

The role of seals in coastal hunter-gatherer lifeways at Robberg, South Africa.

By Leesha Richardson

Supervised by Prof Judith Sealy and Dr Deano Styrder



*Dissertation submitted in fulfilment of the requirements for the degree
of*

Master of Philosophy (MPhil) in Archaeology

In the Department of Archaeology

Faculty of Science

University of Cape Town

February 2020

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

Plagiarism Declaration

I have used the Harvard convention for citation and referencing. Each contribution from, and quotation in, this thesis from the work(s) of other people has been attributed, and has been cited and referenced.

This thesis is my own work:

Signed by candidate

Leesha Richardson

RCHLEE003

Date: 8 February 2020

Abstract

Seals were a major dietary item for coastal hunter-gatherers and herders in South Africa. At Nelson Bay Cave (NBC), more than half of the Holocene mammal bones are from Cape Fur seals (*Arctocephalus pusillus*). Previous analyses of the seal assemblage from this site have studied only selected skeletal elements. This study is the first comprehensive analysis of seal remains from selected archaeological levels at Nelson Bay Cave and from the 2007/2008 excavations at nearby Hoffmans/Robberg Cave (HRC). Body part representation and frequency, age distribution and bone modification have been documented to determine the role of seals in the lifeways of hunter-gatherers and pastoralists at Robberg throughout the Holocene.

The age profiles indicate that seals were obtained directly from a breeding colony throughout the Holocene. A breeding colony at Robberg would have been a rich and reliable resource for coastal foragers throughout the year. There were differences in skeletal element representation in the Early and Middle Holocene, compared with the Late Holocene. Axial skeletal elements are under-represented in earlier time periods, probably due to field butchery and the return of only parts of the seals to the living sites. In the Late Holocene, entire animals were taken back to site. Within each time period, the skeletal profiles of juveniles and adults indicate that both were processed similarly suggesting that aspects such as carcass size, weight and foraging distance were less important factors in transport decisions than the terrain of the Robberg Peninsula and the size of the hunting party. A large proportion of the bones were complete, or almost complete. There was little evidence of canid gnawing. The skeletal element representation, frequency and cut mark patterns suggest that the heads and flippers were highly sought after throughout the Holocene, as recorded in Arctic ethnography. Seals were also of spiritual significance, possibly in aiding transitions from the material into the spirit world.

Acknowledgements

First and foremost, I would like to thank my supervisors Prof Judith Sealy and Dr Deano Stynder for their guidance and support. I would also like to thank Prof John Parkington, Dr Benjamin Schoville, Dr Jamie Hodgkins, Prof Curtis Marean, Dr Erich Fisher, Dr Naomi Cleghorn, Louisa Hutten and Patricia Groenewald for their advice and comments. I would like to give a special thanks to Dolores Jacobs for helping me with the sorting and coding of the NBC and HRC seal assemblage. I would also like to thank Dr Wendy Black and Me Wilhelmina Seconna from IZIKO Museums for their help in accessing the NBC seal collection. Lastly, I would like to thank the South African Research Chairs Initiative (SARChI) of the Department of Science and Technology (DST) and the National Research Foundation (NRF) of South Africa (grant no 84407) for providing funding for this project.

Table of Contents

Plagiarism Declaration	i
Abstract.....	ii
Acknowledgements.....	iii
List of figures.....	ix
List of tables.....	xiv
Chapter 1 : Introduction	1
Chapter 2 : Background.....	3
2.1 Marine resources: brainfood for modern humans	3
2.1.1 Early human origins on the South African coast	3
2.1.2 The nutritional value of seals	5
2.2 Seal taxonomy and ecology	6
2.2.1 Appearance	6
2.2.2 Seasonal blubber and hide variation	7
2.2.3 Diet.....	7
2.2.4 Breeding.....	8
2.2.5 Cape fur seal demography at haul-out and breeding colonies	8
2.2.6 Distribution	9
2.3 The history of sealing in Southern Africa.....	10
2.3.1 Seal harvesting at the Cape of Good Hope (16 th -19 th century).....	10
2.3.2 Seal harvesting in Namibia (20 th – 21 st century).....	11
2.4 Ethnographic studies of pinniped exploitation by coastal hunter-gatherers	11
2.4.1 The different methods of seal hunting	12
2.4.2 Field butchery, storage and transport of seal remains to the consumption site	13
2.4.3 Seal butchery and carcass disarticulation at the consumption site	14
2.4.4 Seal meat and blubber use.....	14

