coupled with the absence of any other suitable caves or shelters in the immediate vicinity suggests that EBC must have accommodated the whole band when necessary. The band may have slept mostly in the open or used *ad hoc* shelters although temporary shelters might not have withstood the frequent high winds. The cave may have been used only for protection when high winds and rain drove them inside.

Tortoise Cave could not accommodate more than 10 persons at most (Robey, *pers.comm.*). Spring Cave BR 5 is about the same size as EBC but some additional protection might have been obtained from the three adjoining large caves/ overhangs. Of the other sizable caves in the area, the largest provides 100 $m^2$ and the average of all the others is about 50 $m^2$. The synchronous use of more than one cave may have been necessary on some occasions.

(2) Group Numbers from Rock Art

Maggs (1967) has suggested a range in group numbers from 10 to 20 individuals derived from his rock art analysis for this area.

(3) Historical Evidence

Band numbers were reported to range from 10 to 80 (Thom 1954; Stow 1905) but Avery (1977: 76-78) considers that 20 to 30 would be more realistic; he also prefers the earlier count of 20 for Herry's strandloopers in 1647 (Raven-Hart 1967: 169) as a better reflection of original size than the higher numbers noted sometime after European contact.

(4) Ethnographic Evidence

For the Kalahari !Kung, Lee (1979: 54-60) reports band numbers ranging from 10 to 30 with a mean of 18,9; Marshall (1959: 10) refers to family bands of rarely more than 20 people; and of the bands encountered by Van der Post (1961: 24 & 29) in the Kalahari, two numbered 18 and the other, in a hyperarid area where mobility was essential to survival, 10; Binford (pers.comm.) has analysed 168 case studies of hunter-gatherer bands in temperate climates and concluded that numbers ranged from 18 to 22 with a mean of 18,6. Finally, the ethnographic and historical records suggest that the social structure of San hunter-gatherers was small, simple and egalitarian.

(5) Time Spent in the Area

We might therefore assume from the above evidence that the hunter-gatherers who frequented Eland's Bay during the pottery period might have ranged in numbers from 10 to 30 and that the average number over that whole period was likely to be in the region of 18. On this estimate of average band numbers, we can now assess the probable time spent in the area each year :

| | |
|---|---|
| Annual food intake represents | 150 person/days |
| Estimated average numbers in the group | 18 |
| Annual time spent in the area | 8,3 days |

(6) Population Density

Relating estimated group numbers at the coast to the 25 $km^2$ of the research area gives a population density of 72 per 100 $km^2$ with a range of 40 to 120 which compares with density for the Kalahari !Kung estimated at 16,6 (Lee 1965: 20) and for highly mobile groups in the more arid

Kalahari at 5,3 to 5,8 (Tanaka 1980: 81). The material difference in these estimates can be attributed to the availability of terrestrial, estuarine and marine resources at Eland's Bay alongside an upwelling zone and a broad, gently sloping seabed which rank such environments as among the most productive anywhere (Perlman 1980: 262). The Eland's Bay estimate is of course based on the research area only which would be integrated into a larger exploitation territory (Bailey & Davidson 1983) and thus push the figure closer to Lee and Tanaka's estimates.

8.10.4 Group Numbers at MTM - 3000 to 1800 BP

At pottery period sites, the kJ $m^{-3}$ from all food intake was estimated at one million. At MTM, mussels alone account for at least 700 000 kJ $m^{-3}$ and limpets and other shellfish species for another 50 000 $kJ^{-3}$, giving a total of 750 000 kJ $m^{-3}$; another 250 000 kJ $m^{-3}$ might be added for non-molluscan foods to bring the total up to the one million kJ $m^{-3}$.

| | |
|---|---|
| Volume of the MTM deposit | 11 000 $m^3$ |
| Total kilojoules in deposit (11 000 $m^3$ x 1 000 000 kJ $m^{-3}$) | 11 000 million kJ |
| Period of accumulation (3 000 to 1800 BP) | 1 200 years |
| Annual food intake | 9 200 000 kJ |
| Number of person/days/p.a. at 9 000 kJ/person/day | 1 022 |

On the above data, the numbers making up the group were larger or they stayed in the area longer each year or they visited the area more often than once a year.

## 8.11 ESTIMATING MARGINS OF ERROR - EB AREA - 1800-300 BP

By postulating a margin of error for each parameter used in these calculations, an overall range in variation can be derived in estimates of the time spent in the area each year :

| Parameter | Assumed Value | | Postulated Range in Variation |
|---|---|---|---|
| Period | 1500 yrs | Nil | Determined by $^{14}C$ Dates |
| Daily kJ need/person | 9 000 kJ | 10% | 8 100 - 9 900 kJ |
| Total volume of all deposits | 2 000 $m^3$ | 50% | 1 000 - 3 000 $m^3$ |
| kJ $m^{-3}$ from all food intake | 1 million | 50% | 0,5 - 1,5 m $kJm^{-3}$ |
| Group numbers | 18 | 50% | 10 - 30 |

Time spent in the area =

$$\frac{\text{Total Volume of Deposit} \times \text{kJ m}^{-3}}{\text{Period} \times \text{Daily kJ Need/Person} \times \text{Group Numbers}}$$

which gives a median time of about 7/8 days per visit if visited regularly once a year and a potential range of one to 37 days.

## 8.12 CONCLUSION

The pattern of shellfish gathering appears to have been both consistent and efficient within the constraints of tides, storms and other activities. The strategy was directed to produce the maximum return for the least effort. Whether the gathering was done by men or women is immaterial as only one-third of the numbers in the band need have engaged in shellfish gathering to produce a regular and adequate supply for the whole band. The dependability of this regular daily source of food would have given the band the freedom to achieve a varied diet by exploiting less dependable resources. Except for *P. granatina*, the shellfish gathering had no effect on the available shellfish biomass but the risks of mussel poisoning may have inhibited the gathering of mussels outside of the winter/ spring months.

The location of many sites adjacent to shellfish beds underscores the importance of shellfish in foraging strategy and of shellfish as the determinant of their location. While all sites in the area contain shell remains, we might predict that with increasing distance from site to shore, more intensive exploitation of non-marine resources should be reflected in site contents. The stone tool assemblage from TC (Robey & Yates, *pers.comm.*) supports such a prediction and the patterning discovered in the rates of predation of shellfish (Table 8.1, p.231), lobsters (Paragraph 4.6.5, p.71) and fish (Table 4.7.3, p.134) similarly indicate a unique relationship between site location and resource availability.

The comparatively short time spent in the area each year suggests that the use of sites was successional or ephemeral rather than synchronous and the choice of site seems to have varied from visit to visit with no persistent preference for any one site. The comparatively small volumes of deposit in the major cave sites (Appendix F, p.307) discount their use as home bases in the sense of lengthily occupied localities. Since resource availability remained unchanged, the explanation behind this apparently random choice of sites from visit to visit may be related to pastoralist invasions, inclement weather, site pollution or other factors.

Brief yearly visits to the area provide support for a model of periodic movement along the coast rather than the trek between the coastal fringe and the mountainous interior, although more compatible with Parkington's hypothesis (discussed in Chapter 9) of a focus of settlement in the immediate hinterland of sandveld. During the period 3000 to 1800 BP the site of MTM was located adjacent to the abundant shellfish biomass at Mussel Point and provides strong evidence of the magnet of shellfish as a food source. Further, shellfish may have been a determining factor for avoiding the area for some millenia after about 8000 BP if during the time of higher sea levels the shellfish-bearing rocks were replaced by sandy shores.

## TABLE 8.1

## PATTERNS IN SHELLFISH PREDATION

### COMPARISONS OF SPECIES FREQUENCIES - MODERN BEACH TRANSECTS WITH ARCHAEOLOGICAL SITES - 1800 - 300 BP

Beach transect data in kJ $m^{-2}$ from Rebelo (1982)
Archaeological data in kJ $m^{-3}$ from sampled & excavated sites (Appendices L to R)

| No. | Group | Distance from Shore | Limpets | % | Mussels | % | Whelks | % | Total |
|---|---|---|---|---|---|---|---|---|---|
| **Beach Transects** | | | | | | | | | |
| Sector 1 - Eland's Bay | | | 802 | 86 | 35 | 2 | 108 | 12 | 945 |
| **Archaeological Sites** | | | | | | | | | |
| 4 | Bay | Up to 250 m | 434 | 89 | 47 | 10 | 4 | 1 | 485 |
| 12 | Bay | 250 - 1000 m | 270 | 64 | 139 | 33 | 15 | 3 | 424 |
| 3 | Vlei | 1000 - 1500 m | 130 | 30 | 277 | 65 | 20 | 5 | 427 |
| 9 | Vlei | Over 1500 m | 47 | 18 | 204 | 76 | 17 | 6 | 268 |
| **Beach Transects** | | | | | | | | | |
| Sector 2 - Baboon Point | | | 510 | 49 | 431 | 41 | 103 | 10 | 1044 |
| **Archaeological Sites** | | | | | | | | | |
| 4 | Baboon Point Sites | | 124 | 41 | 164 | 54 | 17 | 5 | 305 |
| **Beach Transects** | | | | | | | | | |
| Sector 3 - Mussel Point | | | 351 | 3 | 11070 | 84 | 1766 | 13 | 12187 |
| **Archaeological Sites** | | | | | | | | | |
| 2 | Mussel Point Sites | | 2 | 1 | 332 | 99 | - | - | 334 |
| 36 | All Sites | | 162 | 48 | 165 | 49 | 11 | 3 | 338 |

TABLE 8.2

LIMPETS SPECIES SELECTION

BEACH TRANSECTS - TOTAL BIOMASS FROM LIMPETS (kJ in Thousands)

| | Sector 1 | | Sector 2 | | Total | |
|---|---|---|---|---|---|---|
| | kJ | % | kJ | % | kJ | % |
| P. granatina | 22933 | 49,9 | 121 | 1,9 | 23054 | 44,1 |
| P. granularis | 18280 | 39,8 | 858 | 13,6 | 19138 | 36,6 |
| P. argenvillei | 765 | 1,7 | 5315 | 84,4 | 6080 | 11,6 |
| P. barbara | 3999 | 8,6 | - | - | 3999 | 7,7 |
| | 45977 | 100,0 | 6294 | 99,9 | 52271 | 100,0 |



ARCHAEOLOGICAL SITES - TOTAL KILOJOULES (Thousands)

| | Bay Sites | | Vlei Sites | | Baboon Point Sites | | Total | |
|---|---|---|---|---|---|---|---|---|
| | kJ | % | kJ | % | kJ | % | kJ | % |
| P. granatina | 173655 | 73,6 | 35077 | 73,0 | 5120 | 65,6 | 213852 | 73,3 |
| P. granularis | 28810 | 12,2 | 5220 | 10,9 | 880 | 11,3 | 34910 | 12,0 |
| P. argenvillei | 21565 | 9,1 | 4945 | 10,2 | 1407 | 18,0 | 27917 | 9,5 |
| P. barbara | 11925 | 5,1 | 2831 | 5,9 | 399 | 5,1 | 15155 | 5,2 |
| | 235955 | 100,0 | 48073 | 100,0 | 7806 | 100,0 | 291834 | 100,0 |

# TABLE 8.3

## LIMPET ZONATION & FORAGING STRATEGIES

### BEACH TRANSECTS - TOTAL BIOMASS (kJ Thousands) - ALL SECTORS

| | Balanoid Zone (Upshore) | | A - C Zone (Downshore) | | Total | |
|---|---|---|---|---|---|---|
| | Biomass | % | Biomass | % | Biomass | % |
| *P. granatina* | 9025 | 37,1 | 15860 | 49,3 | 24885 | 44,1 |
| *P. granularis* | 15208 | 62,6 | 6299 | 19,6 | 21507 | 38,1 |
| *P. argenvillei* | - | - | 6080 | 18,9 | 6080 | 10,8 |
| *P. barbara* | 76 | 0,3 | 3923 | 12,2 | 3999 | 7,0 |
| | 24309 | 100,0 | 32162 | 100,0 | 56471 | 100,0 |

### COMPARISON OF SPECIES FREQUENCIES

### BEACH TRANSECTS WITH ARCHAEOLOGICAL SITE DATA

| | Beach Transects kJ (Thousands) | % | Archaeological kJ (Thousands) | % |
|---|---|---|---|---|
| *P. granatina* | 24885 | 44,1 | 213852 | 73,3 |
| *P. granularis* | 21507 | 38,1 | 34910 | 12,0 |
| *P. argenvillei* | 6080 | 10,8 | 27917 | 9,5 |
| *P. barbara* | 3999 | 7,0 | 15155 | 5,2 |
| | 56471 | 100,0 | 291834 | 100,0 |

## TABLE 8.4

## COMPARATIVE NUMBERS OF SHELLS & GROSS WEIGHT FOR EACH SPECIES TO PRODUCE 9000 kJ

| | Mean kJ Yield | Mean Gross Weight (g) per Shell | Number of Shells | Total Gross Weight (kg) |
|---|---|---|---|---|
| Limpets | | | | |
| *P. granatina* | 28 | 12,7 | 321 | 4,1 |
| *P. granularis* | 10 | 5,8 | 900 | 5,2 |
| *P. argenvillei* | 67 | 45,0 | 134 | 6,0 |
| *P. barbara* | 60 | 36,0 | 150 | 5,4 |
| Limpets (All Species) | 25 | 11,9 | 360 | 4,3 |
| Mussels | | | | |
| *C. meridionalis* | 28 | 27,7 | 321 | 8,9 |
| Equal Mix Limpets/Mussels | 26,5 | 20,0 | 340 | 6,8 |

TABLE 8.5

LIMPETS - SPECIES SELECTION IN RELATION TO DISTANCE FROM THE SHORE

BAY AND VLEI SITES ONLY

| Distance From Shore | *P. granatina/ P. granularis* | | *P. argenvillei/ P. barbara* | | Total |
|---|---|---|---|---|---|
| | kJ $m^{-3}$ | % | kJ $m^{-3}$ | % | kJ $m^{-3}$ |
| Up to 250 m | 411 | 95 | 23 | 5 | 434 |
| 250 to 1 000 m | 232 | 86 | 38 | 14 | 270 |
| 1 000 to 1 500 m | 108 | 83 | 22 | 17 | 130 |
| Over 1 500 m | 37 | 79 | 10 | 21 | 47 |

## TABLE 8.6(a)

## TOXIC RED WATER OUTBREAKS - 1959 - 1983

Source : Horstman (1981: Table II: 79) updated to 1983 by pers.comm.

| | Date | Species | Area | Mortalities | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Mussels | Fish | Rock Lobster | Octopus | Sea Birds |
| (1) | Dec. 66/ Jan. 67 | *G. grindleyi* Mussels remained toxic for 4 months | Eland's Bay | x | | | | x |
| (2) | Sep. 74 | *G. grindleyi* Mussels remained toxic for 6 months | EB to Blaauberg | x | | | | |
| (3) | Dec. 67 | *G. catenella* | Eland's Bay to North of Olifants River Mouth | x | x | x | x | x |
| (4) | Dec. 68 | *G. catenella* | Eland's Bay to Lamberts Bay | x | | | | |
| (5) | May 78 | *G. catenella* | Saldanha Bay | x | | | | x |
| (6) | Mar. 80 | *G. catenella* | Eland's Bay | x | | | | x |
| (7) | Mar./ Apr. 83 | *G. catenella* | Eland's Bay to Melkbosstrand | x | | | | |

(1) = Grindley & Nel (1970); (2), (3), (6) = Horstman (1981); (4) = Grindley & Sapeika (1969); (5) = Popkiss *et al.* (1979); (7) = Horstman (*pers.comm.*).

## TABLE 8.6(b)

## NON-TOXIC OUTBREAKS CAUSING FAUNAL MORTALITIES

| | Date | Species | Area | Mussels | Fish | Rock Lobster |
|---|---|---|---|---|---|---|
| (1) | Feb./ Apr. 62 | *G. polygramma* | False Bay | x | | |
| (2) | Aug./ Sep. 76 | *Gymnodinium* sp. | False Bay | x | | |
| (3) | Apr. 78 | *Mesodinium rubrum* | St Helena Bay | x | | x |
| (4) | Nov. 73 | *Prorocentrum micans* | Dwarskerbos | x | | |
| (5) | Feb. 67 | *Noctiluca miliaris* | False Bay | | x | |

The above mortalities were attributed to gill-clogging, hypoxia and other secondary effects but slight PSP was suspected from *Prorocentrum micans*.

(1) = Grindley & Taylor (1964); (2) = Brown *et al.* (1979); (3) = Horstman (1981); (4) = Pinto & Silver (1956) (Toxicity); (5) = Unpublished.

TABLE 8.7

SEASONAL INCIDENCE OF RED WATER OUTBREAKS

SOUTHWEST COAST - 1959 - 1983

| Season | Month | No. of Outbreaks | Total for Season | Average Number of Outbreaks During the Three Month Period Beginning | Number |
|---|---|---|---|---|---|
| Summer | Jan. | 13 | | January | 20 |
| | Feb. | 20 | | February | 23 |
| | Mar. | 26 | 59 | March | 24 |
| Autumn | Apr. | 24 | | April | 21 |
| | May | 23 | | May | 17 |
| | June | 15 | 62 | June | 10 |
| Winter | July | 12 | | July | 10 |
| | Aug. | 2 | | August | 10 |
| | Sep. | 17 | 31 | September | 12 |
| Spring | Oct. | 10 | | October | 9 |
| | Nov. | 10 | | November | 10 |
| | Dec. | 8 | 28 | December | 14 |
| Total No. of Outbreaks | | | 180 | $\bar{x}$ = | 15 |
| | | | | s = | 5.7 |

Highest Monthly Incidence : March (one per month)

Lowest Monthly Incidence : August (one every 12/13 years)

Highest Period Incidence : February to May, with average of four a year

Lowest Period Incidence : June to November, with average of 2/3 a year.

## TABLE 8.8

## TOXICITY LEVELS - BLACK MUSSELS

The mean flesh weight of the Black Mussel *C. meridionalis* is taken at 9 grams (Table 4.4.2) in the undernoted :

| | Toxin Level (mg 100 $g^{-1}$ Edible Tissue)* | Equivalent Mean Toxin Content/ Black Mussel |
|---|---|---|
| Closure Level in USA | 0,08 mg | 0,0072 mg |
| Moderate Symptoms | 1,00 mg | 0,0900 mg |
| Lethal Dose | 10,00 mg | 0,9000 mg |

A fatal outcome requires 10 times the amount of toxin that will produce moderate symptoms but one mussel in continuous contact with toxic red tide for 24 hours can contain as much as 180 mg of STX (Horstman 1981: 85), which represents some 2 000 mg of toxin per 100 grams of tissue. The lethal quantity of toxin concentrate is about four times the toxin level determined in mg per 100 g of tissue (Horstman 1981: 74) from which the following comparisons have been calculated :

| | Lethal Quantity of Toxin |
|---|---|
| *Dale & Yentsch (1978, Table 2: 44) | 2,5 mg |
| Sapeika (1974: 16) | 1 - 4 mg |
| Horstman (1981: 44) | 2,0 mg |
| Bower *et al.* (1981: 836) | 0,3-1,0 mg |
| Mean Value Approximately | 2,0 mg |

And applying this mean value to the toxicity levels determined by Horstman (1981, Table VI: 84) from a toxic outbreak gives :

## Toxicity Levels - Black Mussels
## Eland's Bay, 7 March 1980

| Depth (m) | Toxicity (mg 100 $g^{-1}$) | Mean Toxin Content per Black Mussel | No. of Mussels to be Eaten to Reach Lethal Dose of 2 mg |
|---|---|---|---|
| 0 | 0,465 | 0,0419 | 48 |
| 5 | 9,784 | 0,8806 | 2 |
| 10 | 2,657 | 0,2391 | 8 |
| Not Present Below 10 m | | | |

Since mussels were collected from the intertidal zone by prehistoric gatherers, the higher toxicities of subtidal mussels can be ignored and presumably any of these highly toxic animals that were washed ashore were not collected. Moderate symptoms of poisoning would appear after eating some four to five intertidal mussels and death would be likely after eating about 50 of them, but these estimates could vary widely between individual consumers and the toxic concentration in individual mussels. Averages are no safeguard for the gatherer - any one mussel at any one time might have accumulated a lethal concentration. The unit of measurement of toxicity is one mouse unit which is the amount of STX required to kill one White Mouse of 15 gr weight within 15 minutes. Did the prehistoric gatherers first try out the mussels on some small rodent or other mammal that was not averse to eating shellfish?

Toxic red tide may not extend as far north as the Namibian coast. Budack's study of the indigenous Topnaar reports that they eat mussels throughout the year but no poisoning has ever been known, although red tides occur between December and May and especially in December and January (Budack 1977: 37).

## TABLE 8.9

## CHANGES IN SHELLFISH PREDATION PATTERNS THROUGH TIME

### Post-Hiatus Pre-Pottery Period

| Site | Dates BP | Percentage Kilojoules | | |
|---|---|---|---|---|
| | | Limpets | Mussels | Other spp. |
| EBC Layer 9 | 3780 | 4,7 | 91,8 | 3,5 |
| Layers 7/8 | 3510-2950 | 28,4 | 67,8 | 7,7 |
| MTM | 2820-1780 | 3,3 | 95,0 | 1,7 |

### Pottery Period

| Site | Dates BP | Percentage Kilojoules | | |
|---|---|---|---|---|
| | | Limpets | Mussels | Other spp. |
| All Sampled & Excavated Sites | 1680-315 | 47,9 | 48,8 | 3,3 |

# CHAPTER 9

# SEASONAL MOBILITY

The reconstruction of prehistoric diets (Appendices G.1 to G.6) has shown that while these early communities were at the coast, shellfish contributed a major share to their diet and may thus have directly or indirectly influenced decisions on mobility. There are currently two models for mobility which would appear to be mutually exclusive - Parkington's seasonal mobility model (1976a; 1976b; 1977; 1981; n.d.) and Sealy's 'strandloping' model (1984).