2.4.5 Seal viscera use	16
2.4.6 Sealskin use.....	16
2.4.7 Seal bone use.....	17
2.5 The spiritual significance of seals	18
2.5.1 Archaeological depictions of marine animals on the southern coast of South Africa	18
2.5.2 The Knysna seal scapula	20
2.5.3 The spiritual significance of the Knysna seal scapula	23
2.6 Analyses of archaeological faunal assemblages.....	24
2.6.1 The history of faunal analysis in South Africa.	24
2.6.2 Skeletal frequency and representation: human utilisation and transport of animal remains.....	25
2.6.3 Bone fragmentation and surface modification	27
2.6.3.1 <i>Butchering marks</i>	27
2.6.3.2 <i>Evidence of burning</i>	28
2.6.3.3 <i>Bone nutrient extraction</i>	29
2.6.3.4 <i>Carnivore ecology</i>	30
2.6.3.5 <i>Other taphonomic processes</i>	31
2.6.3.6 <i>Bone preservation (Hardness index)</i>	32
2.6.4 The completeness of the archaeological record.	32
2.7 Quantifying animal and seal remains	34
2.7.1 <i>Calculating taxonomic abundance: NISP and MNI</i>	34
2.7.2 <i>Bone completeness and taxa representation: MNE and MAU</i>	35
2.8 Determining the season of death: Determining the age and sex of animals in the archaeological record.....	36
2.8.1 Assigning relative age to mammals in the archaeological record.....	36
2.8.2 Assigning sex to mammals in the archaeological record.....	37
2.8.3 Assigning age and sex to pinnipeds from the archaeological record.....	37

2.8.3. Ageing seals in the archaeological record	37
2.8.3.2 Assigning sex to seals in the archaeological record.....	39
2.9 Archaeological seal remains and seasonality on the South African coast	39
2.9.1 Seasonal seal availability	39
2.9.2 Stable isotope analyses and the interpretation of seasonality at NBC.	42
2.10 The Robberg Peninsula: environment and climate during the Holocene.....	44
2.10.1 Change in sea level at Robberg during the terminal Pleistocene and Holocene ...	44
2.10.2 Physical environment.....	45
2.10.3 Rainfall, temperatures and biological environment.	45
2.10.4 The Robberg Cape fur seal colony.....	46
2.10.5 Other seals found on the Robberg Peninsula.	49
2.11 Excavation history at Robberg.	49
2.11.1 The archaeological history of Robberg.....	49
2.11.2 Excavations at Nelson Bay Cave.	49
2.11.2.1. Post-Wilton and herders levels at NBC	55
2.11.2.2. The Wilton levels at NBC.....	56
2.11.2.3. The Albany levels at NBC.	57
2.11.3 Excavations at Hoffman's/Robberg Cave.....	58
2.11.3.1. Post Wilton levels at HRC.....	63
Chapter 3 : Materials and Methods	64
3.1 Curation of the NBC and HRC seal assemblages	64
3.2 Sample selection	65
3.3 Cataloguing the seal bones	67
3.4 Taxonomic assessment.....	68
3.5 Assigning age and sex to the NBC and HRC seal assemblage	68
3.6 Faunal coding	69
3.6.1 Designing a GIS-based system for Cape fur seals	69

3.6.2 Skeletal element analysis	70
3.6.3 Instruments used	72
3.7 Assessment of fragmentation	72
Chapter 4 : Results.....	74
4.1 Specimen counts and identification.....	74
4.2 Minimum numbers of individuals at NBC and HRC	75
4.3 Skeletal element representation.....	76
4.3.1 Skeletal frequency: NISP versus MNE values.....	76
4.3.2 Skeletal element frequency	79
4.3.3 Skeletal element frequency and food utility index	83
4.4 The age profiles of Cape fur seals at NBC and HRC.....	85
4.5 Taphonomy.....	89
4.5.1 Post-depositional damage	89
4.5.2 Skeletal element completeness	92
4.5.3 Long bone modification.....	93
4.5.3.1 Long bone fracture outlines and angles.....	93
4.5.3.2 Long bone shaft circumferences	94
4.5.3.3 Long bone shafts versus epiphyses	95
4.5.3.4 Comparing terrestrial mammal with seal bone fracture patterns	95
4.5.4 Bone surface modification	96
4.5.4.1 Percussion marks.....	96
4.5.4.2 Tooth marks	99
4.5.4.3 Cut marks.....	102
4.5.4.4 Burning	115
4.6 Summary of results.....	120
Chapter 5 : Discussion	121
5.1 Introduction.....	121