## 9.1 PARKINGTON'S SEASONAL MOBILITY MODEL

This model is based on the prediction that changes in the environment, in the distribution and abundance of resources and in population density will generate pressure on hunter-gatherers to modify their subsistence strategies in ways that will be reflected in changes in food procurement systems, settlement patterns, technological emphases and organisational arrangements. The trajectory of change that is inferred from the archaeological record will be cumulative and short-term oriented and in specific situations may appear as gradual or punctuated and in the longer term unplanned but at each stage represent a compromise between traditional practice and a dynamic adaptation to new situations. Three phases in the prehistoric occupation of the area are distinguished in this model with the proviso that the often long intervals between radiocarbon dates could confuse continuous change with punctuated equilibria of lesser duration. Prehistoric use of EBC is dated back to some 20 000 or more years ago but shortly after 8000 BP until about 4400 BP there is no evidence of hunter-gatherers' presence on the coast possibly as a result of hyperaridity and rising sea levels. They are presumed to have concentrated on exploiting animal and plant resources in the mountainous interior while developing a microlithic toolkit.

Phase I - 4400 to 3000 BP

Initial re-occupation of the coastal area led to a change in the focus of settlement from the mountains to open sites in deflated hollows of the sandy coastal plain and the emergence of a pattern of coastal/inland seasonal mobility with visits radiating from the sandveld to the coast in winter and to the mountainous interior in spring to autumn. This seasonal east-west movement by crossing the north/south orientation of the three physiographic zones of coast, sandveld and mountains enabled hunter-gatherers to exploit seasonal and geographic variations in the resources of these zones. At the coast, subsistence relied largely on gathered foods and particularly mussels, but elsewhere the emphasis was on hunting.

Phase II - 3000 to 1800 BP

At the coast, mussels became the dominant food source but no change is evident elsewhere other than an assumed increase in population density.

Phase III - 1800 to 300 BP

The striking contrast in every aspect of Phase III compared with earlier phases suggests relatively rapid change at a time when pottery and sheep bones first appear and are usually associated with the arrival of pastoralists in the area. The intensive exploitative strategy of Phase II is replaced by an extensive range of exploited foods and now includes previously neglected limpets and other resources which were probably unattractive to pastoralists. The number of sites increased dramatically, many of them used for the first time, and there is a clear shift in settlement from the open veld to situations in the mountains and the rocky hills of the sandveld and the coast but with shallow deposits indicating ephemeral occupations, smaller and more mobile groups and brief visits. The rocky terrain now more intensively used would be marginal for domestic stock. Adzes, wood shavings and plant debris in significant quantity suggest a change in emphasis from hunted game to gathered resources at near-coastal and inland sites. The archaeological evidence for Phase III, unlike earlier phases, records many features in common with seventeenth century accounts of observers of these indigenous communities among whom an exploitative relationship between pastoralists and their hunter-gatherer 'clients' appears to have developed.

9.1.1 Discussion

Parkington's model was derived from a number of independent sources, archaeological, biological and geological and from modern natural phenomena which in the absence of evidence to the contrary can be presumed to have remained substantially unchanged through the last five millenia. His lines of evidence and reasoning are briefly summarised in Table 9.1 (pp.260/1) with my amendments to include later information from this research.

The main driving force behind hunter-gatherer mobility possibly stems from a need to exploit peaks and avoid troughs in resource availability, regional and seasonal; but some environmental factors of this region might have weakened this stimulus. All three ecological zones of coast, sandveld and mountain, fall within the winter rainfall area of the southwest Cape and differ climatically only in the increase in rainfall and the wider range in seasonal mean temperatures with increasing distance from the sea and increasing altitude; all three also fall within the fynbos biome characterised by low nutrient status and low productive capacity but with a unique diversity of plant species. Plants thus grow, flower and fruit at roughly the same time on the coast as inland mostly in summer but the interior would appear to offer a wider range and greater abundance of edible plant foods. In contrast, shellfish at the coast are abundant all the year round and the only limiting factor is the recurrence of toxic 'red tides'. Instances are cited in paragraph 9.5 (p.256) of hunter-gatherers in high productivity coastal environments comparable with EB (Table 9.3, p.263) where periodic migration has apparently been replaced by a more sedentary lifestyle. The high mobility generally assumed as a major characteristic of hunter-gatherers (Binford, pers.comm.) may require to be qualified for these situations.

The risks of poisoning from eating mussels may have been over-emphasised. Certainly, the mussel-dominated mega-middens of the Eland's Bay/Lambert's Bay coast accumulated over only about 1200 years raise doubts about a too facile assumption of deposition wholly or mainly during the 'safe' winter months. It now appears that toxic 'red tides' occur on this coast only about once every four years although mussels can remain toxic potentially for up to six months. This means that mussels had to be avoided for only about 10% of any four-year period. We can reasonably assume that prehistoric people could do so from their experience of forewarning signs and symptoms and from the lack of archaeological evidence of mass mortalities. What was their likely reaction to episodes of toxic 'red tides'?

- To gather limpets to the exclusion of mussels?

- To avoid all shellfish in favour of other resources?

- To move away along the coast or inland?

The first two courses are discounted by the absence of substantial concentrations of limpets in middens and of faunal assemblages in isolation from shellfish; and since 'red tides' can extend for hundreds of kilometres, to move away along the coast would not necessarily take them out of danger. The reaction may thus have been to go inland and such inland visits would tend to occur in summer. On the other hand, visits to the coast in summer may be implied in the evidence for concentrations of rock lobsters (Table 4.6.2, p.130) and bird bones (Table 4.11.2, p.143).

A synoptic view of these seasonal indicators although still inconclusive seems to disclose a trend from an initial post-hiatus seasonal scheduling of movement between inland and coast towards increasing emphasis on coastal visits with possibly an incipient tendency to semi-sedentism or 'strandloping' until the final post-1800 BP phase when pastoralist incursions may have restricted movement to the shoreline and nearby coastal plain.

## 9.2 SEALY'S STRANDLOPING MODEL

### 9.2.1 The Model

Sealy's model is derived from stable carbon isotope analyses of human bones from prehistoric burials in conjunction with an explicitly ecological study of food webs on the premise that the $\delta^{13}C$ readings of the bones will reveal the proportionate $C_3$ and $C_4$ signatures of the terrestrial and marine foods in the diet.

There are two major aspects on which Sealy's conclusions appear incompatible with Parkington's hypothesis. First, the difference in diet deduced by Sealy from coastal and inland skeletons suggests these derive from distinct groups following different dietary regimes and neither could have followed Parkington's coastal/inland seasonal scheduling of movements. Second, all skeletons from the southwest coast reflect a predominantly marine diet over the last 10 000 years, compatible only with 'strandloping'. There are, however, qualifications to the 'strandloping' conclusion. Sealy's interpretation that "a large proportion of their diet was of marine origin in some cases almost 100%" is qualified by her comment that "too much reliance should not be placed on the exact proportions of the different foods consumed" (Sealy 1984: 135-136). Also,

> "the metabolic pathways are not all well understood. If not all foods contribute equally to all body tissues of consumers, then simple $\delta^{13}C$ measurements of these tissues cannot be translated directly into $C_3$- and $C_4$-based foods. This uncertainty also complicates the diet-to-tissue fractionation factors." (Sealy 1984: 68).

Of the human bones analysed, Sealy refers to doubts regarding some specimens on dating and provenance and on total sample size, but otherwise the techniques of stable carbon isotope analysis are well established and results from South Africa and elsewhere are too consistent and coherent to admit the possibility of significant error from this source.

Sealy's strandloping model certainly presents a notable exception to Bailey's conclusion (1975) from his worldwide review of coastal middens. Strandloping in this view as a viable system was adopted only in areas such as Tierra del Fuega where the immediate hinterland was mountainous and barren.

## 9.2.2 The Theory of Krueger and Sullivan (1984)

Doubts have been expressed on another score "... the direct relationship assumed between the $\delta^{13}C$ of bone collagen and the ratio of $C_3$ and $C_4$ foods in the diet may not be adequate to describe the isotopic effects in the more complex human diet" (Krueger & Sullivan 1984: 2-3). Collagen is a protein comprised of 'essential' and 'non-essential' amino acids. The 'essential' amino acids cannot be synthesised by the body and must be derived from ingested protein whereas 'non-essential' amino acids can be synthesised from metabolised food intake. Krueger and Sullivan have suggested that the collagen content of human bone which is the component analysed to produce isotope readings will reflect only the ingested protein while ingested carbohydrates and fats will be metabolised and their $C_3$ and $C_4$ signatures reflected primarily in the inorganic hydroxyapatite of the bone rather than the collagen. "The carbon isotopes of collagen thus may not reflect the diet in total but only the meat in the diet (Op.cit.: 10). Recent empirical evidence has however tended to discount this theory (Van der Merwe: pers.comm.) but a final verdict must await the outcome of ongoing research into the human biochemical processes involved between food intake and collagen formation.

### 9.2.3 Differences in Basic Data Between the Parkington and Sealy Models

The seasonal mobility hypothesis is supported by many independent even if mostly inconclusive arguments. In contrast, dietary reconstruction from isotopic analyses is simply the final stage in a single stage-by-stage chain of argument. Only this final stage remains to be empirically demonstrated.

Parkington's hypothesis was formulated on archaeological and site distributional data based on groups of people over periods delimited by radiocarbon dates; estimated group numbers and time spent at the coast each year are discussed in Paragraph 8.10 (pp.221-227). Each isotopic value relates only to the diet of an individual over about the last 10 years of his life but does not provide information on seasonality or specific locality.

The data base for the seasonal mobility hypothesis embraces over 100 sites and is specific to the unique physiographic zones of EB and its hinterland. Of the total sample of 14 coastal $\delta^{13}C$ readings (Sealy & van der Merwe 1985: Table 1), 13 relate to human bones found between Saldanha and False Bay which is "outside the area for which the seasonal mobility hypothesis was formulated ... (but) included mainly to demonstrate the consistently positive character of coastal isotope values".

## 9.2.4 Discussion

Subject to the qualifications of small sample size and the inexactitude attaching to marine/terrestrial ratios (Sealy 1984) the quoted isotopic values (Sealy & van der Merwe 1985: Table 1), have been analysed (Table 9.2). Half the sample points to individuals with an overall dietary makeup of about 50% marine/50% terrestrial and the remainder 80%/20%, with an average of about two-thirds marine and one-third terrestrial over the whole sample. Only about one-third of all these individuals appear to have lived on a diet of more than 75% seafoods and in only two instances did the diet contain more than 90% seafoods. The conclusion that "a significant proportion of the coastal population consumed an entirely marine diet and must have spent all its time on the shore" seems to require qualification and with only one isotopic reading from the EB coast the relevance to Parkington's hypothesis remains to be demonstrated.

For sites along the southwest coast, a broad geographic and temporal correspondence between resource availability and site contents has been revealed in this study (Chapter 4, pp.49-112). The small sample size of isotopic readings precludes comparison with such archaeologically-derived patterns, even in the near future, as prehistoric human bones in situ have been rare discoveries in the southwest Cape.

Finally, insofar as the analyses of coastal middens reflect the varying proportions of food items eaten by the occupants while using these sites, the results of this study indicate a seafood component in coastal diet of approximately 63% with a range of 41,7% to 78,5% (Appendices G.1 to G.6 and J, ignoring HBC as unrepresentative). These results closely approximate Sealy's conclusions from isotopic readings but the time elements are not comparable.

## 9.3 AN ALTERNATIVE MODEL OF SEASONAL MOBILITY

Sealy's model implies an unchanging reliance on seafoods over some ten millenia by people who lived on the coast which is indicative of a true marine adaptation; in contrast, dynamic changes in foraging strategies, settlement and mobility have been inferred by Parkington from the archaeological record as adaptive responses to changing environmental and demographic pressures.

The lack of quantified data precludes comparison of the relative productivity of the coastal, sandveld and mountainous areas, and the strength of the inducements to hunger-gatherers to move periodically between them. On the archaeological evidence, the interior offered a greater abundance and diversity of geophytes than the coast and perhaps better hunting but dassies and tortoise were taken everywhere; at the coast, shellfish were always available, except for the risks of mussel poisoning, and were supplemented by rock lobsters, fish, terrestrial mammals, seabirds and the occasional bonus of a seal, whale or dolphin. The coastal resources were at least as abundant and diverse as the resources of the interior but generally would have entailed less effort and risk in procurement, less seasonal variation and less subsistence travel time.

It is tempting therefore to speculate that during Phase II the magnet of the abundant easily gathered shellfish on the doorstep of MTM might have tended to break down the traditional coastal/ inland pattern of mobility in favour of semi-sedentism or strandloping and that this trend was disrupted by the pastoralist incursions of Phase III. No other explanation can be offered of sufficient impact to account for the sudden drastic changes from Phase II to Phase III. Under pressure from pastoralist competition for resources and the potential for conflict, the aboriginal hunter-gatherers may have been forced to intensify the exploitation of seafoods by periodic movement along the coast rather than inland and to extend the range of exploited foods while continuing occasional hunting forays into the sandveld where sites of this period mostly reflect ephemeral occupations (Manhire 1984). Donax scatters along the coast apparently of human origin but undated are suggestive of movement along the coast and might have been integrated into a new exploitation territory (Bailey & Davidson 1983) with the numerous small Phase III sites in the area to produce a new pattern of periodic mobility.

This hypothesis might be tested by further research by :

- surveys and sampling of middens and shellfish biomass along this coast;
- an investigation of the area's northward potential for pastoralists' seasonal movement as has already been done for the area to the south (Smith 1984);
- a search for clues that might link coastal and sandveld sites.

## 9.4 COMPARATIVE NET ENERGY YIELDS - SHELLFISH & OTHER RESOURCES

As an initial attempt to compare the productivity of the coast with the interior, a research project is under consideration to assess the net energy yields and nutritional values of coastal shellfish with inland plants. Meantime, by pursuing in more detail the approach of Hawkes and O'Connell (1981) to net energy yields, a preliminary comparison has been made between the shellfish of Eland's Bay with plant foods and agricultural yields in other areas (Table 9.3). In terms of the net energy yield per forager-hour, the return on shellfish is better than on plant foods other than wild wheat and the mussel productivity of Mussel Point, Sector 3 of the Eland's Bay coastline, appears comparable with agricultural productivity in temperate climates if allowance is made for energy and time inputs. Aspects of this comparison are undernoted :

| | Range in kJ Yield per Forager-Hour |
|---|---|
| Eland's Bay Shellfish | 3750 - 6125 |
| Plant Foods | |
| Central Australia | 1882 |
| Mongongo Nuts - Kalahari | 2806 - 4165 |
| Wild Wheat - Turkey | 6526 - 7800 |

## 9.5 SETTLEMENT & SEDENTISM

A trend to semi-sedentism may have been initiated during Phase II in response to the increasing abundance of shellfish from the emergent Mussel Point after 3000 BP. The archaeological evidence suggests neglect of caves and shelters during this phase and concentration on the single open site of MTM adjacent to Mussel Point. The rate of accumulation of deposit and the total volume of MTM give clear signs that bands were now larger and time spent at the site longer or more frequent. Since few, if any, resources can compare with mussels in cost/benefit terms, a strong inducement would develop to intensify their exploitation to the neglect of other more costly resources. Such a trend would have minimised seasonal variability and saved on the costs of mobility and the use of many sites, the making and maintenance of toolkits and the risks in locating and capturing mobile animals; larger and more sedentary groups are likely to experience lower infant mortality and increased life expectancy (Yesner 1977). The transhumanance model postulated by Parkington implies the use of many sites to secure maximum benefit from seasonal and geographic inequality in local resources but the high productivity of Phase II at Eland's Bay may have offset the incentives for such periodic mobility.

Evidence is accumulating of a hunter-gatherer trend to adopt sedentism in high productivity coastal, riverine and estuarine environments. Budack (1977: 12) has suggested that the 'Sea People', a tribal subdivision of the Aonin or Topnaar of the Kuiseb River Valley and the sea had a long tradition of coastal dwelling and subsisted largely on seafoods but may have engaged in barter with the 'Kuiseb People' who lived mostly up-river but visited the coast seasonally. For the Gulf of Maine, orthodox theories of coastal/inland mobility have been challenged by new archaeological evidence which suggests year-round residence at a central place from which sub-groups dispersed seasonally to specialised procurement activity sites (Sanger 1982). For the eastern states of the U.S.A. post-4000 BP, Perlman (1980) has referred to archaeological evidence for contraction in hunter-gatherer foraging ranges and concentration on riverine, estuarine and marshland areas and he also cites instances of hunter-gatherer sedentism in coastal regions of the Middle East, Mesoamerica, Guatemala and Peru which have a unique characteristic in common : sedentism was achieved by coastal hunter-gatherers prior to the neighbouring agriculturists in the interior. An even earlier instance of sedentism is described by Aigner (1985: 138-141) from excavations of a 'vital robust village' at Anangula in the Aleutian Islands which was occupied for several hundred years between 8750 and

8250 BP on radiocarbon dates and other evidence. The climate of this coast is sub-Arctic, foggy and rainy, but free of ice even in winter; the shoreline and sea yield a rich harvest in marine mammals, fish, birds and shellfish but the treeless land produces few edible plants which might have been supplemented by some berries and greens. The settlement pattern disclosed by excavations in the area resembles Sanger's Gulf of Maine hypothetical pattern of year-round residence at a central place with ephemeral seasonal camps for specialised activities such as hunting and fishing. Aigner has attributed the permanence in settlement to the local abundance in coastal resources which could be fully exploited by the Aleuts' evident skills in hunting, especially of the abundant sea mammals of diverse species.

The trend towards sedentism is regarded by Perlman (1980: 258) as an opportunistic response to a highly productive environment rather than as a result of demographic pressure. Phases I and II at Eland's Bay have not produced any of the usual signs of demographic pressure in the form of diversion to more costly resources, lower yields within species, higher mobility or more use of marginal environments (Yesner 1984: 110); rather the opposite. The initial re-occupation of the area after the hiatus appears as a tentative approach in the use of only Tortoise Cave by small bands at long intervals. $^{14}C$ dating indicates the passing of many centuries before Eland's Bay Cave came into use; and these two caves with the later use of Spring Cave appear to have met all their needs for shelter and could cope with growth in numbers up to the start of Phase II; but the rate of increase in population density may have been slow if the women followed the practice of prolonged lactation like their modern kin of the Kalahari for whom the population doubling rate has been calculated at 300 years (Short 1984: 24), or ten times longer than the normal human potential.

During Phase II, shellfish contributed a substantial share to total food intake with little if any risk of dietary deficiency. It may be significant for all phases that the abundant edible seaweeds seem to have been ignored although seaweeds have a higher calorific value than any of the foods eaten (Table 4.2.2). When allowance is made for the rapid growth and reproduction of Eland's Bay shellfish, it seems unlikely that even the intensive predation by larger groups for longer periods during Phase II would have approached the human carrying capacity of the available molluscan resources. Incentives in favour of sedentism were certainly operating during Phase II but whether archaeological research can be sufficiently refined to test this hypothesis remains an open question.