5.2 Major findings of the NBC and HRC seal assemblage.....	121
5.2.1 Specimen counts and identification	121
5.2.2 The age profiles of Cape fur seals at NBC and HRC	121
5.2.3. Skeletal representation, frequency and completeness.....	122
5.2.4 Bone modification.....	125
5.4 The Knysna seal scapula	129
5.5 Changing our perspective of the Robberg seal colony	129
5.6 Limitations and suggestions for future research.....	130
Chapter 6 : Conclusion	132
References	134
Appendix A	160
Appendix B	162

List of figures

Figure 2.1: Painted burial stones from (a) Klasies River Mouth Cave 5 (SAM-29350) and (b) Tsitsikamma Cave. Images from Pearce (2008) (a&b) Rudner & Rudner (1970) (b).	19
Figure 2.2: The Knysna scapula currently housed at the British Museum (image courtesy of © Trustees of the British Museum). Height 17.1 cm, width 20 cm (British Museum Collection Database, 2019).....	21
Figure 2.3: Drawings of animals possibly depicted on the Knysna seal scapula. Left to right: a Cape fur seal, South African penguins and a humpback whale (drawn by Lenél Richardson).....	22
Figure 2.4a-c: Close-ups of the Knysna scapula images. The yellow arrows depict brown ink used to outline and colour the flippers of the seal and outline the birdlike being/s. The black arrows indicate cracks that appear to have been filled with black ink (images courtesy of © Trustees of the British Museum).....	23
Figure 2.5: Seal bones do not have a marrow cavity as seen in this cross-section of a juvenile Cape fur seal radius. Maximum length is 80.3 mm (Photo: Leesha Richardson).	30
Figure 2.6: The Holocene archaeological sites (white/plain balloon) separated by the Keurbooms River estuary, which would have served as a natural barrier between the people of Robberg/Plettenberg Bay and Matjes River Rock Shelter. Beacon Island and Cape Seal Point (starred balloons) are the two seal colonies present during the Holocene. The location of Nelson Bay Cave and Hoffman's/Robberg Cave relative to the current Cape fur seal breeding colony distributed along the coastal area between points A and B, known as Rondeklippe and the historical colony, at point C, known as Seal Point	43
Figure 2.7: The Robberg Peninsula, as seen from the town of Plettenberg Bay (image courtesy of Louisa Hutten).....	45
Figure 2.8: The historical and probable Holocene location of the Cape fur seal colony on the eastern stretch of the Robberg Peninsula known as Cape Seal Point. (Photo: Leesha Richardson).....	48
Figure 2.9: The current location of the Cape fur seal colony on the northern stretch of the Robberg Peninsula known as Rondeklippe (image courtesy of Patricia Groenewald).	48
Figure 2.10: The mouth of Nelson Bay Cave located on the southern stretch of the Robberg Peninsula (Photo: Leesha Richardson).	50

Figure 2.11 Plan of Nelson Bay Cave showing the location of R.Inskeep and R.G. Klein's excavations as well as the location of the disturbances (dumps and cuts) found throughout the cave. From (Deacon & Deacon 1998) after Inskeep (1987).	51
Figure 2.12: Facing north towards the interior of Nelson Bay Cave. The corrugated iron roof, as seen in the bottom right corner, covers the area excavated in Richard Klein's 1970 field season. This roof was erected in 1992 and serves to protect a museum display of Nelson Bay Cave's archaeological history (Photo: Leesha Richardson).	51
Figure 2.13: Section drawing of the Late Holocene stratigraphic units 22-59 from squares B IV to -1 at NBC. From Inskeep (1987).	52
Figure 2.14: The western long section profile of the 1970/71 excavations by R.G. Klein. From J. Deacon (1984) after R.G. Klein (1972b) and unpublished.	54
Figure 2.15: Hoffman's/Robberg Cave (black arrow) as seen from Nelson Bay Cave (Photo: Leesha Richardson).	58
Figure 2.16:Hoffman's/Robberg cave as seen from the Robberg hiking trail (image courtesy of Louisa Hutten).	59
Figure 2.17: Site plan of Hoffman's/Robberg Cave, Hoffman's trench and the squares excavated in 2007-8: E- (from left to right E6a-c, E5a-d and E4a) and D-squares (from left to right D6, D5 and D4) (image courtesy of Judith Sealy).	60
Figure 2.18: Section drawing of the Late Holocene stratigraphic units from squares E4 to E6 at Hoffman's/Robberg Cave (image courtesy of Judith Sealy).	61
Figure 2.19: Northern profile wall of J.Sealy's excavations at Hoffman's/Robberg cave by the end of the 2008 field season (image courtesy of Louisa Hutten).	62
Figure 4.1: Numbers of seal bone per litre of sediment removed from BSBJ (~10 000 BP), RC (~6 000 – 9 000 BP) and IC (~5 000 BP) at NBC and deposits below (~4 000 BP) and above (~3 300BP) Ivan at HRC.	75
Figure 4.2: %MAU for each skeletal element at NBC using NISP and MNE values.	78
Figure 4.3: %MAU for each skeletal element at HRC using NISP and MNE values.	78
Figure 4.4: Skeletal element frequency (%MAU) of the Middle- to Late Holocene levels IC, RC and BSBJ at NBC.	82
Figure 4.5: Skeletal element frequency (%MAU) of the Late Holocene levels I1, I2 at NBC and HRC at Hoffman's/Robberg Cave.	82
Figure 4.6: The %MAU from BSBJ (Brown Soil Below Jake), RC (RICE Complex) and IC (Ivan complex) compared with %SMBUI from Woodborne (1996).	84