TABLE 9.1

DATA IN SUPPORT OF COASTAL/INLAND SEASONAL MOBILITY

| Indicator | Detail | Season Indicated |
|---|---|---|
| COASTAL SITES | | |
| *Arctocephalus pusillus* Cape Fur Seal | All seals of this species are born between late November and early December. The EBC sample of post-hiatus seal mandibles comprises almost entirely 7-11 month old animals. (The pre-hiatus sample shows no similar restricted age grouping.) The seasonal rings in seal canines have also tentatively indicated winter. | Winter |
| *Procavia capensis* Hyrax, Dassie or Rock Rabbit | Stage of tooth eruption in juveniles which comprise half the post-hiatus EBC sample demonstrates killing in winter. (The pre-hiatus sample is dominated by new born animals which would have been killed in summer.) | Winter |
| Mussel Poisoning | Toxic red tides occur at EB every 3-5 years between spring and autumn. Winter is the only 'safe' season. | Winter |
| Birds Migratory Species | The bones of winter visitors account for 2% of the total sample. | Winter |
| Bird Mortality on Beaches | 80% occur between November and April; oceanic birds (5% of total MNI) must have been scavenged from the beach and most of the resident coastal species (87%) were probably acquired the same way which may account for concentrations of bird bones as at EBO, i.e. taken in summer. | Summer |
| *Jasus lalandii* Rock Lobster | Catching restricted during the moulting months of winter/spring whereas summer takings could have been boosted by strandings as indicated by a large MNI per m³ of deposit. | Summer |
| NEAR COASTAL SITES | | |
| Diepkloof (18 km from the coast) | Food debris comprises a mix of marine/terrestrial resources compatible with coastal/inland mobility. | |
| INLAND SITES | | |
| *Procavia capensis* | De Hangen juveniles (50% of total sample) are dominated by new born animals and thus similar to the EBC pre-hiatus pattern with which this inland site is partly contemporary. | Summer |
| Plants | Peak availability of edible geophytes occurs in summer. Archaeological plant remains comprise mostly corm casings but fruits, seeds, greens, etc. may also have been taken. An alternative daily staple during the winter trough appears problematic. | Summer |
| STONE TOOLS AND RAW MATERIALS | The trend during the Holocene away from the pre-hiatus securing of raw materials from far afield to the later post-hiatus more restricted range with finally the use of local stone only and the similarity in the stone tool assemblages from TC and sandveld sites are both suggestive of the movement of people between coast and the interior. | |
| SETTLEMENT PATTERNS | | |
| 7800 - 4400 BP Hiatus Period | An absence of human occupation over an extensive area of the coast can be presumed from the EBC and TC hiatus in occupation. If this assumption is true, then re-occupation of the EB area would stem from inland. | |
| 4400 - 3000 BP EBC, TC & SC | An initial arrival from inland is suggested by the earliest re-occupation date of 4400 BP for TC compared with 3800 for EBC and 3500 BP for SC and | |

| | |
|---|---|
| | continuance of the inland hunting emphasis in the toolkit of TC. |
| 3000 - 1800 BP | This is the period of mussel-dominated megamiddens in the open with small evidence of the exploitation of other resources. This intensification and indications of larger groups and longer and more frequent visits to the coast suggest attenuation of links with the interior and a possible trend to semi-sedentism or strandloping. |
| 1800 - 300 BP | Pastoralist incursions may have finally severed coastal/ inland links and diverted mobility along the coast. Chronological ordering of radiocarbon dates for the first appearance of pottery and sheep indicate that these incursions originated from the south of EB; the decreasing rainfall gradient to the north of EB may have inhibited further pastoralist penetration. This strandloping hypothesis might be tested on dated seal and hyrax bones from sites to the north of EB. If no unambiguous patterns emerge and thus no definite seasonal indication, strandloping stands as a reasonable assumption; if the EBC pattern of winter occupation is repeated then presumably the rest of the year was spent away from the coast. |

# TABLE 9.2

## ANALYSIS OF $\delta^{13}C$ COASTAL READINGS

(Sealy & van der Merwe 1985: 138-140)

Mean values quoted are after enrichment of human bone by 5‰ on fractionation.

| Dietary Source | Mean $\delta^{13}C$ ‰ | Range $\delta^{13}C$ ‰ |
|---|---|---|
| **Coastal** | | |
| Marine only | -10,6 | - 7,3 to -14,4 |
| **Inland** | | |
| Plants only | -20,4 | -17,3 to -24,2 |
| Animals only | -18,6 | -15,9 to -20,8 |
| 50% Plants/50% Animals | -19,5 | -16,6 to -22,5 |
| **Coastal/Inland** | | |
| 50% Marine<br>25% Plants<br>25% Terrestrial Animals | -15,1 | -12,0 to -18,5 |

## ANALYSIS OF $\delta^{13}C$ COASTAL READINGS

| Number of Readings | Mean $\delta^{13}C$ ‰ | Indicated Contributions: Marine % | Terrestrial % |
|---|---|---|---|
| 7 | -14,8±0,3 | 54 | 46 |
| 7 | -12,3±0,8 | 81 | 19 |
| 14 | -13,5±1,4 | 67 | 33 |

## TABLE 9.3

## COMPARATIVE NET ENERGY YIELDS
## SHELLFISH & OTHER RESOURCES

### Hawkes, K. & O'Connell, J.F. (1981: 622-626)

Alyawara of Central Australia :

Rainfall 300 mm p.a. mostly falling in violent summer thunderstorms

Observations over 10 months of one-day trips from a base camp

| | |
|---|---|
| Range in energy yields from plant foods per forager-hour | 836 - 8360 kJ |
| Median value for closest and most frequently visited habitat | 1882 kJ |

### Kee, R.B. (1979: 182-203)

!Kung of the Kalahari :

Rainfall highly variable 200 - 600 mm p.a.

Mongongo nuts (Figure 7.2)

| | | Apr.-Sept | Oct.-Mar. |
|---|---|---|---|
| Gross yield per 12 kg backload (kJ) | | 70 800 | 47 700 |
| Time expended | | | |
| Travel | 6 hours | | |
| Roasting | 1 hour | | |
| Cracking | 10 hours | | |
| Total | 17 hours | | |
| Net yield per forager-hour (kJ) | | 4 165 | 2 806 |

### Harlan, J.R. (1967: 197-201)

Collection of wild einkorn (*Triticum boeoticum*) in Turkey

| | |
|---|---|
| Wild einkorn | 1 384 kJ 100 $g^{-1}$ raw edible grain |
| Modern einkorn | 1 390 kJ 100 $g^{-1}$ raw edible grain |
| Modern wheat (Tables of the Composition of Foods) | 1 386 kJ 100 $g^{-1}$ raw edible grain |

Gross Yield :

| | Sickle with Flint Blades | Hand Stripping |
|---|---|---|
| Yield/forager-hour (g) | 2 450 | 2 050 |
| Grain content 46% | 1 127 | 943 |
| kJ Yield/forager-hour | 15 598 | 13 051 |

Time expended

| | |
|---|---|
| Collecting | 1 hour |
| Roasting at 350° | ½ hour |
| Pounding, winnowing & cooking (say) | ½ hour |
| Total | 2 hours |

Net energy per forager-hour

| | |
|---|---|
| Hand stripping | 6 526 kJ |
| Sickle | 7 800 kJ |

Perlman, S.M. (1980: 274-298)

Comparative return rates in meat per forager-hour (Table 6.2) to which I have added estimated energy yields :

| Resource | Edible Weight (g) Range | Mean | kJ 100 $g^{-1}$ | Total kJ |
|---|---|---|---|---|
| Shellfish (Boston Harbour) (presumed to be mussels) | 1361-4082 | 2177 | 330 | 7 185 |
| Small game (snared) | 91-1678 | 907 | 700 | 6 349 |
| Deer - Autumn | 1814-6350 | 4082 | 700 | 28 574 |
| - Winter & Spring | 1588-3856 | 2495 | 700 | 17 465 |

Eland's Bay Shellfish

Rainfall : 150 - 250 mm p.a.

Estimated average number collected/forager-hour

Mussels based on 1 519 samples from 230 collectors over 6 months — 175

(Tregoning & Van der Elst (n.d.); Siegfried *et al.* (n.d.) have recorded a much higher average)

| | |
|---|---|
| Limpets based on an average of 50 limpets measured on the rocks in 10 minutes at 13 sites (Buchanan *et al.* (1978)) | 150 |

Gross Energy Yield/Forager-Hour - Eland's Bay Coastline, Sectors 1 and 2

| | |
|---|---|
| 175 Mussels at 28 kJ each | 4 900 kJ |
| 150 Limpets at 25 kJ each | 3 750 kJ |

Eland's Bay Coastline, Sector 3

| | |
|---|---|
| 175 Mussels at 35 kJ each | 6 125 kJ |

Walking time would be pro rata to the distance of site to shore; for the most distant sites, two to three hours at most for the return trip for which the above estimates must be correspondingly reduced. Preparation times would be insignificant.

Comparative Productivity

Primary Productivity - Agriculture (Jochim 1981: 37)

| | |
|---|---|
| Grassland | 3 000 - 18 000 kJ $m^{-2}$ $y^{-1}$ |
| Temperate agriculture | 37 000 - 50 000 kJ $m^{-2}$ $y^{-1}$ |

Productivity (Gametes) - Mussels

| | |
|---|---|
| *Choromytilus meridionalis* (Griffiths 1981) (False Bay) | 31 320 kJ $m^{-2}$ $y^{-1}$ |
| *Perna perna* (Berry 1978) (East Coast) | 28 461 kJ $m^{-2}$ $y^{-1}$ |
| *Mytilus edulis* (Dare 1976) (England) | 27 720 kJ $m^{-2}$ $y^{-1}$ |

Biomass

Cultured Mussels

| | |
|---|---|
| Norfolk, England (Davies 1969: 422-425) | 10 725 kJ $m^{-2}$ |
| Wales and Netherlands (Davies 1969: 422-425) | 14 969 kJ $m^{-2}$ |

Natural Populations

| | |
|---|---|
| False Bay (Griffiths 1981: 116) | 19 556 kJ $m^{-2}$ |
| Eland's Bay, Mussel Point, A-C Zone (Rebelo 1982) | 17 570 kJ $m^{-2}$ |

# CHAPTER 10

## DISCUSSION

The quantification of archaeological food debris emerges from this study as a potential source of information on prehistoric human ecology and behaviour. Not only has the attempt to assess molluscan and non-molluscan contributions to diet provided a measure of their relative importance to the consumers in terms of calorific and nutritional value but has also disclosed patterns and generated hypotheses relevant to hunter-gatherer foraging, settlement and mobility in terms that are amenable to testing by further research and more refined techniques of analysis.

It is a truism that hunter-gatherers are intimately acquainted with the net returns to be gained from the food resources in their vicinity from which is derived the general assumption that their choice and intensity of exploitation of particular resources is primarily governed by the aim of maximising returns for minimum effort and risk, or briefly an optimal foraging strategy. While such a strategy is a prerequisite to health, reproduction and survival, a strictly determinist approach tends to overlook human variability in attitudes to food selection often for non-economic reasons and the vicissitudes of the daily life of the hunter-gatherer. Nevertheless, although the collated data are inadequate for testing the overall foraging strategy against a hypothetical optimal foraging model, the patterns disclosed in shellfish gathering are indicative of the maximisation of returns within the constraints of time, tide and accessibility as demonstrated by the selection of the largest available animals, the preference for mussels over limpets and in limpet species frequencies; further, the tactics and timing of gathering were consistent and cost-efficient with only rare exceptions.

Prehistoric gathering at Eland's Bay had no archaeologically observable impact on the shellfish biomass on the rocks with the single exception of the limpet P. granatina and to the gatherers must have appeared as a virtually inexhaustible resource that required little effort to collect or prepare, was always dependable as a daily staple and could satisfy all their group's energy needs from shellfish from a few hours of collecting by some one-third of their numbers, perhaps by the women while the men hunted and fished; but mussel collecting may at times have been precluded or restricted by the red tides or mass mortalities which affect mussels but not limpets. The dominance of shellfish in their daily lives is most evident in their choice of dune or near-dune sites which were located close to shellfish beds and which reflect the species frequencies of these beds; as distance from site to shore increases, a preference for mussels becomes more clearly evident; the furthest midden site at some 6 km from the shore may represent the limit of physical carrying capacity of unshelled animals and the maximum economic range. The paucity of shellfish remains at sites beyond this range suggests 'snacking' which would also explain some late Holocene minuscule shell scatters on and around the hills at Eland's Bay.

The terminal Pleistocene/Holocene record of shellfish gathering at Eland's Bay has revealed significant changes in mussel/limpet ratios through time but with a clear preference for mussels where choice could be exercised. This preference is consistent with archaeological, ethnographic and modern evidence from other sources and may be attributable to higher calorific value, ease and speed of collection in quantity and perhaps digestibility and palatability but offset by the risks of mussel poisoning when gathered during the late spring to autumn months.

The initiation of this sequence of shellfish gathering some 11 000 years ago is signalled by limpet remains only but the succession thereafter is first the appearance of a few mussels, then mussels attaining an equal role with limpets and finally mussels as the dominant species for the last 2 000 years prior to the hiatus in occupation, the onset of which is dated to shortly after 8 000 BP.

The explanation for the late appearance and later rise to dominance of mussels seems more likely to be environmental than behavioural - mussels may be late invaders from the south Atlantic (Kilburn & Rippey 1982); their arrival on the west coast may have been delayed until suitable habitats were available through the post-glacial rise in sea level; mussels appear to be less tolerant of adverse sea temperatures than limpets; and Bailey (1975) has commented on the late appearance of mussels in the archaeological record elsewhere. Parkington (1981: 354) has proposed an alternative hypothesis that the initial absence of mussels may be explained by prehistoric mussel avoidance during summer occupations and that the subsequent change to mussel dominance may be indicative of the rescheduling of visits to the coast from summer to the safer winter months to minimise the risks of mussel poisoning. Since after the initial phase of limpets only, mussels are never again totally absent from the record and their subsequent contribution to shellfish energy yields in sites ranges from 10% to near 100%, the Parkington hypothesis implies that subsequent visits were mostly timed for winter occupation which may conflict with other seasonal indications. An environmental explanation thus appears on present evidence to be the more plausible.

When hunting bands returned to the Eland's Bay area about 4400 BP, shellfish availability may have been severely limited by the higher sea level and they had to be satisfied with the comparatively poor shellfish resources of Baboon Point while shellfish-bearing rocks elsewhere were subtidal. The pattern of mussel preference immediately reasserts itself however despite the intervening millenia of the hiatus, and despite the mussel biomass at Baboon Point being located mostly on the risky downshore zone; the risks of gathering mussels on this rugged stormy promontory may account for the presence in deposits of limpets which are numerous on the safer upshore zone. By 3000 BP all the shellfish-bearing rocky stretches of the Eland's Bay coastline were now at least partly exposed by the continuing fall in sea level. It is significant that although the rocks of the Bay itself support large limpet colonies, little if any attention was paid to this sector where mussels are virtually absent; the emergent mussel colonies of Mussel Point seem to have attracted practically all the gathering activity from a single adjacent site where a massive volume of shellfish remains accumulated of which mussels account for about 95% in energy terms; sites elsewhere and particularly Eland's Bay Cave and Tortoise Cave were seldom used. The prior ranking of mussels over other species of shellfish is most clearly demonstrated in this phase and on present evidence almost to the exclusion of non-molluscan food resources. Shortly after 1800 BP, this apparently mature system was subjected to severe disruption; the site at Mussel Point was abandoned, at least as a mussel eating station, and gathering was extended to the limpets in the Bay which now assume an equal role with mussels.

Throughout the whole sequence prior to 1800 BP, the marine environment had governed shellfish accessibility and the extent to which gatherers could exercise their preference for mussels over limpets but the rise in importance post-1800 BP of the lower ranked limpets is not explicable on similar grounds.

The inference of winter occupation derived from mussel remains in sites may be reliable only for deposits of substantial volume dominated throughout by mussels. Shell middens are residual palimpsests of multiple episodes of gathering which are seldom distinguishable by radiocarbon dates often separated by long intervals of time and which are subject to post-depositional processes that can cause disturbance and mixing of deposits. Observed variations in mussel/limpet ratios in these sites may reflect simply times of restricted mussel availability as a result of environmental causes unrelated to season of occupation. The persistent presence of mussels in all Holocene sites suggests that gatherers were aware of the dangers of mussel poisoning and were able to detect and avoid them but their depended on the seasonal availability of plant foods mainly geophytes as the staple food. Botanical research into the edible plants of the interior is still in its early stages but preliminary indications suggest a net productivity comparable with the shellfish of the Bay and Baboon Point but substantially lower than the mussels of Mussel Point (Liengme, pers.comm.) after allowance is made for the time and effort in search, extraction and preparation of plant foods and the need for digging sticks and grindstones. Geophytes could ensure an adequate supply of energy but unlike shellfish would require supplementing by animal foods to avoid deficiencies in dietary essentials. The archaeological evidence for the period from 4400 to 1800 BP implies increasing interest in coastal resources and the pastoralist incursions generally associated with the appearance of domestic stock may have been only the final decisive factor in breaking what had already become a tenuous link with the interior. This hypothesis could be refuted by a post-pastoralist pattern in shellfish gathering which showed that coastal visits were timed for spring lows as might be expected of hunter-gatherers coming from the interior but the observed pattern while indicative of gathering at low states of the tide give no grounds for assuming that visits were timed to coincide with spring lows.

Inter-site comparisons of faunal remains have demonstrated a relationship between site location and resource availability.

The pre-pottery occupants of the inland site of Tortoise Cave some 4 km from the shore were, on the evidence of the stone tool assemblage, active in hunting for which this site is suitably located; during the pottery period, fish remains are most prominent in sites along Verloren Vlei, while the density of rock lobster mandibles is greatest in sites round the Bay where lobster populations are known to mass, and among the shore sites shellfish remains reflect the species frequencies of the adjacent shellbeds and include one site with the highest concentration of seabird bones. Similarly, comparison of faunal remains reported in sites along the southwest coast are consistent with predictions based on modern conditions; the density of lobster mandibles peak in west coast sites where modern commercial exploitation is concentrated while rock fishing and hunting were more productive activities from sites to the east of Cape Point where reef fish are more abundant, diverse and often larger and where according to historical records game animals were more frequently sighted than on the semi-arid west coast.

This essay in quantification of food intake has failed to discover signs of dietary stress either in quantity or quality and, while its conclusions are subject to many qualifications and necessarily ignore foods eaten which leave no trace, the changing patterns in foraging and settlement that have been disclosed and the consistencies in the results suggest that these patterns may reflect real aspects of prehistoric behaviour. The analysis has also failed to discover new evidence about Holocene palaeoenvironments but the mere absence of such evidence supports Klein's view (1972) that conditions similar to modern were established at the Cape early in the Holocene.

The conclusions from this study can now be reviewed against the original aims outlined in the Introduction (p.5) :

- the relative importance of molluscan and non-molluscan and of terrestrial and marine components in prehistoric coastal diets have been demonstrated in terms of energy and nutritional values;

- the reconstructed diet based on food debris found at coastal sites appears to have been adequate in quantity and quality;

- analyses of molluscan data have proved a highly productive source of information on prehistoric behaviour and ecology;

- variability in site contents tends to mirror geographic and temporal variations in local resources;

to which can be added that :

- food storage at the latitude of Eland's Bay (32° S) was not a viable option but was probably unnecessary;

- the high mobility characteristic of hunter-gatherers may be replaced by a trend to a more sedentary lifestyle in high productivity marine and estuarine environments;
- extrapolation of modern data on human energy needs into prehistory can provide a useful basic factor in analytical calculations;
- further research is required into the abundance and diversity of edible plants in the southwestern Cape, their energy and nutritional values and the comparative net energy yields from plants and shellfish.

The initial re-occupation about 3800 B.P. of the large Eland's Bay Cave overlooking the sea implies increasing attention to seafoods which culminates shortly after 3000 B.P. in neglect of caves in favour of concentration on a single site adjacent to the massive mussel colonies on the emergent Mussel Point, by far the most productive of all the rocky shores at Eland's Bay. Significantly, mussels become the dominant food source, perhaps contributing as much as 75% or more to food intake while the large limpet populations on the emergent rocks of the Bay were ignored and even non-molluscan resources appear in a minor role. With the first appearance of pottery and domestic stock in the archaeological record about 1800 B.P., signs of radical and rapid change in the economic and social system emerge - there is a reversal in the trend during preceding phases towards larger groups and longer coastal visits and perhaps even towards semi-sedentism and instead bands are now smaller and more mobile and concentration of activity on a single large site is replaced by numerous dispersed and ephemeral sites on or near the hills suggestive of a refuge reaction which can be explained only by assuming that the advent of pottery and domestic stock signal the arrival of alien pastoralists into the area with the consequent threat of competition and conflict. No other sufficiently cogent reason can be advanced for the abandonment of the Mussel Point site and the drastic change in foraging strategies from the intensive exploitation of mussels to a more extensive range of more costly resources. Shellfish continue as the staple food but now comprise mussels and limpets in roughly equal proportion and the shellfish contribution to diet is substantially lower.

At the end of this final phase, when Europeans come on the scene, there are references in the records to pastoralists in the area between whom and the hunter-gatherers a relationship of patron/client or master/servant seems to have developed in places, but by 1740 A.D., only 40 years after trekboers had moved into the area from the south, the local and sometimes mixed bands of pastoralists and hunter-gatherers had broken up, their social structures had dis-integrated and their members had become a class of landless labourers (Penn n.d.). For the preceding 20 thousand millenia or more, prehistoric communities had successfully survived in this region on the natural resources of land, sea and vlei. Their skills in making artifacts for use and adornment and their aesthetic sensitivity still evident today in their ubiquitous rock paintings reveal a lifestyle of wider horizons that is beyond the scope of this inherently materialistic study.

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# A P P E N D I C E S

# APPENDIX A

## SITE REPORT FORM

Site Ref.: Name of Site:

1. Photographs :

   General view; interior; view from site (with orientation ...°)

2. Diagrams :

   Draw overleaf plans & cross-sections of site and talus with measurements

3. Description of Site :

   Deposit, terrain, vegetation, disturbance, erosion, exposure, approach, altitude, etc.

4. Distances to nearest :

| | | |
|---|---|---|
| Site | ........ | m |
| Shore Rocks | ........ | m |
| Fresh Water | ........ | m |

5. Deposit Depth :

   Record depth of deposit of site and talus at 1 m intervals

   Across :

   Front to Back :

6. Sampling : 1 $m^2$ Surface Samples ........

   Test Holes ........ volume ........ $m^3$

   Sieve Samples (3 mm), Bag and Label

7. Surface Search

   Search whole surface area and record finds overleaf

Appendix A (continued)

8. Rock Art

   Present/absent

9. Other Comments

Date ................ Name .............................