Figure 4.7: The %MAU from I1 (Inskeep 1), HRC (Hoffman's/Robberg Cave) and I2 (Inskeep2) compared with %SMBUI from Woodborne (1996).	85
Figure 4.8: Minimum number of elements (MNE) of adult, sub-adult and juvenile seals from I1, I2, HRC, IC, RC and BSBJ. MNE values tabulated beneath the bar chart and the percentage values of each age group labelled at the top of each bar.	85
Figure 4.9: Minimum number of elements (MNE) for juvenile and sub-adult + adult bones from I1, I2, HRC, IC, RC and BSBJ. Percentage values for each age group labelled at the top of each bar.....	86
Figure 4.10: Skeletal representation and frequency (NISP) of sub-adult + adult (A) and juvenile (J) Cape fur seal bones from BSBJ (~10 000 BP), RC (~9 000 – 6 000 BP) and IC (~5 000 BP) at NBC. Seal template modified from Bebej (2009) and Post (2004). NISP values were used to calculate skeletal frequency. Note: dental and non-identified specimens excluded from this figure.	87
Figure 4.11: Skeletal representation and frequency of sub-adult + adult (A) and juvenile (J) Cape fur seal bones from (Top to bottom) HRC, (~4 000 – 3 000 BP), I2 (~3 000 – 2 000 BP) and I1 (~2 000 – 500 BP) at NBC. Seal template modified from Bebej (2009) and Post (2004). NISP values were used to calculate skeletal frequency. Note: dental and non-identified specimens were used in this figure.	88
Figure 4.12: Embedded stone (quartzite) and shell in an adult carpal (Specimen: LR256) from Layer Cedric, NBC. Photographed with a DinoLight microscope with 30x magnification...	90
Figure 4.13: Embedded stone and shell on a juvenile phalanx (Specimen: LR381) from IC (Ivan Complex), NBC. Photographed with a DinoLight microscope with 15x magnification.	91
Figure 4.14: Trampling marks visible (top right) on the middle shaft of an adult rib (Specimen LR906) from IC (Ivan Complex), NBC. Photographed with a DinoLight microscope with 15x magnification.....	91
Figure 4.15: Long bone shaft completeness at NBC and HRC. 3=100% circumference preserved, 2=>50% and 1=<50% (Bunn 1983). The sample size depicted as bar labels. Digitopodia are included in this figure.	94
Figure 4.16: The percentages of long bone shafts compared with epiphyses at NBC and HRC. The sample size depicted as bar labels. Digitopodia are included in this figure.	95
Figure 4.17: (a) lateral (b) medial and (c) ventral views of a seal mandible from HRC (Specimen LR 357). Percussion marks (arrowed) are visible on the body of the mandible...	97