Appendix A (continued)

DRAWINGS (with measurements)

Indicate on plans where samples taken

| Plans | Cross-Sections |
| --- | --- |

FINDS FROM SURFACE SEARCH

| Pottery | Stone Tools | | | Bone Tools | OES | Ochre | Other |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | Formal | Utilized | Waste | | | | |

CALCULATIONS

| | Caves/RS | Talus | Open Sites |
| --- | --- | --- | --- |
| Superficial Area ($m^2$) | ........ | ..... | .......... |
| Average Depth of Deposit | ........ | ..... | .......... |
| Estimated Volume ($m^3$) | ........ | ..... | .......... |

## APPENDIX B

## COMPARISON OF SAMPLES FROM THE SAME SITE

| Site Ref. | Type of Site | Source of Sample | Type of Sample | Weight of Shell: Limpets % | Weight of Shell: Mussels % | Weight of Shell: Other spp. % |
|---|---|---|---|---|---|---|
| VV1 | Cave | Talus (upper) | Surface | 4,4 | 91,6 | 4,0 |
| | | Talus (lower) | Surface | 1,2 | 95,7 | 3,1 |
| VV4 | Cave | Cave | Test Pit | 1,4 | 96,3 | 2,2 |
| | | Talus | Surface | 10,4 | 85,0 | 4,6 |
| SC1 | Cave | Cave | Test Pit | 1,9 | 91,1 | 7,0 |
| | | Talus (front) | Surface | 3,8 | 90,8 | 5,4 |
| | | Talus (side) | Surface | 17,6 | 77,2 | 5,2 |
| DD1 | Cave | Talus | Surface | 1,9 | 94,6 | 3,5 |
| | | Talus | Surface | 2,8 | 93,0 | 4,2 |
| DD2 | Cave | Cave | Test Pit | 1,9 | 96,0 | 1,5 |
| | | Talus | Surface | 7,6 | 88,4 | 4,0 |
| | | Talus | Surface | 4,4 | 94,0 | 1,5 |
| BK4 | Cave | Cave | Test Pit | 8,3 | 86,5 | 5,2 |
| | | Talus | Surface | 25,6 | 70,3 | 4,1 |
| DP1 | Cave | Cave | Test Pit | 8,4 | 86,1 | 5,5 |
| | | Talus | Surface | 13,9 | 80,2 | 5,9 |
| BR6 | Cave | Cave | Test Pit | 29,0 | 60,4 | 10,6 |
| | | Talus | Test Pit | 30,7 | 57,8 | 11,5 |
| BR8 | Cave | Cave | Test Pit | 13,5 | 71,7 | 14,8 |
| | | Cave | Test Pit | 22,8 | 66,2 | 11,0 |
| JT1 | Cave | Cave | Surface | 65,2 | 24,6 | 10,2 |
| | | Cave | Surface | 74,5 | 19,0 | 6,4 |
| JT2 | Open | Open Midden | Test Pit | 40,4 | 50,8 | 8,7 |
| | | Open Midden | Test Pit | 66,8 | 28,1 | 5,1 |
| EC1 | Open | Shell Scatter | Surface | 27,0 | 51,6 | 21,4 |
| | | | Test Pit | 41,4 | 54,5 | 4,0 |
| VN1/2 | Open | Shell Scatter | Test Pit | 12,6 | 79,1 | 8,3 |
| | | | Surface | 8,7 | 79,3 | 12,0 |

# APPENDIX C

## ANALYSIS OF SHELLFISH SAMPLE

Site Ref. : | Name of Site :

Type of Sample : | Volume of Sample : m³

| Species | | | | | | | Totals N g |
|---|---|---|---|---|---|---|---|
| Patella | (Shell measurements overleaf) | | | | | | |
| | Shells | | Apices | | Frags | | |
| | N | g | N | g | g | | |
| Identified | | | | | | | |
| P. granatina | | | | | | | |
| P. granularis | | | | | | | |
| P. argenvillei | | | | | | | |
| P. barbara | | | | | | | |
| .............. | | | | | | | |
| .............. | | | | | | | |
| .............. | | | | | | | |
| Total Identified | | | | | | | |
| Unidentified | | | | | | | |
| Sub-Total Patella | | | | | | | |
| Mussels | | | | | | | |
| | Measured | | Hinges | | Frags | | |
| | N | g | R g | L g | g | | |
| C. meridionalis | | | | | | | |
| A. ater | | | | | | | |
| Donax sp. | | | | | | | |
| Sub-Total Mussels | | | | | | | |
| Other Sp. | | | | | | | |
| | | | Apices | | Frags | | |
| | | | N | g | g | | |
| Burnupena sp. | | | | | | | |
| Argobuccinum | | | | | | | |
| .............. | | | | | | | |
| .............. | | | | | | | |
| Sub-Total Other sp. | | | | | | | |

Total - All Shellfish

Balanus ......... g
Waste ......... g

Total Weight of Sample

# APPENDIX D

## CORRECTIONS FOR 12 mm SIEVING

### Increase in Shell Count from 3 mm over 12 mm Sieving

| Species | N 12 mm Mesh | N 3 mm Mesh | Increase | Percentage Increase |
|---|---|---|---|---|
| Patella | | | | |
| Sample 1 | 493 | 510 | 17 | 3,4 |
| Sample 2 | 97 | 103 | 6 | 6,2 |
| Sample 3 | 232 | 248 | 16 | 6,9 |
| Sample 4 | 564 | 587 | 23 | 4,1 |
| Total | 1386 | 1448 | 62 | 4,5 |
| Choromytilus | | | | |
| Sample 1 | 388 | 478 | 90 | 23,2 |
| Sample 2 | 11 | 17 | 6 | - |
| Sample 3 | 1640 | 2047 | 407 | 24,8 |
| Sample 4 | 15 | 18 | 3 | - |
| Sample 5 | 245 | 299 | 54 | 22,0 |
| Sample 6 | 7 | 8 | 1 | - |
| Total | 2306 | 2867 | 561 | 24,3 |

# APPENDIX E

## SAMPLED SITES
## NON-MOLLUSCAN MATERIALS FOUND

### Notes on Attached Schedule

Stone (x = Present)

Recoveries from samples and from a cursory search of the site surface were mainly chips, chunks, cores and flakes of quartz, quartzite, shale and silcrete but included one rubber, three scrapers, miscellaneous retouched or utilized pieces, three *Donax* 'scrapers' and one piece of ochre. Stone artifacts were collected from some of these sites in the EB area in 1951 (Rudner, *pers.comm.*).

Pottery

Finds of pottery have been used as indicators of date in association with depth of deposit, and the contents and location of sites. The absence of pottery from some sites is partly attributable to the brief time available for surface searching and possibly also to collections in 1951 for early pottery studies (Rudner, *pers.comm.*). Seven of the sites without pottery are superficial shell scatters with an aggregate volume of deposit of less than 40 $m^3$ but similar in other respects to sites with pottery. The other five are :

DD1 : An extensive superficial shell scatter with a volume of deposit of 45 $m^3$ round a small unoccupied rock shelter on a prominent hill. These signs indicate a pottery period deposit.

VN1 and VN2 : Superficial shell scatters in and around deflation hollows to the north of the Vlei where accumulations of formal stone tools have been found (Mazel 1978). These sites may therefore be related to the pre-pottery system (Manhire 1984).

| Site Ref. | Type of Site | Pottery | Ostrich Egg-Shell | O.E.S. Beads | Bone Fragments: Fish N | Bone Fragments: Fish g | Bone Fragments: Other N | Bone Fragments: Other g | Crayfish Mandibles R | Crayfish Mandibles L | Stone Tools/ Utilized Waste |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VV1 | C | 1 | | 2 | 8 | 1,5 | 5 | 7,5 | | | x |
| VV4 | C | 3 | | | 5 | 2,0 | 15 | 11,0 | | | x |
| TT1 | C | 5 | 1 | 1 | 1 | - | 9 | 6,0 | | | x |
| TT2 | C | 2 | 10 | 1 | 4 | 2,0 | 50 | 23,0 | 1 | | x |
| SC1 | C | 1 | 1 | 1 | 9 | 2,5 | 16 | 17,5 | 1 | | x |
| SC2 | R/S | | | | 3 | 2,0 | 4 | 4,5 | | | |
| DD1 | C | | 5 | 1 | | | | | | | x |
| DD2 | C | Several | | 1 | 1 | - | 3 | 2,0 | | | x |
| DD3 | R/S | | | | 1 | - | 9 | 8,0 | | | x |
| BK4 | C | | | 2 | 68 | 13,0 | 40 | 9,0 | 3 | 1 | x |
| BK7 | R/S | 21 | | | | | | | | | x |
| DP1 | C | Several | 3 | 1 | 94 | 21,0 | 92 | 38,5 | 1 | 2 | x |
| BR1 | C | Several | 2 | 1 | 3 | 1,0 | 22 | 7,0 | 1 | - | x |
| BR2 | O | | | | | | 1 | 2,0 | | | x |
| BR4 | C | 1 | 2 | 1 | 121 | 12,0 | 12 | 2,0 | 20 | 26 | x |
| BR5 | C | 1 | 9 | | 34 | 3,0 | 186 | 68,0 | 10 | 1 | x |
| BR6 | C | Several | 2 | | 2 | - | 21 | 14,0 | 26 | 23 | x |
| BR7 | C | Several | 8 | | 3 | - | 66 | 5,0 | 6 | 6 | x |
| BR8 | C | Several | 2 | 3 | 2 | - | 20 | 25,0 | 11 | 5 | x |
| EV3 | O | | | | 5 | 1,0 | 36 | 42,0 | 4 | - | |
| EV4 | O | 1 | 1 | | 4 | 1,0 | 42 | 15,0 | 3 | 3 | |
| PR1/2 | O | | | | | | 2 | 1,0 | | | |
| JT1 | C | 1 | | | 1 | - | 10 | 4,0 | | | |
| JT2 | O | 5 | 2 | | 5 | 3,0 | 23 | 50,0 | 4 | 1 | |
| JT3 | R/S | 1 | | | 7 | 1,0 | 48 | 12,0 | 1 | 1 | |
| JT6 | R/S | 5 | 1 | | | | | | | | x |
| EC1 | O | Several | 1 | | 5 | 2,0 | 31 | 18,8 | | | x |
| EC5 | O | | | | 4 | 2,0 | 11 | 16,0 | | | x |
| VN1 | O | | 1 | | 3 | - | 43 | 5,0 | | | x |
| VN2 | O | | 1 | | | | 1 | - | | | x |
| Totals | | | 52 | 15 | 393 | 70,0 | 818 | 413,8 | 92 | 69 | |

## APPENDIX F

### SERIAL NUMBERS AND SITE REFERENCES

### CLASSIFICATION OF SITES WITH DEPOSIT VOLUMES & TOTAL KILOJOULES FROM SHELLFISH

| Serial No. | Site Ref. | Major Caves Deposit $m^3$ | Major Caves Total kJ (Thousands) | Minor Caves & R/S Deposit $m^3$ | Minor Caves & R/S Total kJ (Thousands) | Open Sites Deposit $m^3$ | Open Sites Total kJ (Thousands) | Comment E=Excavated S=Sampled |
|---|---|---|---|---|---|---|---|---|
| 1 | VV1 | 141 | 35 102 | | | | | S |
| 2 | VV2 | | | | | | | Secondary Deposit |
| 3 | VV3 | | | | | | | Rock Art Only |
| 4 | VV4 | 60 | 12 144 | | | | | S |
| 5 | VV5 | | | 0,10 | 10 | | | |
| 6 | VV6 | | | | x | | | No Archaeological Debris |
| 7 | PK1 | | | 1,00 | 100 | | | |
| 8 | PK2 | | | 2,00 | 200 | | | |
| 9 | TT1 | 13 | 2 421 | | | | | S |
| 10 | TT2 | 381 | 166 964 | | | | | S (Robey 1984) |
| 11 | SC1 | 47 | 7 345 | | | | | S |
| 12 | SC2 | | | 1,40 | 49 | | | S |
| 13 | SC3 | | | 4,00 | 400 | | | |
| 14 | DD1 | 45 | 12 487 | | | | | S |
| 15 | DD2 | 312 | 47 754 | | | | | S |
| 16 | DD3 | | | 1,10 | 133 | | | S |
| 17 | DD4 | | | | x | | | No Archaeological Debris |
| 18 | DD5 | | | | x | | | - Ditto - |
| 19 | DD6 | | | | x | | | - Ditto - |
| 20 | DD7 | | | | x | | | - Ditto - |
| 21 | BK1 | | | | Negligible | | | |
| 22 | BK2 | | | | Negligible | | | |
| 23 | BK3 | | | 0,10 | 10 | | | |
| 24 | BK4 | 17 | 1 930 | | | | | S |
| 25 | BK5 | | | 0,25 | 25 | | | |
| 26 | BK6 | | | 2,25 | 225 | | | |
| 27 | BK7 | | | 5,00 | 143 | | | S |
| 28 | BK8 | | | 1,00 | 100 | | | |
| 29 | BK9 | | | | | 2,5 | 250 | |
| 30 | BK10 | | | | | 48,0 | 4 800 | |
| 31 | BK11 | | | | | 0,5 | 50 | |
| 32 | BK12 | | | 1,00 | 100 | | | |
| 33 | DP1 | 169 | 79 460 | | | | | S |
| 34 | DP2 | | | | | 5,0 | 500 | |
| 35 | DP3 | | | | x | | | Cave - No Debris |
| 36 | DP4 | | | | | 7,5 | 750 | |
| 37 | BR1 | 95 | 75 598 | | | | | S |
| 38 | BR2 | | | | | 9,0 | 1 550 | S |
| 39 | BR3 | | | 2,00 | 200 | | | |
| 40 | BR4 | | | 2,50 | 538 | | | S |
| 41 | BR5 | 115 | 86 296 | | | | | S |
| 42 | BR6 | 51 | 23 701 | | | | | S |
| 43 | BR7 | 14 | 7372 | | | | | S |
| 44 | BR8 | 170 | 33 754 | | | | | S |
| 45 | EV1 | | | | | 0,4 | 100 | E (Horwitz 1979) |
| 46 | EV2 | | | | | 4,0 | 1 600 | E (Horwitz 1979) |
| 47 | EV3 | | | | | 3,4 | 2 077 | S |
| 48 | EV4 | | | | | 1,0 | 465 | S |
| 49 | EV5 | | | | | 2,0 | 200 | |
| 50 | EV6 | | | | | 5,0 | 500 | |
| 51 | PR1 | | | | | 50,0 | 13 795 | S |
| 52 | PR2 | | | | | 80,0 | 8 000 | |
| 53 | PR3 | | | | | | x | * |
| 54 | JT1 | 16 | 11 307 | | | | | S |
| 55 | JT2 | | | | | 274,0 | 80 816 | S/E (Horwitz 1979) |
| 56 | JT3 | | | 0,40 | 25 | | | S |
| 57 | JT4 | | | 1,00 | 100 | | | |
| 58 | JT5 | | | 3,00 | 300 | | | |
| 59 | JT6 | | | 3,00 | 319 | | | S |
| 60 | EC1 | | | | | 7,5 | 4 456 | S |
| 61 | EC2 | | | | | 6,3 | 1 900 | E (Horwitz 1979) |
| 62 | EC3 | | | | | 10,0 | 1 000 | |

| Serial No. | Site Ref. | Major Caves Deposit m³ | Major Caves Total kJ (Thousands) | Minor Caves & R/S Deposit m³ | Minor Caves & R/S Total kJ (Thousands) | Open Sites Deposit m³ | Open Sites Total kJ (Thousands) | Comment E=Excavated S=Sampled |
|---|---|---|---|---|---|---|---|---|
| 63 | EC4 | 40 | 10 300 | | | | | E (Parkington 1976a) |
| 64 | EC5 | | | | | 5,0 | 1 392 | S |
| 65 | EC6 | | | 2,50 | 250 | | | |
| 66 | ES1 | | | | | | | E (see Ch.7) |
| 67 | ES2 | | | | | 0,2 | 71 | S |
| 68 | ES3 | | | | | 3,9 | 1 301 | S |
| 69 | ES4 | | | | | 3,0 | 300 | |
| 70 | ES5 | | | | x | | | Large Empty Cave |
| 71 | ES6 | | | 0,90 | 90 | | | |
| 72 | ES7 | | | | | 0,5 | 50 | |
| 73 | ES8 | | | | | 0,5 | 50 | |
| 74 | ES9 | | | 3,20 | 320 | | | |
| 75 | ES10 | | | | | 8,5 | 850 | |
| 76 | VN1 | | | | | 15,0 | 985 | S |
| 77 | VN2 | | | | | 6,8 | 1 212 | S |
| Totals | | 1686 | 613 932 | 37,70 | 3637 | 559,5 | 129 022 | |

Total - All Sites : Volume of Deposit 2283,2 m³

Total kJ 764 591 000

*Deposit with pottery but mixed with road materials and beach wash-ups

# APPENDIX G.1

## DIETARY RECONSTRUCTION

## ELAND'S BAY RESEARCH AREA

Dating : 1800-300 BP

Total Volume of Samples : 39,7403 m³

| | | kJ m⁻³ | % | Nm⁻³ | Mean kJ Yield/ Animal |
|---|---|---|---|---|---|
| Shellfish | | 350 000 | 44,8 | 14 000,0 | 25 |
| Rock Lobsters | | 29 572 | 3,8 | 37,0 | 800 |
| Fish | | 10 901 | 1,4 | 7,3 | 1 484 |
| Mammals | | 192 625 | 24,6 | 2,7 | 71 481 |
| Seals | | 129 748 | 16,6 | 1,3 | 103 125 |
| Birds | | | | | |
| Marine | 54 900 | | | | |
| Other | 6 452 | 61 352 | 7,9 | 10,0 | 6 135 |
| Tortoise | | 7 358 | 0,9 | 3,7 | 2 000 |
| | | 781 556 | 100,0 | | |
| Marine | | 575 121 | 73,6 | | |
| Terrestrial | | 206 435 | 26,4 | | |

# APPENDIX G.1(a)

## REVISED TO INCLUDE ESTIMATES FOR CETACEANS & PLANTS

| | kJ m⁻³ | % |
|---|---|---|
| Shellfish | 350 000 | 35,0 |
| Rock Lobsters | 29 572 | 3,0 |
| Fish | 10 901 | 1,1 |
| Mammals | 192 625 | 19,3 |
| Cetaceans | 210 000 | 21,0 |
| Seals | 129 748 | 13,0 |
| Birds | 61 352 | 6,1 |
| Tortoise | 7 358 | 0,7 |
| Plants | 8 444 | 0,4 |
| | 1 000 000 | 100,0 |
| Marine | 785 121 | 78,5 |
| Terrestrial | 214 879 | 21,5 |

# APPENDIX G.2

## DIETARY RECONSTRUCTION

## DUIKER EILAND

Dating : Surface 1700 ± 50 BP
Layer 2 1930 ± 70 BP

Total Volume of Samples : 0,7807 m³

| | kJ m⁻³ | % | Nm⁻³ | Mean kJ Yield/ Animal |
|---|---|---|---|---|
| Shellfish | 303 558 | 9,5 | 12 735,0 | 23,8 |
| Rock Lobster | 428 334 | 13,4 | 535,0 | 800 |
| Fish | 34 890 | 1,1 | 35,7 | 977 |
| Mammals | 488 779 | 15,2 | 17,3 | 28 235 |
| Seals | 1 024 721 | 31,9 | 10,2 | 100 462 |
| Birds (All Marine) | 917 853 | 28,6 | 117,8 | 7 791 |
| Tortoise | 10 247 | 0,3 | 5,1 | 2 000 |
| | 3 208 382 | 100,0 | | |
| Marine | 2 709 356 | 84,4 | | |
| Terrestrial | 499 026 | 15,6 | | |

# APPENDIX G.3

## DIETARY RECONSTRUCTION

## PATERNOSTER

Dating : Layer 1 870 ± 50 BP and 855 ± 45 BP
Layer 5 3110 ± 60 BP

Total Volume of Samples : 2,7582 $m^3$

| | kJ $m^{-3}$ | % | $Nm^{-3}$ | Mean kJ Yield/ Animal |
|---|---|---|---|---|
| Shellfish | 373 688 | 21,4 | 21 747,0 | 17,2 |
| Rock Lobster | 97 200 | 5,6 | 121,5 | 800 |
| Fish | 19 921 | 1,1 | 30,1 | 662 |
| Mammals | 840 207 | 48,2 | 9,8 | 85 735 |
| Seals | 186 943 | 10,7 | 1,8 | 103 857 |
| Birds (All Marine) | 184 421 | 10,6 | 29,0 | 6 359 |
| Tortoise | 42 056 | 2,4 | 21,0 | 2 000 |
| | 1 744 436 | 100,0 | | |
| Marine | 862 173 | 49,4 | | |
| Terrestrial | 882 263 | 50,6 | | |

# APPENDIX G.4

## DIETARY RECONSTRUCTION

## HOUT BAY CAVE

Dating : Layer 1 1460 ± 50 BP
Layer 5 1840 ± 50 BP

Total Volume of Sample : 1,3 $m^3$

| | | $kJ\ m^{-3}$ | % | $Nm^{-3}$ | Mean kJ Yield/ Animal |
|---|---|---|---|---|---|
| Shellfish | | 291 120 | 7,1 | 14 675,0 | 19,8 |
| Rock Lobster | | 1 440 | 0,03 | 2,3 | 600 |
| Fish | | 73 576 | 1,8 | 86,1 | 854 |
| Mammals | | 3 099 738 | 76,0 | 17,7 | 175 126 |
| Seals | | 461 538 | 11,3 | 4,6 | 100 334 |
| Birds | | | | | |
| Marine | 136 870 | | | | |
| Other | 7 230 | 144 100 | 3,5 | 22,3 | 6 462 |
| Tortoise | | 6 154 | 0,15 | 3,0 | 2 000 |
| | | 4 077 666 | 99,88 | | |
| Marine | | 964 544 | 23,7 | | |
| Terrestrial | | 3 113 122 | 76,3 | | |

This was a rescue dig of a residual deposit adhering to the back wall of the cave where bones may have been thrown and concentrated. Identification of some mammal bones may be doubtful. The reconstruction is unlikely to be representative of the original deposit.

# APPENDIX G.5

## DIETARY RECONSTRUCTION

## PEARLY BEACH/HAWSTON

Dating : Undated

Total Volume of Sample : 1 365 m³

Data from 10 sites have been combined

| | | kJ m⁻³ | % | Nm⁻³ | Mean kJ Yield/ Animal |
|---|---|---|---|---|---|
| Shellfish | | 426 775 | 17,6 | 18 440,0 | 23,1 |
| Rock Lobster | | 9 670 | 0,4 | 16,0 | 600 |
| Fish | | 107 157 | 4,4 | 84,2 | 1 272 |
| Mammals | | 1 084 780 | 44,7 | 15,4 | 70 510 |
| Cetaceans | | 265 100 | 10,9 | 0,7 | 185 570 |
| Seals | | 439 560 | 18,1 | 4,4 | 100 000 |
| Birds | | | | | |
| Marine | 43 000 | | | | |
| Other | 28 670 | | | | |
| | | 71 670 | 3,0 | 11,7 | 7 127 |
| Tortoise | | 23 443 | 0,9 | 11,7 | 2 000 |
| | | 2 428 155 | 100,0 | | |
| Marine | | 1 291 262 | 53,2 | | |
| Terrestrial | | 1 136 893 | 46,8 | | |

# APPENDIX G.6

## DIETARY RECONSTRUCTION

## DIE KELDERS

Dating : Layer 2 1509 ± 100 BP
Layer 12 1960 ± 85 BP

Total Volume of Sample : 37,3 m³

| | | $kJ\ m^{-3}$ | % | $Nm^{-3}$ | Mean kJ Yield/ Animal |
|---|---|---|---|---|---|
| Shellfish | | 300 000 | 16,4 | 13 600,0 | 22,1 |
| Rock Lobster | | Nil | | | |
| Fish | | 102 381 | 5,6 | 141,6 | 723 |
| Mammals | | 1 042 779 | 57,0 | 48,4 | 21 536 |
| Cetaceans | | 45 040 | 2,5 | 0,2 | 210 000 |
| Seals | | 273 458 | 5,0 | 2,5 | 109 577 |
| Birds | | | | | |
| Marine | 41 705 | | | | |
| Other | 4 233 | 45 938 | 2,5 | 2,0 | 8 132 |
| Tortoise | | 18 660 | 1,0 | 9,3 | 2 000 |
| | | 1 828 256 | 100,0 | | |
| Marine | | 762 584 | 41,7 | | |
| Terrestrial | | 1 065 672 | 58,3 | | |

## APPENDIX H.1

## SUMMARY - ALL SITES - SHELLFISH

| | Volume of Sample ($m^3$) | $Nm^{-3}$ | kJ $m^{-3}$ | Mean kJ Yield per Animal | % of Total Diet |
|---|---|---|---|---|---|
| Eland's Bay Research Area | 1,8003 | 14 000 | 350 000 | 25,0 | 44,8 |
| Duiker Eiland | 0,2625 | 12 735 | 303 558 | 23,8 | 9,5 |
| Paternoster | 0,6250 | 21 747 | 373 688 | 17,2 | 21,9 |
| Hout Bay Cave | 0,4250 | 14 675 | 291 120 | 19,8 | 7,1 |
| Smitswinkelbaai | 0,4000 | 23 005 | 375 230 | 16,3 | * |
| Rooiels Cave | 2,6000 | 8 298 | 314 959 | 36,6 | * |
| Pearly Beach/Hawston | 1,3650 | 18 440 | 426 775 | 23,1 | 17,6 |
| Die Kelders | 1,5260 | 13 600 | 300 000 | 22,1 | 16,4 |
| | 9,0038 | 1 255 000 | 2 735 330 | | |
| Mean | 1,1255 | 15 811 | 341 916 | 23,0 | |
| Standard Deviation | 0,8332 | 4 919 | 47 691 | 6,3 | |

* Data incomplete

## APPENDIX H.2

### SUMMARY - ALL SITES - ROCK LOBSTERS

| | Volume of Sample ($m^3$) | $Nm^{-3}$ | kJ $m^{-3}$ | Mean kJ Yield per Animal | % of Total Diet |
|---|---|---|---|---|---|
| Eland's Bay Research Area | 39,7403 | 37,0 | 29 572 | 800 | 3,8 |
| Duiker Eiland | 0,7807 | 535,0 | 428 334 | 800 | 13,4 |
| Paternoster | 2,7582 | 121,5 | 97 200 | 800 | 5,6 |
| Bonteberg Shelter | 4,0000 | 47,0 | 28 200 | 600 | * |
| Hout Bay Cave | 1,3000 | 2,3 | 1 440 | 600 | 0,03 |
| Smitswinkelbaai | Nil | | | | |
| Rooiels Cave | 2,6000 | 15,0 | 9 000 | 600 | * |
| Pearly Beach/Hawston | 1,3650 | 16,0 | 9 670 | 600 | 0,4 |
| Die Kelders | Nil | | | | |
| | 52,5442 | 773,8 | 603 416 | | |
| Mean | 11,4000 | 110,5 | 86 202 | | |
| Standard Deviation | 15,8000 | 191,3 | 154 244 | | |

*Data incomplete

## APPENDIX H.3

### SUMMARY - ALL SITES - FISH

| | Volume of Sample ($m^3$) | $Nm^{-3}$ | kJ $m^{-3}$ | Mean kJ Yield per Animal | % of Total Diet |
|---|---|---|---|---|---|
| Eland's Bay Research Area | 39,7403 | 7,3 | 10 901 | 1484 | 1,4 |
| Duiker Eiland | 0,7807 | 35,7 | 34 890 | 977 | 1,1 |
| Paternoster | 2,7582 | 30,1 | 19 921 | 662 | 1,1 |
| Hout Bay Cave | 1,3000 | 86,1 | 73 576 | 854 | 1,8 |
| Smitswinkelbaai | 12,5000 | 35,0 | 134 196 | 3834 | * |
| Rooiels Cave | 2,6000 | 229,0 | 581 780 | 2540 | * |
| Pearly Beach/Hawston | 1,3650 | 84,2 | 107 157 | 1272 | 4,4 |
| Die Kelders | 37,3000 | 141,6 | 102 381 | 723 | 5,6 |
| | 98,3442 | 649,0 | 1 064 802 | | |
| Mean | 12,3000 | 81,1 | 133 100 | 1543 | |
| Standard Deviation | 16,6000 | 73,5 | 186 648 | 1106 | |

*Data incomplete

# APPENDIX H.4

## SUMMARY - ALL SITES - TERRESTRIAL MAMMALS

| | Volume of Sample ($m^3$) | $Nm^{-3}$ | kJ $m^{-3}$ | Mean kJ Yield per Animal | % of Total Diet |
|---|---|---|---|---|---|
| Eland's Bay Research Area | 39,1400 | 2,7 | 192 625 | 71 481 | 24,6 |
| Duiker Eiland | 0,7807 | 17,3 | 488 779 | 28 253 | 15,2 |
| Paternoster | 2,7582 | 9,8 | 840 207 | 85 735 | 48,2 |
| Hout Bay Cave | 1,3000 | 17,7 | 3 099 738 | 175 126 | 79,6 |
| Pearly Beach/Hawston | 1,3650 | 15,4 | 1 084 780 | 70 510 | 44,7 |
| Die Kelders | 37,3000 | 48,4 | 1 042 779 | 21 536 | 57,0 |
| | 82,6439 | 111,3 | 6 748 908 | | |
| Mean | 13,8000 | 18,6 | 1 124 818 | 75 440 | |
| Standard Deviation | 19,000 | 15,7 | 1 025 980 | 55 164 | |

## APPENDIX H.5

## SUMMARY - ALL SITES - CETACEANS

| | Volume of Sample ($m^3$) | $Nm^{-3}$ | kJ $m^{-3}$ | Mean kJ Yield per Animal |
|---|---|---|---|---|
| Pearly Beach/Hawston | 1,365 | 0,70 | 265 100 | 185 570 |
| Die Kelders | 37,300 | 0,21 | 45 040 | 210 000 |
| | 38,665 | 0,46 | 155 070 | 197 785 |

## APPENDIX H.6

## SUMMARY - ALL SITES - SEALS

| | Volume of Sample ($m^3$) | $Nm^{-3}$ | kJ $m^{-3}$ | % of Total Diet |
|---|---|---|---|---|
| Eland's Bay Research Area | 39,7403 | 1,3 | 129 748 | 16,6 |
| Duiker Eiland | 0,7807 | 10,2 | 1 024 721 | 31,9 |
| Paternoster | 2,7582 | 1,8 | 186 943 | 10,7 |
| Hout Bay Cave | 1,3000 | 4,6 | 461 538 | 11,8 |
| Pearly Beach/Hawston | 1,3650 | 4,4 | 439 560 | 18,1 |
| Die Kelders | 37,3000 | 2,5 | 273 458 | 15,0 |
| | 83,2442 | 24,8 | 2 515 968 | |
| Mean | 13,9000 | 4,1 | 419 328 | |
| Standard Deviation | 19,1000 | 3,3 | 324 909 | |

# APPENDIX H.7

## SUMMARY - ALL SITES - BIRDS

| | Volume of Sample ($m^3$) | $Nm^{-3}$ | $kJ\ m^{-3}$ Marine | Other | Total | Mean kj Yield per Animal | % of Total Diet |
|---|---|---|---|---|---|---|---|
| Eland's Bay Research Area | 39,1400 | 10,0 | 54 900 | 6 452 | 61 352 | 6135 | 7,9 |
| Duiker Eiland | 0,7807 | 117,8 | 917 853 | Nil | 917 853 | 7791 | 28,6 |
| Paternoster | 2,7582 | 29,0 | 184 421 | Nil | 184 421 | 6359 | 10,6 |
| Hout Bay Cave | 1,3000 | 22,3 | 136 870 | 7 230 | 144 100 | 6462 | 3,7 |
| Rooiels Cave | 2,6000 | 15,4 | 147 352 | 1 250 | 148 602 | 9659 | * |
| Pearly Beach/Hawston | 1,3650 | 11,7 | 43 000 | 28 670 | 71 670 | 6114 | 3,0 |
| Die Kelders | 37,3000 | 5,7 | 41 705 | 4 233 | 45 938 | 7359 | 2,5 |
| | 85,2439 | 211,9 | 1 526 101 | 47 835 | 1 573 936 | | |
| Mean | 12,2000 | 30,3 | 218 014 | 9 567 | 224 848 | 7126 | |
| Standard Deviation | 17,8000 | 39,4 | 313 794 | 10 928 | 309 954 | 1288 | |

*Data incomplete

# APPENDIX H.8

## SUMMARY - ALL SITES - TORTOISE

| | Volume of Sample ($m^3$) | $Nm^{-3}$ | kJ $m^{-3}$ | Mean kJ Yield per Animal | % of Total Diet |
|---|---|---|---|---|---|
| Eland's Bay Research Area | 39,1400 | 3,7 | 7 358 | | 0,9 |
| Duiker Eiland | 0,7807 | 5,1 | 10 247 | | 0,3 |
| Paternoster | 2,7582 | 21,0 | 42 056 | | 2,4 |
| Hout Bay Cave | 1,3000 | 3,0 | 6 154 | | 0,2 |
| Pearly Beach/Hawston | 1,3650 | 11,7 | 23 443 | | 0,9 |
| Die Kelders | 37,3000 | 9,3 | 18 660 | | 1,0 |
| | 82,6439 | 53,8 | 107 918 | 2 000 | |
| Mean | 13,8000 | 9,0 | 17 986 | 2 000 | |
| Standard Deviation | 19,0000 | 6,8 | 13 582 | - | |

# APPENDIX I

## SHELLFISH CONTRIBUTION TO TOTAL DIET

| | kJ $m^{-3}$ Total Diet | kJ $m^{-3}$ Shellfish | % |
|---|---|---|---|
| Eland's Bay Research Area | 781 556 | 350 000 | 44,8 |
| Duiker Eiland | 3 208 382 | 303 558 | 9,5 |
| Paternoster | 1 744 436 | 373 668 | 21,4 |
| Hout Bay Cave | 4 077 666 | 291 120 | 7,1 |
| Pearly Beach/Hawston | 2 428 155 | 426 775 | 17,6 |
| Die Kelders | 1 828 256 | 300 000 | 16,4 |
| | 14 068 451 | 2 045 121 | |
| Mean | 2 344 742 | 340 854 | 14,5 |
| Standard Deviation | 1 168 463 | 53 059 | |
| **Excluding Hout Bay Cave** | | | |
| Mean | 1 998 157 | 350 800 | 17,6 |
| Standard Deviation | 897 622 | 52 698 | |

# APPENDIX J

## DIETARY RECONSTRUCTION - ALL SITES

The purpose of the table overleaf is to compare the proportionate contributions of marine and terrestrial resources with Sealy's data (1984) for coastal diets. Column 2 is derived from the aggregate total kilojoules and aggregate sample volumes for each category from all sites. This avoids the weakness in Column 1 data which give equal weight to kJ $m^{-3}$ values for each site, irrespective of the volume of the sample. Whales and dolphins were reported only from Pearly Beach/Hawston, DK1. No estimates have been included for plant foods and other unknowns.

## APPENDIX J (Continued)

## DIETARY RECONSTRUCTION - ALL SITES

| | Column 1 | | Column 2 | | |
|---|---|---|---|---|---|
| | Mean kJ Yield $m^{-3}$ | | Mean kJ Yield $m^{-3}$ | | |
| | Appendices H.1 to H.8 | % | Total Volume of Samples ($m^3$) | kJ $m^{-3}$ | % |
| Shellfish | 341 916 | 13,7 | 9,0038 | 341 768 | 23,2 |
| Rock Lobster | 86 202 | 3,4 | 52,5442 | 36 711 | 2,5 |
| Fish | 133 100 | 5,3 | 98,3442 | 78 970 | 5,4 |
| Mammals | 1 124 818 | 44,9 | 82,6439 | 661 204 | 44,9 |
| Cetaceans | 155 070 | 6,2 | 38,6650 | 52 809 | 3,6 |
| Seals | 419 328 | 16,8 | 83,2442 | 214 692 | 14,6 |
| Birds | 224 848 | 9,0 | 85,2439 | 75 054 | 4,9 |
| Tortoise | 17 986 | 0,7 | 82,6439 | 13 891 | 0,9 |
| Total Diet kJ $m^{-3}$ | 2 503 268 | 100,0 | | 1 475 099 | 100,0 |
| Marine | 1 353 719 | 54,1 | | 797 819 | 54,1 |
| Terrestrial | 1 149 549 | 45,9 | | 677 280 | 45,9 |

## APPENDIX J (Continued)

## DIETARY RECONSTRUCTION - ALL SITES

| | Column 1 | | Column 2 | | |
|---|---|---|---|---|---|
| | Mean kJ Yield $m^{-3}$ | | Mean kJ Yield $m^{-3}$ | | |
| | Appendices H.1 to H.8 | % | Total Volume of Samples ($m^3$) | kJ $m^{-3}$ | % |
| Shellfish | 341 916 | 13,7 | 9,0038 | 341 768 | 23,2 |
| Rock Lobster | 86 202 | 3,4 | 52,5442 | 36 711 | 2,5 |
| Fish | 133 100 | 5,3 | 98,3442 | 78 970 | 5,4 |
| Mammals | 1 124 818 | 44,9 | 82,6439 | 661 204 | 44,9 |
| Cetaceans | 155 070 | 6,2 | 38,6650 | 52 809 | 3,6 |
| Seals | 419 328 | 16,8 | 83,2442 | 214 692 | 14,6 |
| Birds | 224 848 | 9,0 | 85,2439 | 75 054 | 4,9 |
| Tortoise | 17 986 | 0,7 | 82,6439 | 13 891 | 0,9 |
| Total Diet kJ $m^{-3}$ | 2 503 268 | 100,0 | | 1 475 099 | 100,0 |
| Marine | 1 353 719 | 54,1 | | 797 819 | 54,1 |
| Terrestrial | 1 149 549 | 45,9 | | 677 280 | 45,9 |

# APPENDIX K.1

## KILOJOULE YIELDS AND SHELL WEIGHTS

| Base Width (mm) | *P. granatina* kJ | *P. granatina* g | *P. granularis* kJ | *P. granularis* g | *P. argenvillei* kJ | *P. argenvillei* g | *P. barbara* kJ | *P. barbara* g |
|---|---|---|---|---|---|---|---|---|
| 25 | 4,40 | 1,00 | 1,60 | 1,20 | 1,56 | | 7,80 | 1,20 |
| 26 | 4,54 | 1,10 | 2,24 | 1,38 | 1,68 | | 7,86 | 1,30 |
| 27 | 4,68 | 1,20 | 2,88 | 1,56 | 1,79 | | 7,92 | 1,40 |
| 28 | 4,82 | 1,30 | 3,52 | 1,74 | 1,91 | | 7,98 | 1,50 |
| 29 | 4,96 | 1,40 | 4,16 | 1,92 | 2,03 | | 8,04 | 1,60 |
| 30 | 5,10 | 1,50 | 4,80 | 2,10 | 2,15 | | 8,10 | 1,70 |
| 31 | 5,24 | 1,60 | 5,44 | 2,28 | 2,26 | | 8,16 | 1,80 |
| 32 | 5,38 | 1,70 | 6,08 | 2,46 | 2,38 | | 8,22 | 1,90 |
| 33 | 5,52 | 1,80 | 6,72 | 2,64 | 2,50 | | 8,28 | 2,00 |
| 34 | 5,66 | 1,90 | 7,36 | 2,82 | 2,61 | | 8,34 | 2,10 |
| 35 | 5,80 | 2,00 | 8,00 | 3,00 | 2,73 | | 8,40 | 2,25 |
| 36 | 6,36 | 2,20 | 10,2 | 3,30 | 3,20 | | 9,10 | 2,50 |
| 37 | 6,92 | 2,40 | 12,30 | 3,60 | 3,70 | | 9,70 | 2,70 |
| 38 | 7,48 | 2,60 | 14,50 | 3,90 | 4,10 | | 10,40 | 2,90 |
| 39 | 8,04 | 2,80 | 16,60 | 4,20 | 4,60 | | 11,00 | 3,20 |
| 40 | 8,60 | 3,00 | 18,80 | 4,50 | 5,10 | | 11,70 | 3,50 |
| 41 | 9,16 | 3,20 | 21,00 | 4,80 | 5,50 | | 12,30 | 3,80 |
| 42 | 9,72 | 3,40 | 23,10 | 5,10 | 6,00 | | 13,00 | 4,10 |
| 43 | 10,28 | 3,60 | 25,30 | 5,40 | 6,50 | | 13,60 | 4,40 |
| 44 | 10,84 | 3,80 | 27,40 | 5,70 | 6,90 | | 14,30 | 4,70 |
| 45 | 11,40 | 4,00 | 29,60 | 6,00 | 7,40 | 5,00 | 14,90 | 5,00 |
| 46 | 13,70 | 4,40 | 31,80 | 6,45 | 9,90 | 5,50 | 16,00 | 5,50 |
| 47 | 16,00 | 4,80 | 34,10 | 6,90 | 12,30 | 6,00 | 17,10 | 6,00 |
| 48 | 18,30 | 5,20 | 36,30 | 7,35 | 14,30 | 6,50 | 18,30 | 6,50 |
| 49 | 20,60 | 5,60 | 38,60 | 7,80 | 17,20 | 7,00 | 19,40 | 7,00 |
| 50 | 22,90 | 6,00 | 40,80 | 8,25 | 19,70 | 7,50 | 20,50 | 7,50 |
| 51 | 25,20 | 6,40 | 43,00 | 8,70 | 22,20 | 8,00 | 21,60 | 8,00 |
| 52 | 27,50 | 6,80 | 45,30 | 9,15 | 24,6 | 8,50 | 22,70 | 8,50 |
| 53 | 29,80 | 7,20 | 47,50 | 9,60 | 27,10 | 9,00 | 23,90 | 9,00 |
| 54 | 32,10 | 7,60 | 49,80 | 10,05 | 29,50 | 9,50 | 25,00 | 9,50 |
| 55 | 34,40 | 8,00 | 52,00 | 10,50 | 32,00 | 10,00 | 26,10 | 10,00 |
| 56 | 37,30 | 8,40 | 54,20 | 11,15 | 34,60 | 10,80 | 29,40 | 11,00 |
| 57 | 40,30 | 8,80 | 56,30 | 11,80 | 37,30 | 11,60 | 32,70 | 12,00 |
| 58 | 43,20 | 9,20 | 58,50 | 12,45 | 39,90 | 12,40 | 36,00 | 13,00 |
| 59 | 46,20 | 9,60 | 60,60 | 13,10 | 42,50 | 13,20 | 39,30 | 14,00 |
| 60 | 49,10 | 10,00 | 62,80 | 13,75 | 45,20 | 14,00 | 42,60 | 15,00 |
| 61 | 52,00 | 10,40 | 65,00 | 14,40 | 47,80 | 14,80 | 45,90 | 16,00 |
| 62 | 55,00 | 10,80 | 67,10 | 15,05 | 50,40 | 15,60 | 49,20 | 17,00 |
| 63 | 57,90 | 11,20 | 69,30 | 15,70 | 53,00 | 16,40 | 52,50 | 18,00 |
| 64 | 60,90 | 11,60 | 71,40 | 16,35 | 55,70 | 17,20 | 55,80 | 19,00 |
| 65 | 63,80 | 12,00 | 73,60 | 17,00 | 58,30 | 18,00 | 59,10 | 20,00 |
| 66 | 66,00 | 12,80 | 75,60 | 17,75 | 60,10 | 19,40 | 62,90 | 20,40 |
| 67 | 68,30 | 13,60 | 77,60 | 18,50 | 61,80 | 20,80 | 66,80 | 20,80 |
| 68 | 70,50 | 14,40 | 79,50 | 19,25 | 63,60 | 22,20 | 70,60 | 21,20 |
| 69 | 72,80 | 15,20 | 81,50 | 20,00 | 65,30 | 23,60 | 74,50 | 21,60 |
| 70 | 75,00 | 16,00 | 83,50 | 20,75 | 67,10 | 25,00 | 78,30 | 22,00 |
| 71 | 77,20 | 16,80 | 85,50 | 21,50 | 68,80 | 26,40 | 82,10 | 22,40 |
| 72 | 79,50 | 17,60 | 87,50 | 22,25 | 70,60 | 27,80 | 86,00 | 22,80 |
| 73 | 81,70 | 18,40 | 89,40 | 23,00 | 72,30 | 29,20 | 89,80 | 23,20 |
| 74 | 84,00 | 19,20 | 91,40 | 24,00 | 74,10 | 30,60 | 93,70 | 23,60 |
| 75 | 86,20 | 20,00 | 93,40 | 25,00 | 75,80 | 32,00 | 97,50 | 24,00 |
| 76 | 89,00 | 21,00 | | | 78,00 | 33,00 | 101,00 | 25,40 |
| 77 | 91,80 | 22,00 | | | 80,20 | 34,00 | 104,50 | 26,80 |
| 78 | 94,60 | 23,00 | | | 82,50 | 35,00 | 107,90 | 28,20 |
| 79 | 97,40 | 24,00 | | | 84,70 | 36,00 | 111,40 | 29,60 |
| 80 | 100,20 | 25,00 | | | 86,90 | 37,00 | 114,90 | 31,00 |
| 81 | 103,00 | 26,00 | | | 89,10 | 38,00 | 118,40 | 32,40 |
| 82 | 105,80 | 27,00 | | | 91,30 | 39,00 | 121,90 | 33,80 |
| 83 | 108,60 | 28,00 | | | 93,60 | 40,00 | 125,30 | 35,20 |
| 84 | 111,40 | 29,00 | | | 95,80 | 41,00 | 128,80 | 36,60 |
| 85 | 114,20 | 30,00 | | | 98,00 | 42,00 | 132,30 | 38,00 |
| 86 | 116,70 | 31,00 | | | 100,20 | 43,00 | | |
| 87 | 119,10 | 32,00 | | | 102,40 | 44,00 | | |
| 88 | 121,60 | 33,00 | | | 104,60 | 45,00 | | |
| 89 | 124,00 | 34,00 | | | 106,80 | 46,00 | | |

## APPENDIX K.2

## KILOJOULE YIELDS AND SHELL WEIGHTS - CHOROMYTILUS MERIDIONALIS

| Length (mm) | g | kJ | Length (mm) | g | kJ | Length (mm) | g | kJ |
|---|---|---|---|---|---|---|---|---|
| 20 | 0,50 | 0,68 | 60 | 6,50 | 12,36 | 100 | 32,75 | 47,75 |
| 21 | 0,55 | 0,77 | 61 | 6,80 | 12,91 | 101 | 33,90 | 49,02 |
| 22 | 0,60 | 0,87 | 62 | 7,10 | 13,48 | 102 | 35,05 | 50,32 |
| 23 | 0,65 | 0,98 | 63 | 7,40 | 14,06 | 103 | 36,20 | 51,63 |
| 24 | 0,70 | 1,09 | 64 | 7,70 | 14,66 | 104 | 37,35 | 52,97 |
| 25 | 0,75 | 1,22 | 65 | 8,00 | 15,27 | 105 | 38,50 | 54,33 |
| 26 | 0,80 | 1,35 | 66 | 8,45 | 15,90 | 106 | 38,90 | 55,71 |
| 27 | 0,85 | 1,49 | 67 | 8,90 | 16,55 | 107 | 39,30 | 57,11 |
| 28 | 0,90 | 1,64 | 68 | 9,35 | 17,21 | 108 | 39,70 | 58,53 |
| 29 | 0,95 | 1,80 | 69 | 9,80 | 17,89 | 109 | 40,10 | 59,98 |
| 30 | 1,00 | 1,97 | 70 | 10,25 | 18,58 | 110 | 40,50 | 61,44 |
| 31 | 1,05 | 2,15 | 71 | 10,70 | 19,29 | 111 | 40,90 | 62,93 |
| 32 | 1,10 | 2,34 | 72 | 11,50 | 20,02 | 112 | 41,30 | 64,44 |
| 33 | 1,15 | 2,54 | 73 | 11,60 | 20,76 | 113 | 41,70 | 65,98 |
| 34 | 1,20 | 2,75 | 74 | 12,05 | 21,52 | 114 | 42,10 | 67,53 |
| 35 | 1,25 | 2,97 | 75 | 12,50 | 22,30 | 115 | 42,50 | 69,11 |
| 36 | 1,37 | 3,20 | 76 | 13,25 | 23,10 | 116 | 43,80 | 70,71 |
| 37 | 1,50 | 3,44 | 77 | 14,00 | 23,91 | 117 | 45,60 | 72,34 |
| 38 | 1,62 | 3,69 | 78 | 14,75 | 24,74 | 118 | 46,40 | 73,99 |
| 39 | 1,75 | 3,95 | 79 | 15,50 | 25,59 | 119 | 47,70 | 75,66 |
| 40 | 1,87 | 4,23 | 80 | 16,25 | 26,46 | 120 | 49,00 | 77,35 |
| 41 | 2,00 | 4,51 | 81 | 17,00 | 27,34 | 121 | 50,30 | 79,07 |
| 42 | 2,12 | 4,81 | 82 | 17,75 | 28,24 | 122 | 51,60 | 80,81 |
| 43 | 2,25 | 5,12 | 83 | 18,50 | 29,16 | 123 | 52,90 | 82,57 |
| 44 | 3,37 | 5,44 | 84 | 19,25 | 30,10 | 124 | 54,20 | 84,36 |
| 45 | 2,50 | 5,77 | 85 | 20,00 | 31,06 | 125 | 55,50 | 86,17 |
| 46 | 2,75 | 6,12 | 86 | 20,70 | 32,04 | 126 | 56,80 | 88,01 |
| 47 | 3,00 | 6,48 | 87 | 21,40 | 33,03 | 127 | 58,10 | 89,87 |
| 48 | 3,25 | 6,85 | 88 | 22,10 | 34,04 | 128 | 59,40 | 91,75 |
| 49 | 3,50 | 7,23 | 89 | 22,80 | 35,08 | 129 | 60,70 | 93,66 |
| 50 | 3,75 | 7,63 | 90 | 23,50 | 36,13 | 130 | 62,00 | 95,60 |
| 51 | 4,00 | 8,04 | 91 | 24,10 | 37,20 | 131 | 63,30 | 97,55 |
| 52 | 4,25 | 8,46 | 92 | 24,90 | 38,29 | 132 | 64,60 | 99,54 |
| 53 | 4,50 | 8,90 | 93 | 25,60 | 39,40 | 133 | 65,00 | 101,54 |
| 54 | 4,75 | 9,35 | 94 | 26,30 | 40,54 | 134 | 67,20 | 103,58 |
| 55 | 5,00 | 9,82 | 95 | 27,00 | 41,69 | 135 | 68,50 | 105,64 |
| 56 | 5,30 | 10,30 | 96 | 28,15 | 42,86 | 136 | 70,00 | 107,72 |
| 57 | 5,60 | 10,79 | 97 | 29,30 | 44,05 | 137 | 72,00 | 109,83 |
| 58 | 5,90 | 11,30 | 98 | 30,40 | 54,26 | 138 | 74,00 | 111,96 |
| 59 | 6,20 | 11,82 | 99 | 31,60 | 46,49 | 139 | 76,00 | 114,12 |

## APPENDIX L.1(a)

## SAMPLED SITES

## PATELLA - MEASURED SHELLS - NUMBERS & WEIGHTS

| Site Ref. | *P. granatina* N | *P. granatina* (g) | *P. granularis* N | *P. granularis* (g) | *P. argenvillei* N | *P. argenvillei* (g) | *P. barbara* N | *P. barbara* (g) | Total N | Total (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| VV1 | 2 | 8,3 | | | | | | | 2 | 8,3 |
| VV4 | 4 | 21,8 | 1 | 2,4 | | | | | 5 | 24,2 |
| TT1 | 1 | 3,2 | | | | | | | 1 | 3,2 |
| SC1 | 6 | 39,5 | | | | | | | 6 | 39,5 |
| DD2 | 1 | 4,5 | | | | | | | 1 | 4,5 |
| BK4 | | | 4 | 10,8 | | | | | 4 | 10,8 |
| DP1 | 10 | 65,0 | 7 | 31,5 | 3 | 37,3 | 1 | 17,5 | 21 | 151,3 |
| BR1 | 7 | 138,7 | 3 | 15,5 | | | 2 | 37,0 | 12 | 191,2 |
| BR4 | 9 | 56,2 | 1 | 3,4 | 1 | 16,4 | | | 11 | 76,0 |
| BR5 | 12 | 105,1 | 8 | 34,5 | 1 | 34,0 | 1 | 14,0 | 22 | 187,6 |
| BR6 | 15 | 113,4 | 11 | 36,1 | | | | | 26 | 149,5 |
| BR7 | 2 | 9,4 | 5 | 14,7 | 2 | 62,5 | 1 | 28,5 | 10 | 115,1 |
| BR8 | 9 | 54,9 | 2 | 8,3 | 1 | 18,2 | | | 12 | 81,4 |
| EV3 | 54 | 464,4 | 39 | 154,2 | | | 2 | 26,0 | 95 | 644,6 |
| EV4 | 15 | 187,5 | 8 | 29,0 | 2 | 58,5 | 1 | 14,4 | 26 | 289,4 |
| PR1 | 1 | 7,0 | | | | | | | 1 | 7,0 |
| JT1 | 7 | 45,6 | 9 | 37,8 | 1 | 18,5 | 2 | 31,0 | 19 | 132,9 |
| JT2 | 30 | 302,2 | 18 | 75,9 | 10 | 233,2 | 1 | 20,0 | 59 | 631,3 |
| JT3 | 2 | 8,2 | 3 | 14,8 | | | | | 5 | 23,0 |
| EC1 | 7 | 101,1 | 3 | 10,2 | 1 | 41,6 | 2 | 38,1 | 13 | 191,0 |
| EC5 | | | 2 | 6,8 | 1 | 36,5 | | | 3 | 43,3 |
| ES2 | 1 | 6,5 | | | | | 1 | 9,5 | 2 | 16,0 |
| ES3 | 1 | 2,7 | | | | | | | 1 | 2,7 |
| VN2 | 1 | 3,1 | | | | | | | 1 | 3,1 |
| | 197 | 1748,3 | 124 | 485,9 | 23 | 556,7 | 14 | 236,0 | 358 | 3026,9 |

# APPENDIX L.1(b)

## SAMPLED SITES

## PATELLA - IDENTIFIED APICES - NUMBERS & WEIGHTS

| Site Ref. | *P. granatina* N | *P. granatina* (g) | *P. granularis* N | *P. granularis* (g) | *P. argenvillei* N | *P. argenvillei* (g) | *P. barbara* N | *P. barbara* (g) | Total N | Total (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| VV1 | 10 | 18,4 | 8 | 9,2 | | | | | 18 | 27,6 |
| VV4 | 9 | 12,0 | 2 | 2,6 | 1 | 35,0 | | | 12 | 49,6 |
| TT1 | 5 | 4,8 | 9 | 5,5 | | | | | 14 | 10,3 |
| TT2 | 7 | 24,0 | 1 | 1,0 | 2 | 16,0 | | | 10 | 41,0 |
| SC1 | 5 | 33,2 | 5 | 12,2 | | | | | 10 | 45,4 |
| DD2 | 5 | 3,5 | 2 | 4,4 | | | 1 | 2,0 | 8 | 9,9 |
| BK4 | 10 | 31,0 | 9 | 22,4 | | | | | 19 | 53,4 |
| DP1 | 33 | 80,7 | 27 | 47,2 | 3 | 22,8 | | | 63 | 150,7 |
| BR1 | 15 | 91,0 | 4 | 15,0 | | | 3 | 3,0 | 22 | 109,0 |
| BR2 | 2 | 8,0 | 1 | 4,0 | | | | | 3 | 12,0 |
| BR4 | 30 | 131,8 | 19 | 56,0 | 1 | 16,0 | | | 50 | 203,8 |
| BR5 | 97 | 320,5 | 41 | 117,0 | | | 1 | 18,0 | 139 | 455,5 |
| BR6 | 115 | 348,0 | 31 | 67,8 | | | | | 146 | 415,8 |
| BR7 | 22 | 120,5 | 8 | 11,1 | 2 | 13,0 | 2 | 4,0 | 34 | 148,6 |
| BR8 | 38 | 131,8 | 14 | 24,5 | 3 | 47,0 | 1 | 11,4 | 56 | 214,7 |
| EV3 | 482 | 1926,0 | 186 | 525,0 | 4 | 59,0 | 5 | 120,0 | 677 | 2630,0 |
| EV4 | 83 | 421,0 | 33 | 62,0 | 1 | 21,0 | 1 | 4,4 | 118 | 508,4 |
| PR1 | 7 | 13,8 | 5 | 9,5 | | | | | 12 | 23,3 |
| JT1 | 49 | 174,5 | 32 | 72,0 | 2 | 50,0 | 1 | 9,0 | 84 | 305,5 |
| JT2 | 100 | 390,6 | 34 | 87,6 | 9 | 250,3 | 3 | 57,5 | 146 | 786,0 |
| JT3 | 8 | 23,5 | 19 | 41,2 | | | 1 | 15,0 | 28 | 79,7 |
| JT6 | 1 | 12,5 | 1 | 3,3 | | | | | 2 | 15,8 |
| EC1 | 34 | 194,7 | 15 | 27,8 | 14 | 269,5 | 2 | 35,6 | 65 | 527,6 |
| EC5 | 11 | 69,0 | 2 | 4,0 | 1 | 35,5 | | | 14 | 108,5 |
| ES3 | | | 2 | 2,3 | | | | | 2 | 2,3 |
| VN2 | 1 | 2,2 | | | 2 | 13,6 | 1 | 11,0 | 4 | 26,8 |
| | 1179 | 4587,0 | 510 | 1234,6 | 45 | 848,7 | 22 | 290,9 | 1756 | 6961,2 |

## APPENDIX L.1(c)

## SAMPLED SITES

## PATELLA - IDENTIFIED FRAGMENTS - WEIGHT

| Site Ref. | *P. granatina* (g) | *P. granularis* (g) | *P. argenvillei* (g) | *P. barbara* (g) | Total (g) |
|---|---|---|---|---|---|
| VV1 | 28,2 | 11,5 | 9,5 | 1,0 | 50,2 |
| VV4 | 33,3 | 2,0 | 11,2 | 1,0 | 47,5 |
| TT1 | 47,5 | 6,2 | 1,0 | 1,5 | 56,2 |
| TT2 | 15,5 | 4,2 | 10,8 | - | 30,5 |
| SC1 | 62,7 | 7,9 | 2,5 | 2,0 | 75,1 |
| DD1 | 12,4 | 6,5 | 5,8 | 7,0 | 31,7 |
| DD2 | - | 1,5 | - | 4,0 | 5,5 |
| BK4 | 82,0 | 16,8 | - | - | 98,8 |
| DP1 | 110,8 | 26,8 | - | 3,0 | 140,6 |
| BR1 | 120,0 | 15,5 | - | 25,0 | 160,5 |
| BR2 | 16,0 | 4,0 | 5,0 | 4,0 | 29,0 |
| BR4 | 65,0 | 13,0 | 2,0 | - | 80,0 |
| BR5 | 301,0 | 90,0 | - | - | 391,0 |
| BR6 | 214,0 | 51,0 | 5,0 | 4,0 | 274,0 |
| BR7 | 247,0 | 64,0 | 18,0 | - | 429,0 |
| BR8 | 110,0 | 14,0 | 8,0 | 3,0 | 135,0 |
| EV3 | 639,0 | 178,0 | 11,0 | 20,0 | 848,0 |
| EV4 | 254,0 | 61,0 | 5,0 | 8,0 | 328,0 |
| PR1 | 59,0 | 17,0 | 1,0 | 3,0 | 80,0 |
| JT1 | 605,0 | 102,0 | 19,0 | - | 726,0 |
| JT2 | 420,7 | 55,5 | 30,1 | 55,0 | 561,3 |
| JT3 | 35,5 | 14,8 | 4,0 | - | 54,3 |
| JT6 | 65,0 | 6,7 | - | 30,5 | 102,2 |
| EC1 | 459,9 | 109,5 | 201,8 | 81,6 | 852,8 |
| EC5 | 22,0 | 13,5 | - | - | 35,5 |
| ES2 | - | - | - | 5,3 | 5,3 |
| ES3 | - | 0,2 | - | - | 0,2 |
| VN1 | 16,2 | 5,0 | - | - | 21,2 |
| VN2 | 16,5 | 6,5 | 9,0 | 15,2 | 47,2 |
| | 4158,2 | 904,6 | 359,7 | 274,1 | 5696,6 |

# APPENDIX L.1(d)

## SAMPLED SITES

## PATELLA - IDENTIFIED & UNIDENTIFIED SPECIES - NUMBERS & WEIGHTS

| Site Ref. | Identified | | | | | | | Unidentified | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | | Apices | | Frags | Total | | Apices | | Frags | Total | All Species | |
| | N | (g) | N | (g) | (g) | N | (g) | N | (g) | (g) | (g) | N | (g) |
| VV1 | 2 | 8,3 | 18 | 27,6 | 50,2 | 20 | 86,1 | | | 11,8 | 11,8 | 20 | 97,9 |
| VV4 | 5 | 24,2 | 12 | 49,6 | 47,5 | 17 | 121,3 | | | | | 17 | 121,3 |
| TT1 | 1 | 3,2 | 14 | 10,3 | 56,2 | 15 | 69,7 | | | 25,0 | 25,0 | 15 | 94,7 |
| TT2 | | | 10 | 41,0 | 30,5 | 10 | 71,5 | 36 | 14,5 | 130,8 | 145,3 | 46 | 216,8 |
| SC1 | 6 | 39,5 | 10 | 45,4 | 75,1 | 16 | 160,0 | 10 | 18,0 | 11,9 | 29,9 | 26 | 189,9 |
| SC2 | | | | | | | | | | 14,0 | 14,0 | | 14,0 |
| DD1 | | | | | 31,7 | | 31,7 | 11 | 9,4 | 45,0 | 54,4 | 11 | 86,1 |
| DD2 | 1 | 4,5 | 8 | 9,9 | 5,5 | 9 | 19,9 | 22 | 23,1 | 179,5 | 202,6 | 31 | 222,5 |
| DD3 | | | | | | | | | | 8,5 | | | 8,5 |
| BK4 | 4 | 10,8 | 19 | 53,4 | 98,8 | 23 | 163,0 | 44 | 21,0 | 91,2 | 112,2 | 67 | 275,2 |
| BK7 | | | | | | | | 6 | 7,0 | 7,5 | 14,5 | 6 | 14,5 |
| DP1 | 21 | 151,3 | 63 | 150,7 | 140,6 | 84 | 442,6 | 52 | 52,0 | 155,9 | 207,9 | 136 | 650,5 |
| BR1 | 12 | 191,2 | 22 | 109,0 | 160,5 | 34 | 460,7 | 38 | 60,0 | 71,0 | 131,0 | 72 | 591,7 |
| BR2 | | | 3 | 12,0 | 29,0 | 3 | 41,0 | 9 | 9,0 | 11,0 | 20,0 | 12 | 61,0 |
| BR4 | 11 | 76,0 | 50 | 203,3 | 80,0 | 61 | 359,8 | 19 | 13,0 | 56,0 | 69,0 | 80 | 428,8 |
| BR5 | 22 | 187,6 | 139 | 455,5 | 391,0 | 161 | 1034,1 | 121 | 100,5 | 464,0 | 564,5 | 282 | 1598,6 |
| BR6 | 26 | 149,5 | 146 | 415,8 | 274,0 | 172 | 839,3 | [illegible] | [illegible] | 154,0 | 182,5 | 204 | 1021,8 |
| BR7 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 44 | 692,7 | 142 | 153,8 | 343,0 | 496,8 | 186 | 1189,5 |
| BR8 | 12 | 81,4 | 56 | 214,7 | 135,0 | 68 | 431,1 | 38 | 68,5 | 122,0 | 190,5 | 106 | 621,6 |
| EV3 | 95 | 644,6 | 677 | 2630,0 | 848,0 | 772 | 4122,6 | 165 | 223,0 | 628,0 | 851,0 | 937 | 4973,6 |
| EV4 | 26 | 289,4 | 118 | 508,4 | 328,0 | 144 | 1125,8 | 121 | 157,5 | 300,0 | 457,5 | 265 | 1583,3 |
| PR1 | 1 | 7,0 | 12 | 23,3 | 80,0 | 13 | 110,3 | 14 | 19,5 | 120,0 | 139,5 | 27 | 249,8 |
| JT1 | 19 | 132,9 | 84 | 305,5 | 726,0 | 103 | 1164,4 | 141 | 158,4 | 997,0 | 1155,4 | 244 | 2319,8 |
| JT2 | 59 | 631,3 | 146 | 786,0 | 561,3 | 205 | 1978,6 | 93 | 143,4 | 295,5 | 438,9 | 298 | 2417,5 |
| JT3 | 5 | 23,0 | 28 | 79,7 | 54,3 | 33 | 157,0 | 25 | 15,0 | 77,0 | 92,0 | 58 | 249,0 |
| JT6 | | | 2 | 15,8 | 102,2 | 2 | 118,0 | 30 | 39,2 | 238,0 | 277,2 | 32 | 395,2 |
| EC1 | 13 | 191,0 | 65 | 527,6 | 852,8 | 78 | 1571,4 | 102 | 128,6 | 676,8 | 805,4 | 180 | 2376,8 |
| EC5 | 3 | [illegible] | 14 | [illegible] | [illegible] | 17 | 187,3 | 10 | 10,2 | 38,5 | 48,7 | 27 | 236,0 |
| ES2 | 2 | [illegible] | | | 5,3 | 2 | 21,3 | | | | | 2 | 21,3 |
| ES3 | 1 | [illegible] | [illegible] | [illegible] | [illegible] | 3 | 5,2 | | | | | 3 | 5,2 |
| YN1 | | | | | [illegible] | | [illegible] | 16 | 3,1 | 18,0 | 21,1 | 16 | 42,3 |
| YN2 | 1 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 77,1 | 3 | 3,7 | 17,5 | 21,2 | 8 | 98,3 |
| | 358 | 3026,9 | 1756 | 6961,2 | 5696,6 | 2114 | 15684,7 | 1300 | 1479,9 | 5308,4 | 6788,3 | 3414 | 22473,0 |

## APPENDIX L.1(e)

## SAMPLED SITES

## PATELLA - SUMMARY BY SPECIES

| | Measured | | Apices | | Frags | Total | | Mean Weight | % of | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | (g) | N | (g) | (g) | N | (g) | (g) | Nos | Weight |
| *P. granatina* | 197 | 1748,3 | 1179 | 4587,0 | 4158,2 | 1376 | 10493 | 7,6 | 65,1 | 66,9 |
| *P. granularis* | 124 | 485,9 | 510 | 1234,6 | 904,6 | 634 | 2651 | 4,1 | 30,0 | 16,7 |
| *P. argenvillei* | 23 | 556,7 | 45 | 848,7 | 359,7 | 68 | 1765 | 26,0 | 3,2 | 11,3 |
| *P. barbara* | 14 | 236,0 | 22 | 290,9 | 274,1 | 36 | 801 | 22,3 | 1,7 | 5,1 |
| | 358 | 3026,9 | 1756 | 6961,2 | 5696,6 | 2114 | 15685 | 7,4 | 100,0 | 100,0 |
| Unidentified (Apices & Frags) | — | — | 1300 | 1479,9 | 5308,4 | 1300 | 6788 | — | — | — |
| | 358 | 3026,9 | 3056 | 8441,1 | 11005,0 | 3414 | 22473 | 6,6 | 100,0 | 100,0 |

# APPENDIX L.1(f)

## SAMPLED SITES

## PATELLA - KILOJOULES FROM MEASURED SHELLS

| Site Ref. | *P. granatina* N | *P. granatina* kJ | *P. granularis* N | *P. granularis* kJ | *P. argenvillei* N | *P. argenvillei* kJ | *P. barbara* N | *P. barbara* kJ | Total N | Total kJ |
|---|---|---|---|---|---|---|---|---|---|---|
| VV1 | 2 | 24 | | | | | | | 2 | 24 |
| VV4 | 4 | 62 | 1 | 7 | | | | | 5 | 69 |
| TT1 | 1 | 9 | | | | | | | 1 | 9 |
| SC1 | 6 | 152 | | | | | | | 6 | 152 |
| DD1 | 1 | 11 | | | | | | | 1 | 11 |
| BK4 | | | 4 | 45 | | | | | 4 | 45 |
| DP1 | 10 | 204 | 7 | 149 | 3 | 133 | 1 | 78 | 21 | 564 |
| BR1 | 7 | 500 | 3 | 48 | | | 2 | 118 | 12 | 666 |
| BR4 | 9 | 197 | 1 | 10 | 1 | 56 | | | 11 | 263 |
| BR5 | 12 | 419 | 8 | 113 | 1 | 98 | 1 | 43 | 22 | 673 |
| BR6 | 15 | 352 | 11 | 101 | | | | | 26 | 453 |
| BR7 | 2 | 23 | 5 | 40 | 2 | 140 | 1 | 111 | 10 | 314 |
| BR8 | 9 | 189 | 2 | 30 | 1 | 74 | | | 12 | 293 |
| EV3 | 54 | 1981 | 39 | 529 | | | 2 | 82 | 95 | 2592 |
| EV4 | 15 | 698 | 8 | 96 | 2 | 145 | 1 | 43 | 26 | 982 |
| PR1 | 1 | 34 | | | | | | | 1 | 34 |
| JT1 | 7 | 162 | 9 | 126 | 1 | 56 | 2 | 68 | 19 | 412 |
| JT2 | 30 | 1192 | 18 | 247 | 10 | 628 | 1 | 78 | 59 | 2145 |
| JT3 | 2 | 14 | 3 | 25 | | | | | 5 | 39 |
| EC1 | 7 | 309 | 3 | 21 | 1 | 82 | 2 | 124 | 13 | 536 |
| EC5 | | | 2 | 27 | 1 | 70 | | | 3 | 97 |
| ES2 | 1 | 14 | | | | | 1 | 67 | 2 | 81 |
| ES3 | 1 | 8 | | | | | | | 1 | 8 |
| VN2 | 1 | 5 | | | | | | | 1 | 5 |
| | 197 | 6559 | 124 | 1614 | 23 | 1482 | 14 | 812 | 358 | 10467 |

## APPENDIX L.1(g)

## SAMPLED SITES

## PATELLA - KILOJOULES FROM IDENTIFIED APICES

| Site | *P. granatina* | | *P. granularis* | | *P. argenvillei* | | *P. barbara* | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ref. | N | kJ | N | kJ | N | kJ | N | kJ | N | kJ |
| VV1 | 10 | 280 | 8 | 80 | | | | | 18 | 360 |
| VV4 | 9 | 252 | 2 | 20 | 1 | 67 | | | 12 | 339 |
| TT1 | 5 | 140 | 9 | 90 | | | | | 14 | 230 |
| TT2 | 7 | 196 | 1 | 10 | 2 | 134 | | | 10 | 340 |
| SC1 | 5 | 140 | 5 | 50 | | | | | 10 | 190 |
| DD1 | 5 | 140 | 2 | 20 | | | 1 | 60 | 8 | 220 |
| BK4 | 10 | 280 | 9 | 90 | | | | | 19 | 370 |
| DP1 | 33 | 924 | 27 | 270 | 3 | 201 | | | 63 | 1395 |
| BR1 | 15 | 420 | 4 | 40 | | | 3 | 180 | 22 | 640 |
| BR2 | 2 | 56 | 1 | 10 | | | | | 3 | 66 |
| BR4 | 30 | 840 | 19 | 190 | 1 | 67 | | | 50 | 1097 |
| BR5 | 97 | 2716 | 41 | 410 | | | 1 | 60 | 139 | 3186 |
| BR6 | 115 | 3220 | 31 | 310 | | | | | 146 | 3530 |
| BR7 | 22 | 616 | 8 | 80 | 2 | 134 | 2 | 120 | 34 | 950 |
| BR8 | 38 | 1064 | 14 | 140 | 3 | 201 | 1 | 60 | 56 | 1465 |
| EV3 | 482 | 13496 | 186 | 1860 | 4 | 268 | 5 | 300 | 677 | 15924 |
| EV4 | 83 | 2324 | 33 | 330 | 1 | 67 | 1 | 60 | 118 | 2781 |
| PR1 | 7 | 196 | 5 | 50 | | | | | 12 | 246 |
| JT1 | 49 | 1372 | 32 | 320 | 2 | 134 | 1 | 60 | 84 | 1886 |
| JT2 | 100 | 2800 | 34 | 340 | 9 | 603 | 3 | 180 | 146 | 3923 |
| JT3 | 8 | 224 | 19 | 190 | | | 1 | 60 | 28 | 474 |
| JT6 | 1 | 28 | 1 | 10 | | | | | 2 | 38 |
| EC1 | 34 | 952 | 15 | 150 | 14 | 938 | 2 | 120 | 65 | 2160 |
| EC5 | 11 | 308 | 2 | 20 | 1 | 67 | | | 14 | 395 |
| ES3 | | | 2 | 20 | | | | | 2 | 20 |
| VN2 | 1 | 28 | | | 2 | 134 | 1 | 60 | 4 | 222 |
| | 1179 | 33012 | 510 | 5100 | 45 | 3015 | 22 | 1320 | 1756 | 42447 |

## APPENDIX L.1(h)

## SAMPLED SITES

## PATELLA - KILOJOULES FROM UNIDENTIFIED APICES (AFTER PERCENTAGE ALLOCATION TO SPECIES)

| Site Ref. | *P. granatina* N | *P. granatina* kJ | *P. granularis* N | *P. granularis* kJ | *P. argenvillei* N | *P. argenvillei* kJ | *P. barbara* N | *P. barbara* kJ | Total N | Total kJ |
|---|---|---|---|---|---|---|---|---|---|---|
| TT2 | 24 | 672 | 11 | 110 | | | 1 | 60 | 36 | 842 |
| SC1 | 7 | 196 | 3 | 30 | | | | | 10 | 226 |
| DD1 | 7 | 196 | 3 | 30 | 1 | 67 | | | 11 | 293 |
| DD2 | 14 | 392 | 6 | 60 | 1 | 67 | 1 | 60 | 22 | 579 |
| BK4 | 29 | 812 | 13 | 130 | 1 | 67 | 1 | 60 | 44 | 1069 |
| BK7 | 4 | 112 | 2 | 20 | | | | | 6 | 132 |
| DP1 | 34 | 952 | 16 | 160 | 1 | 67 | 1 | 60 | 52 | 1239 |
| BR1 | 25 | 700 | 11 | 110 | 1 | 67 | 1 | 60 | 38 | 937 |
| BR2 | 6 | 168 | 3 | 30 | | | | | 9 | 198 |
| BR4 | 12 | 336 | 6 | 60 | 1 | 67 | | | 19 | 463 |
| BR5 | 79 | 2212 | 36 | 360 | 4 | 268 | 2 | 120 | 121 | 2960 |
| BR6 | 21 | 588 | 9 | 90 | 1 | 67 | 1 | 60 | 32 | 805 |
| BR7 | 92 | 2576 | 43 | 430 | 5 | 335 | 2 | 120 | 142 | 3461 |
| BR8 | 25 | 700 | 11 | 110 | 1 | 67 | 1 | 60 | 38 | 937 |
| EV3 | 107 | 2996 | 50 | 500 | 6 | 402 | 2 | 120 | 165 | 4018 |
| EV4 | 79 | 2212 | 36 | 360 | 4 | 268 | 2 | 120 | 121 | 2960 |
| PR1 | 9 | 252 | 4 | 40 | 1 | 67 | | | 14 | 359 |
| JT1 | 91 | 2548 | 42 | 420 | 6 | 402 | 2 | 120 | 141 | 3490 |
| JT2 | 61 | 1708 | 28 | 280 | 2 | 134 | 2 | 120 | 93 | 2242 |
| JT3 | 16 | 448 | 8 | 80 | 1 | 67 | | | 25 | 595 |
| JT6 | 20 | 560 | 9 | 90 | 1 | 67 | | | 30 | 717 |
| EC1 | 66 | 1848 | 31 | 310 | 4 | 268 | 1 | 60 | 102 | 2486 |
| EC5 | 6 | 168 | 3 | 30 | | | 1 | 60 | 10 | 258 |
| VN1 | 10 | 280 | 5 | 50 | | | 1 | 60 | 16 | 390 |
| VN2 | 2 | 56 | 1 | 10 | | | | | 3 | 66 |
| | 846 | 23688 | 390 | 3900 | 42 | 2814 | 22 | 1320 | 1300 | 31722 |

## APPENDIX L.1(i)

## SAMPLED SITES

## PATELLA - TOTAL KILOJOULES

| Site Ref. | Measured Shells | | Identified Apices | | Unidentified Apices | | Total | |
|---|---|---|---|---|---|---|---|---|
| | N | kJ | N | kJ | N | kJ | N | kJ |
| VV1 | 2 | 24 | 18 | 360 | | | 20 | 384 |
| VV4 | 5 | 69 | 12 | 339 | | | 17 | 408 |
| TT1 | 1 | 9 | 14 | 230 | | | 15 | 239 |
| TT2 | | | 10 | 340 | 36 | 842 | 46 | 1182 |
| SC1 | 6 | 152 | 10 | 190 | 10 | 226 | 26 | 568 |
| DD1 | 1 | 11 | | | 11 | 293 | 12 | 304 |
| DD2 | | | 8 | 220 | 22 | 579 | 30 | 799 |
| BK4 | 4 | 45 | 19 | 370 | 44 | 1069 | 67 | 1484 |
| BK7 | | | | | 6 | 132 | 6 | 132 |
| DP1 | 21 | 564 | 63 | 1395 | 52 | 1239 | 136 | 3198 |
| BR1 | 12 | 666 | 22 | 640 | 38 | 937 | 72 | 2243 |
| BR2 | | | 3 | 66 | 9 | 198 | 12 | 264 |
| BR4 | 11 | 263 | 50 | 1097 | 19 | 463 | 80 | 1823 |
| BR5 | 22 | 673 | 139 | 3186 | 121 | 2960 | 282 | 6819 |
| BR6 | 26 | 453 | 146 | 3530 | 32 | 805 | 204 | 4788 |
| BR7 | 10 | 314 | 34 | 950 | 142 | 3461 | 186 | 4725 |
| BR8 | 12 | 293 | 56 | 1465 | 38 | 937 | 106 | 2695 |
| EV3 | 95 | 2592 | 677 | 15924 | 165 | 4018 | 937 | 22534 |
| EV4 | 26 | 982 | 118 | 2781 | 121 | 2960 | 265 | 6723 |
| PR1 | 1 | 34 | 12 | 246 | 14 | 359 | 27 | 639 |
| JT1 | 19 | 412 | 84 | 1886 | 141 | 3490 | 244 | 5788 |
| JT2 | 59 | 2145 | 146 | 3923 | 93 | 2242 | 298 | 8310 |
| JT3 | 5 | 39 | 28 | 474 | 25 | 595 | 58 | 1108 |
| JT6 | | | 2 | 38 | 30 | 717 | 32 | 755 |
| EC1 | 13 | 536 | 65 | 2160 | 102 | 2486 | 180 | 5182 |
| EC5 | 3 | 97 | 14 | 395 | 10 | 258 | 27 | 750 |
| ES2 | 2 | 81 | | | | | 2 | 81 |
| ES3 | 1 | 8 | 2 | 20 | | | 3 | 28 |
| VN1 | | | | | 16 | 390 | 16 | 390 |
| VN2 | 1 | 5 | 4 | 222 | 3 | 66 | 8 | 293 |
| | 358 | 10467 | 1756 | 42447 | 1300 | 31722 | 3414 | 84636 |

# APPENDIX L.1(j)

## SAMPLED SITES

## PATELLA - TOTAL KILOJOULES BY SPECIES

| Species | Measured Shells | | Identified Apices | | Unidentified Apices | |
|---|---|---|---|---|---|---|
| | N | kJ | N | kJ | N | kJ |
| *P. granatina* | 197 | 6559 | 1179 | 33012 | 846 | 23688 |
| *P. granularis* | 124 | 1614 | 510 | 5100 | 390 | 3900 |
| *P. argenvillei* | 23 | 1482 | 45 | 3015 | 42 | 2814 |
| *P. barbara* | 14 | 812 | 22 | 1320 | 22 | 1320 |
| | 358 | 10467 | 1756 | 42447 | 1300 | 31722 |

| Species | Totals | | Percentages | | Mean |
|---|---|---|---|---|---|
| | N | kJ | N | kJ | kJ |
| *P. granatina* | 2222 | 63259 | 65,1 | 74,7 | 28,5 |
| *P. granularis* | 1024 | 10614 | 30,0 | 12,6 | 10,4 |
| *P. argenvillei* | 110 | 7311 | 3,2 | 8,6 | 66,5 |
| *P. barbara* | 58 | 3452 | 1,7 | 4,1 | 59,5 |
| | 3414 | 84636 | 100,0 | 100,0 | 24,8 |

# APPENDIX M

## SAMPLED SITES

## C. MERIDIONALIS - KILOJOULES

kJ Calculated on : (a) 28 kJ/ shell;
(b) 100 g shell weight = 150 kJ

| Site Ref. | M.N.I. | Weight (g) | Estimated Kilojoules on M.N.I. (a) | Estimated Kilojoules on Weight (b) | Difference % |
|---|---|---|---|---|---|
| VV1 | 36 | 2912 | 1008 | 4368 | +76,9 |
| VV4 | 95 | 4012 | 2660 | 6018 | +55,8 |
| TT1 | 88 | 2307 | 2464 | 3460 | +28,7 |
| TT2 | 210 | 2286 | 5880 | 3429 | -41,7 |
| SC1 | 169 | 2040 | 4732 | 3060 | -35,3 |
| SC2 | 20 | 265 | 560 | 398 | -24,9 |
| DD1 | 149 | 3423 | 4172 | 5134 | +18,7 |
| DD2 | 101 | 3714 | 2828 | 5571 | +49,2 |
| DD3 | 70 | 803 | 1960 | 1204 | -38,6 |
| BK4 | 133 | 1427 | 3724 | 2140 | +42,5 |
| BK7 | 13 | 98 | 364 | 147 | -59,6 |
| DP1 | 311 | 4584 | 8708 | 6876 | -21,0 |
| BR1 | 142 | 3126 | 3976 | 4689 | +15,2 |
| BR2 | 43 | 916 | 1204 | 1374 | +12,3 |
| BR4 | 19 | 197 | 532 | 296 | -44,4 |
| BR5 | 11 | 322 | 308 | 483 | +36,2 |
| BR6 | 83 | 2050 | 2324 | 3075 | +24,4 |
| BR7 | 40 | 336 | 1120 | 504 | -55,0 |
| BR8 | 153 | 2389 | 4284 | 3583 | -16,4 |
| EV3 | 60 | 1219 | 1680 | 1828 | + 8,1 |
| EV4 | 11 | 148 | 308 | 222 | -27,9 |
| PR1 | 108 | 2952 | 3024 | 4428 | +31,7 |
| JT1 | 41 | 713 | 1148 | 1069 | - 6,9 |
| JT2 | 121 | 1910 | 3388 | 2865 | -15,4 |
| JT3 | 9 | 192 | 252 | 288 | +12,5 |
| JT6 | 8 | 201 | 224 | 302 | +25,8 |
| EC1 | 131 | 3788 | 3668 | 5682 | +35,4 |
| EC5 | 71 | 1849 | 1988 | 2773 | +28,3 |
| ES2 | 141 | 3087 | 3948 | 4630 | +14,7 |
| ES3 | 132 | 2762 | 3696 | 4143 | +10,8 |
| VN1 | 54 | 256 | 1512 | 384 | -74,6 |
| VN2 | 41 | 893 | 1148 | 1339 | +14,3 |
| | 2814 | 57177 | 78792 | 85762 | + 8,1 |

Samples from Sites VV1 and VV4 were found to be incomplete and were therefore excluded. The revised totals are : M.N.I. : 2683; Weight (g) : 50253; Estimated on M.N.I. : 75124; Kilojoules on Weight : 75376; Difference : +0,3%

Appendix M (continued)

For individual sites the kilojoule estimates by the two methods vary appreciably, but tend to merge as sample size increases :

| | Sites with 100 or More M.N.I. | Sites with Less Than 100 M.N.I. | Totals |
|---|---|---|---|
| N | 13 | 17 | 30 |
| M.N.I. | 2001 | 682 | 2683 |
| Weight (g) | 37448 | 12765 | 50253 |
| Estimated kJ on M.N.I. (a) | 56027 | 19097 | 75124 |
| Estimated kJ on Weight (b) | 56230 | 19146 | 75376 |

# APPENDIX N

## SAMPLED SITES

## AULACOMYA ATER - KILOJOULES

| Site Ref. | M.N.I. | Weight (g) | Kilojoules |
|---|---|---|---|
| VV1 | 1 | 2 | 10 |
| VV4 | 4 | 11 | 40 |
| TT1 | 1 | 2 | 10 |
| TT2 | 26 | 163 | 417 |
| SC1 | 2 | 17 | 20 |
| BK4 | 5 | 21 | 50 |
| DP1 | 1 | 12 | 10 |
| BR1 | 2 | 23 | 20 |
| BR2 | 1 | 1 | 10 |
| BR4 | 1 | 3 | 10 |
| BR5 | 3 | 5 | 30 |
| BR8 | 27 | 93 | 270 |
| EV3 | 1 | 1 | 10 |
| EV4 | 1 | 7 | 10 |
| JT2 | 15 | 112 | 150 |
| EC1 | 1 | 5 | 10 |
| VN1 | 1 | 8 | 10 |
| | 93 | 486 | 1087 |

# APPENDIX O

## SAMPLED SITES

## BURNUPENA SPECIES/ARGOBUCCINUM ARGUS - KILOJOULES

| Site Ref. | N | Weight (g) | kJ |
|---|---|---|---|
| VV1 | 29 | 114 | 217,5 |
| VV4 | 15 | 110 | 112,5 |
| TT1 | 2 | 19 | 15,0 |
| TT2 | 60 | 258 | 450,0 |
| SC1 | 24 | 131 | 180,0 |
| SC2 | 3 | 8 | 22,5 |
| DD1 | 15 | 141 | 112,5 |
| DD2 | 18 | 118 | 135,0 |
| DD3 | 1 | 8 | 7,5 |
| BK4 | 11 | 87 | 82,5 |
| BK7 | 1 | 2 | 7,5 |
| DP1 | 66 | 319 | 495,0 |
| BR1 | 28 | 237 | 210,0 |
| BR2 | 10 | 68 | 75,0 |
| BR4 | 3 | 22 | 22,5 |
| BR5 | 23 | 127 | 172,5 |
| BR6 | 36 | 371 | 270,0 |
| BR7 | 5 | 47 | 37,5 |
| BR8 | 80 | 483 | 600,0 |
| EV3 | 10 | 72 | 75,0 |
| EV4 | 3 | 15 | 22,5 |
| PR1 | 16 | 74 | 120,0 |
| JT1 | 28 | 275 | 210,0 |
| JT2 | 63 | 347 | 472,5 |
| JT3 | 4 | 5 | 30,0 |
| JT6 | 1 | 8 | 7,5 |
| EC1 | 103 | 986 | 772,5 |
| EC5 | 65 | 536 | 487,5 |
| ES2 | 11 | 54 | 82,5 |
| VN1 | 5 | 28 | 37,5 |
| VN2 | 20 | 135 | 150,0 |
| | 759 | 5205 | 5692,5 |

## APPENDIX Q

## SAMPLED SITES

## ALL SHELLFISH SPECIES - TOTAL KILOJOULES (DEPOSITS)

| Site Ref. | Volume of Sample: Surface $m^3$ | Volume of Sample: Test Pit $m^3$ | Volume of Sample: Total $m^3$ | Total kJ From Sample kJ | Volume of Deposit $m^3$ | Total kJ (Thousands) | kJ $m^{-3}$ |
|---|---|---|---|---|---|---|---|
| VV1 | 0,020 | - | 0,0200 | 4979 | 141,0 | 35102 | 248 950 |
| VV4 | 0,010 | 0,0225 | 0,0325 | 6578 | 60,0 | 12144 | 202 400 |
| TT1 | 0,020 | - | 0,0200 | 3724 | 13,0 | 2421 | 186 200 |
| TT2 | - | 0,0125 | 0,0125 | 5478 | 381,0 | 166964 | 438 240 |
| SC1 | 0,020 | 0,0045 | 0,0245 | 3828 | 47,0 | 7345 | 156 244 |
| SC2 | - | 0,0120 | 0,0120 | 420 | 1,4 | 49 | 35 000 |
| DD1 | 0,020 | - | 0,0200 | 5550 | 45,0 | 12487 | 277 500 |
| DD2 | 0,020 | 0,0225 | 0,0425 | 6505 | 312,0 | 47754 | 153 059 |
| DD3 | 0,010 | - | 0,0100 | 1211 | 1,1 | 133 | 121 100 |
| BK4 | 0,010 | 0,0225 | 0,0325 | 3756 | 16,7 | 1930 | 115 569 |
| BK7 | 0,010 | - | 0,0100 | 286 | 5,0 | 143 | 28 600 |
| DP1 | 0,010 | 0,0125 | 0,0225 | 10579 | 169,0 | 79460 | 470 178 |
| BR1 | 0,009 | - | 0,0090 | 7162 | 95,0 | 75598 | 795 777 |
| BR2 | 0,010 | - | 0,0100 | 1723 | 9,0 | 1550 | 172 300 |
| BR4 | 0,010 | (Est.) | 0,0100 | 2151 | 2,5 | 538 | 215 100 |
| BR5 | 0,010 | - | 0,0100 | 7504 | 115,0 | 86296 | 750 400 |
| BR6 | - | 0,0175 | 0,0175 | 8133 | 51,0 | 23701 | 464 743 |
| BR7 | 0,010 | - | 0,0100 | 5266 | 14,0 | 7372 | 526 600 |
| BR8 | - | 0,0360 | 0,0360 | 7148 | 170,0 | 33754 | 198 555 |
| EV3 | 0,040 | - | 0,0400 | 24447 | 3,4 | 2077 | 611 175 |
| EV4 | 0,015 | - | 0,0150 | 6977 | 1,0 | 465 | 465 133 |
| PR1 | - | 0,0188 | 0,0188 | 5187 | 50,0 | 13795 | 275 904 |
| JT1 | 0,010 | - | 0,0100 | 7067 | 16,0 | 11307 | 706 700 |
| JT2 | - | 0,0400 | 0,0400 | 11797 | 274,0 | 80816 | 294 948 |
| JT3 | - | 0,0225 | 0,0225 | 1426 | 0,4 | 25 | 63 337 |
| JT6 | 0,010 | - | 0,0100 | 1064 | 3,0 | 319 | 106 400 |
| EC1 | 0,010 | 0,0096 | 0,0196 | 11646 | 7,5 | 4456 | 594 184 |
| EC5 | - | 0,0144 | 0,0144 | 4010 | 5,0 | 1392 | 278 472 |
| ES2 | - | 0,0135 | 0,0135 | 4793 | 0,2 | 71 | 355 037 |
| ES3 | - | 0,0125 | 0,0125 | 4171 | 3,9 | 1301 | 333 680 |
| VN1 | - | 0,0125 | 0,0125 | 821 | 15,0 | 985 | 65 680 |
| VN2 | 0,010 | - | 0,0100 | 1782 | 6,8 | 1212 | 178 200 |
| 32 | 0,304 | 0,3063 | 0,6003 | 177177 | 2035,0 | 693174 | 340 626 |

# APPENDIX R

## EXCAVATED SITES

## ALL SHELLFISH SPECIES - TOTAL KILOJOULES (SAMPLES & DEPOSITS)

(a) Site Reference EC4
Eland's Bay Cave (Parkington 1976a) (Layers 1 to 6)

| | N | % | Kilojoules | % |
|---|---|---|---|---|
| *P. granatina* | 2008 | 61,8 | 56224 | 68,0 |
| *P. granularis* | 988 | 30,4 | 9880 | 12,0 |
| *P. argenvillei* | 182 | 5,6 | 12194 | 14,8 |
| *P. barbara* | 72 | 2,2 | 4320 | 5,2 |
| Total *Patella* | 3250 | 100,0 | 82618 | 100,0 |
| *Patella* - All Species | 3250 | 37,6 | 82618 | 40,9 |
| *C. meridionalis* | 4233 | 48,9 | 111104 | 54,9 |
| *Burnupena* spp./*A. argus* | 810 | 9,4 | 6075 | 3,0 |
| Other spp. | 354 | 4,1 | 2435 | 1,2 |
| Total - All Species | 8647 | 100,0 | 202235 | 100,0 |

| | |
|---|---|
| Volume of Sample | 0,7875 $m^3$ |
| kJ $m^{-3}$ | 256 806 |
| Volume of Total Deposit | 40 $m^3$ |
| Total Kilojoules in Deposit | 10,3 million kJ |

(b) Site Reference EC2
Eland's Bay Open (Horwitz 1979)

| | N | % | Kilojoules | % |
|---|---|---|---|---|
| *P. granatina* | 856 | 60,4 | 23968 | 69,9 |
| *P. granularis* | 477 | 33,7 | 4770 | 13,7 |
| *P. argenvillei* | 76 | 5,4 | 5092 | 14,8 |
| *P. barbara* | 8 | 0,6 | 480 | 1,4 |
| Total - *Patella* | 1417 | 100,1 | 34310 | 100,0 |
| *Patella* - All Species | 1417 | 36,8 | 34310 | 44,3 |
| *C. meridionalis* | 1216 | 31,6 | 34048 | 43,9 |
| *Aulacomya ater* | 10 | 0,2 | 100 | 0,1 |
| *Burnupena* spp. | 1208 | 31,4 | 9060 | 11,7 |
| Total - All Species | 3851 | 100,0 | 77518 | 100,0 |

| | |
|---|---|
| Volume of Sample | 0,25 $m^3$ |
| kJ $m^{-3}$ | 310 072 |
| Volume of Total Deposit | 6,25 $m^3$ |
| Total Kilojoules in Deposit | 1,9 million kJ |

Appendix R (continued)

(c) Site Reference JT2
Hail Stone Midden (Horwitz 1979)

| | N | % | Kilojoules | % |
|---|---|---|---|---|
| *P. granatina* | 869 | 65,1 | 24332 | 76,7 |
| *P. granularis* | 415 | 31,1 | 4150 | 13,1 |
| *P. argenvillei* | 28 | 2,1 | 1876 | 5,9 |
| *P. barbara* | 23 | 1,7 | 1380 | 4,3 |
| Total *Patella* | 1335 | 100,0 | 31738 | 100,0 |
| *Patella* - All Species | 1335 | 80,1 | 31738 | 83,9 |
| *C. meridionalis* | 175 | 10,5 | 4900 | 13,0 |
| *Aulacomya ater* | 1 | - | 10 | - |
| *Burnupena* spp. | 156 | 9,4 | 1170 | 3,1 |
| Total - All Species | 1667 | 100,0 | 37818 | 100,0 |

| | |
|---|---|
| Volume of Sample | 0,1282 $m^3$ |
| kJ $m^{-3}$ | 294 948 |
| Volume of Total Deposit | 274 $m^3$ |
| Total Kilojoules in Deposit | 80,8 million kJ |

(d) Site Reference EV2
Connies Limpet Bar (Horwitz 1979)

| | N | % | Kilojoules | % |
|---|---|---|---|---|
| *P. granatina* | 1376 | 72,9 | 38528 | 85,6 |
| *P. granularis* | 489 | 25,9 | 4890 | 10,9 |
| *P. argenvillei* | 14 | 0,7 | 938 | 2,1 |
| *P. barbara* | 9 | 0,5 | 640 | 1,4 |
| Total *Patella* | 1888 | 100,0 | 44996 | 100,0 |
| *Patella* - All Species | 1888 | 86,1 | 44996 | 88,6 |
| *C. meridionalis* | 170 | 7,8 | 4760 | 9,4 |
| *Aulacomya ater* | 12 | 0,5 | 120 | 0,2 |
| *Burnupena* spp. | 122 | 5,6 | 915 | 1,8 |
| Total - All Species | 2192 | 100,0 | 50791 | 100,0 |

| | |
|---|---|
| Volume of Sample | 0,125 $m^3$ |
| kJ $m^{-3}$ | 406 328 |
| Volume of Total Deposit | 4 $m^3$ |
| Total Kilojoules in Deposit | $\pm$ 1,6 million kJ |

Appendix R (continued)

(e) Site Reference EV1
Post Office Midden (Horwitz 1979)

| | N | % | Kilojoules | % |
|---|---|---|---|---|
| *Patella* - All Species | 21 | 6,5 | 504 | 5,7 |
| *C. meridionalis* | 296 | 91,1 | 8288 | 93,4 |
| *Aulacomya ater* | 8 | 2,4 | 80 | 0,9 |
| Total - All Species | 325 | 100,0 | 8872 | 100,0 |

| | |
|---|---|
| Volume of Sample | 0,0375 $m^3$ |
| kJ $m^{-3}$ | 236 586 |
| Volume of Total Deposit | 0,4 $m^3$ |
| Total Kilojoules in Deposit | 0,1 million kJ |

## APPENDIX S.1(a)

## BEACH TRANSECTS : ANALYSIS OF SAMPLES - SECTOR 1

| | $kJ\ m^{-2}$ | $N\ m^{-2}$ | Area $m^2$ | Total kJ (Thousands) | % | Mean kJ Per Animal |
|---|---|---|---|---|---|---|
| **Balanoid Zone** | | | | | | |
| Limpets : *P. granatina* | 233,8 | 6,4 | 33810 | 7904 | 28,4 | 36,4 |
| *P. granularis* | 404,2 | 23,8 | 33810 | 13665 | 49,2 | 17,0 |
| *P. barbara* | 2,3 | 0,1 | 32650 | 76 | 0,3 | 23,0 |
| Total *Patella* | 640,3 | 30,3 | 33810 | 21645 | 77,9 | 21,1 |
| Mussels : *C. meridionalis* | 34,1 | 1,1 | 33810 | 1153 | 4,1 | 32,2 |
| Whelks : All Species | 147,7 | 19,7 | 33810 | 4993 | 18,0 | 7,5 |
| Total Balanoid Zone | 822,1 | 51,1 | 33810 | 27791 | 100,0 | 16,1 |
| **Argenvillei-Cochlear Zone** | | | | | | |
| Limpets : *P. granatina* | 617,0 | 13,3 | 24360 | 15029 | 58,8 | 46,3 |
| *P. granularis* | 189,5 | 15,6 | 24360 | 4615 | 18,0 | 12,1 |
| *P. argenvillei* | 22,5 | 0,3 | 23820 | 765 | 3,0 | 75,0 |
| *P. barbara* | 164,7 | 3,0 | 23820 | 3923 | 15,3 | 54,9 |
| Total *Patella* | 993,7 | 32,2 | 24360 | 24332 | 95,1 | 30,9 |
| Mussels : *C. meridionalis* | 71,4 | 13,6 | 540 | 38 | 0,1 | 5,2 |
| Whelks : All Species | 50,7 | 6,8 | 23820 | 1207 | 4,7 | 7,5 |
| Total A-C Zone | 1115,8 | 52,6 | - | 25577 | 99,9 | 21,2 |
| **Intertidal Zone** | | | | | | |
| Limpets : *P. granatina* | 394,3 | 9,3 | 58170 | 22933 | 43,0 | 42,4 |
| *P. granularis* | 314,3 | 20,3 | 58170 | 18280 | 34,2 | 15,5 |
| *P. argenvillei* | 22,5 | 0,3 | 23820 | 765 | 1,4 | 75,0 |
| *P. barbara* | 70,8 | 1,3 | 56470 | 3999 | 7,5 | 54,5 |
| Total *Patella* | 801,9 | 31,2 | - | 45977 | 86,1 | 25,7 |
| Mussels : *C. meridionalis* | 34,7 | 1,3 | 34350 | 1191 | 2,2 | 26,7 |
| Whelks : All Species | 107,6 | 14,4 | 57630 | 6200 | 11,6 | 7,5 |
| Total Intertidal Zone | 944,2 | 46,9 | - | 53368 | 99,9 | 20,1 |

# APPENDIX S.1(c)

## BEACH TRANSECTS : ANALYSIS OF SAMPLES - SECTOR 3

| | | kJ m$^{-2}$ | N m$^{-2}$ | Area m$^2$ | Total kJ (Thousands) | % | Mean kJ Per Animal |
|---|---|---|---|---|---|---|---|
| **Balanoid Zone** | | | | | | | |
| Limpets : | *P. granatina* | 147,2 | 4,6 | 6800 | 1001 | 2,1 | 32,0 |
| | *P. granularis* | 166,2 | 42,4 | 6800 | 1130 | 2,3 | 3,9 |
| | Total *Patella* | 313,4 | 47,0 | 6800 | 2131 | 4,4 | 6,7 |
| Mussels : | *C. meridionalis* | 6119,7 | 380,5 | 6800 | 41614 | 85,1 | 16,1 |
| Whelks : | All Species | 757,6 | 101,0 | 6800 | 5152 | 10,5 | 7,5 |
| Total Balanoid Zone | | 7190,7 | 528,5 | 6800 | 48897 | 100,0 | 13,6 |
| **Argenvillei-Cochlear Zone** | | | | | | | |
| Limpets : | *P. granatina* | 160,4 | 3,0 | 5180 | 831 | 0,8 | 53,5 |
| | *P. granularis* | 239,2 | 51,0 | 5180 | 1239 | 1,1 | 4,7 |
| | Total *Patella* | 399,6 | 54,0 | 5180 | 2070 | 1,9 | 7,4 |
| Mussels : | *C. meridionalis* | 17570,3 | 1113,2 | 5180 | 91014 | 83,4 | 15,8 |
| Whelks : | All Species | 3090,0 | 412,0 | 5180 | 16006 | 14,7 | 7,5 |
| Total A-C Zone | | 21059,9 | 1579,2 | 5180 | 109090 | 100,0 | 13,1 |
| **Intertidal Zone** | | | | | | | |
| Limpets : | *P. granatina* | 152,9 | 3,9 | 11980 | 1832 | 1,2 | 39,2 |
| | *P. granularis* | 197,8 | 46,1 | 11980 | 2369 | 1,5 | 4,3 |
| | Total *Patella* | 350,7 | 50,0 | 11980 | 4201 | 2,7 | 7,0 |
| Mussels : | *C. meridionalis* | 11071,0 | 697,3 | 11980 | 132628 | 83,9 | 15,9 |
| Whelks : | All Species | 1766,0 | 235,5 | 11980 | 21158 | 13,4 | 7,5 |

# APPENDIX S.2

## BEACH TRANSECTS : AVAILABLE SHELLFISH BIOMASS

### Total Kilojoules (in Thousands)

| | Zone | Sector 1 | Sector 2 | Sector 3 | Total | Percentage Zone | Percentage Spp. |
|---|---|---|---|---|---|---|---|
| Limpets | Balanoid | 21 645 | 534 | 2 131 | 24 310 | 43,0 | |
| | A-C | 24 332 | 5 837 | 2 070 | 32 239 | 57,0 | |
| | Total | 45 977 | 6 371 | 4 201 | 56 549 | 100,0 | 25,2 |
| % by Sector | | 81,3 | 11,3 | 7,4 | | | |
| Mussels | Balanoid | 1 153 | 367 | 41 614 | 43 134 | 31,0 | |
| | A-C | 38 | 5 019 | 91 014 | 96 071 | 69,0 | |
| | Total | 1 191 | 5 386 | 132 628 | 139 205 | 100,0 | 62,0 |
| % by Sector | | 0,9 | 3,9 | 95,2 | | | |
| Whelks | Balanoid | 4 993 | 175 | 5 152 | 10 320 | 36,0 | |
| | A-C | 1 207 | 1 115 | 16 006 | 18 328 | 64,0 | |
| | Total | 6 200 | 1 290 | 21 158 | 28 648 | 100,0 | 12,8 |
| % by Sector | | 21,6 | 4,5 | 73,9 | | | |
| All Species | Balanoid | 27 791 | 1 076 | 48 897 | 77 764 | 34,7 | |
| | A-C | 25 577 | 11 971 | 109 090 | 146 638 | 65,3 | |
| | Total | 53 368 | 13 047 | 157 987 | 224 402 | 100,0 | 100,0 |
| % by Sector | | 23,8 | 5,8 | 70,4 | | | |

# APPENDIX S.3

## BEACH TRANSECTS : COMMENTS

### (a) Appendix S.1 - "Area" Sector 1

"Area" is the net superficial area of rock surface. Rebelo's analysis (1982) was divided into four sectors of the shoreline but his Sector 2 is a steep, narrow boulder beach at the crayfish factories where only *P. granularis* is well represented (Figure 3.2). Sector 1 in this analysis, therefore, combines the data from Rebelo's Sectors 1 and 2, for which the areas are :

| | Sector 1 ($m^2$) | Sector 2 ($m^2$) |
|---|---|---|
| Balanoid Zone | 32 650 | 1 160 |
| A-C Zone | 23 820 | 540 |

The areas quoted in Appendix S.1 for each species have been restricted to the areas in which the species is present. For instance, in the A-C Zone, *C. meridionalis* is present only in Rebelo's Sector 2 and is absent from his Sector 1.

### (b) P. granularis and P. granatina

*P. argenvillei* and *P. barbara* rarely occur outside the A-C Zone and *P. cochlear* never outside the spray zone. *P. granularis* and *P. granatina* inhabit both zones, but 70% of the biomass of *P. granularis* is located in the Balanoid Zone, against only 36% of the biomass of *P. granatina*. For both species, the larger animals with the higher mean kilojoule yield per animal are found in the A-C Zone.

Sectors 1, 2 & 3 Combined - Total Kilojoules (in Thousands)

| | Balanoid Zone | A-C Zone | Total |
|---|---|---|---|
| P. granatina | 9 026 = 36,3% | 15 860 = 63,7% | 24 886 = 53,6% |
| P. granularis | 15 208 = 70,8% | 6 299 = 29,2% | 21 507 = 46,4% |
| | 24 238 = 52,2% | 22 159 = 47,8% | 46 393 |

Mean Kilojoule Yields per Animal

| | Balanoid Zone | A-C Zone | Total |
|---|---|---|---|
| P. granatina | 34,1 | 47,7 | 42,0 |
| P. granularis | 5,5 | 5,8 | 5,6 |

(c) Prehistoric Selection for Size

The following comparison indicates prehistoric selection for size for all species other than P. granatina. This exception is discussed in Chapter 8.

| | | Mean kJ Yield per Animal | |
|---|---|---|---|
| | | Beach Transects Sectors 1, 2 & 3 | Archaeological All Sites |
| Limpets : | P. granatina | 42,0 | 28 |
| | P. granularis | 5,6 | 10 |
| | P. argenvillei | 45,2 | 67 |
| | P. barbara | 54,5 | 60 |
| Mussels : | C. meridionalis | 16,0 | 28 |

(d) Other Species Present But Ignored

The only major omission from Appendix S is the Ribbed Mussel Aulacomya ater which contributed to total biomass (in thousands of kilojoules) :

| | |
|---|---|
| Sector 1 | 16 167 |
| Sector 2 | 18 164 |
| Sector 3 | 55 |
| | 34 386 |

or roughly 15% of the total biomass from all species. The reasons for this omission are given in Chapter 4, paragraph 4.1. The other genera/species identified in the samples from beach transects but insignificant contributors to shellfish biomass and ignored by Rebelo in energy distributions are listed below :

| | |
|---|---|
| Venerupis | Tricola |
| Siphonaria | Fasciola |
| Crepidula | Fissurella |
| Helcion | Donax |
| Oxystele | Bullia |
| Clinella | Thais. |