Figure 4.18: Percentage of each skeletal element from NBC showing one or more carnivore tooth marks. Diagram modified from Bebej (2009) and Post (2004).	100
Figure 4.19: Juvenile seal metacarpal from NBC (specimen: LR3639) with carnivore bite marks on the (a) distal diaphysis and (b) proximal epiphysis. Photographed with a DinoLight microscope with 15x magnification.	101
Figure 4.20: Percentages of each skeletal element at NBC showing one or more cut marks. Diagram modified from Bebej (2009) and Post (2004).	103
Figure 4.21: Percentages of each skeletal element at HRC showing one or more cut marks. Diagram modified from Bebej (2009) and Post (2004).	103
Figure 4.22: Locations of cut marks on the skeletal elements at NBC. Diagram modified from Bebej (2009) and Post (2004).	106
Figure 4.23: Locations of cut marks on skeletal elements at HRC. Diagram modified from Bebej (2009) and Post (2004).	109
Figure 4.24: (a) dorsal and (b) medial view of a Cape fur seal mandible (Specimen: LR 5) from Garth (Inskeep 2), NBC. Cut marks (arrowed) are visible on the body of the mandible. Image photographed with a DinoLight microscope with 20x and 15x magnification.	111
Figure 4.25: Cut marks present on the occiput of a Cape fur seal cranium (Specimen: LR 1388) from IC (Ivan Complex), NBC. Image photographed with a DinoLight microscope with 15x magnification.	112
Figure 4.26: Cut marks on the phalanx (Specimen: LR 377) of a Cape fur seal from IC (Ivan Complex), NBC. Image photographed with a DinoLight microscope with 40x magnification.	112
Figure 4.27: Cut marks on the phalanx (Specimen: LR 562) of a Cape fur seal from IC (Ivan Complex), NBC. Image photographed with a DinoLight microscope with 35x magnification.	113
Figure 4.28: Cut marks on the phalanx (Specimen: LR 664) of a Cape fur seal from IC (Ivan Complex), NBC. Image photographed with a DinoLight microscope with 25x magnification.	113
Figure 4.29: Cut marks on the canine (Specimen: LR 896) of an adult Cape fur seal from IC (Ivan Complex), NBC. Image photographed with a DinoLight microscope with 15x magnification.	114
Figure 4.30: Percentages of burned bones for each skeletal element at NBC. Diagram modified from Bebej (2009) and Post (2004).	116

Figure 4.31: Percentages of burned bones for each skeletal element at HRC. Diagram modified from Bebej (2009) and Post (2004).	117
---	-----

List of tables

Table 2.1: The mean length and weight values of Cape fur seals. After Rand (1956).	7
Table 2.2: Radiocarbon dates from the Middle- to Late Holocene deposits at Nelson Bay Cave. After Inskeep & Vogel (1985) and Inskeep (1987).	53
Table 2.3: Accelerator mass spectrometry (AMS) dates from the Late- Pleistocene and Early- to Middle Holocene layers at Nelson Bay Cave. After Loftus et al. (2016).	54
Table 2.4: Radiocarbon dates from Hoffman's/Robberg Cave. After Kyriacou (2009).	62
Table 4.1: Numbers of identified seal specimens from selected stratigraphic units at NBC and HRC.	74
Table 4.2: Minimum number of individuals (MNI) from I1, I2, HRC, IC, RC and BSBJ.	75
Table 4.3: Calculated %MAU values for each skeletal element at NBC using NISP and MNE values.	76
Table 4.4: Calculated %MAU values for each skeletal element from HRC using NISP and MNE values.	77
Table 4.5: %MAU for Early Holocene levels from RC and BSBJ at NBC using MNE values.	79
Table 4.6: %MAU for Middle- to Late Holocene levels from HRC at Hoffman's/Robberg Cave and IC at NBC using MNE values.	80
Table 4.7: %MAU for Late Holocene levels I1 and I2 at NBC using MNE values.	81
Table 4.8: Skeletal element frequency (%MAU) and food utility index (%SMBUI) from IC, RC and BSBJ at NBC.	83
Table 4.9: Skeletal element frequency (%MAU) and food utility index (%SMBUI) for I1 and I2 at NBC and HRC at Hoffmans'/Robberg Cave.	84
Table 4.10: Minimum number of elements (MNE) of adult, sub-adult and juvenile seal bones from Robberg.	86
Table 4.11: Numbers of seal bones from NBC and HRC showing weathering, root etching, exfoliation, and trampling. The stages of weathering (0-5) recorded according to Behrensmeyer's (1978) criteria. Four categories (0-3) for root etching, exfoliation and trampling are percentages of cortical surfaces showing damage.	89
Table 4.12: Seal skeletal elements from NBC and HRC and their average percentage of completeness.	92
Table 4.13: Average percentage completeness of various seal skeletal element types at NBC and HRC.	93

Table 4.14: Long bone shaft fracture outlines and angles (NISP) at NBC and HRC, according to the criteria of Villa and Mahieu (1991).	94
Table 4.15: Numbers of percussion marks (PM) on each skeletal element from NBC and HRC.	96
Table 4.16: Numbers of carnivore tooth marks (TM) on each skeletal element from NBC and HRC.	99
Table 4.17: Percentages of skeletal element types at NBC with one or more carnivore tooth marks.....	100
Table 4.18: The numbers of cut marks (CM) on each skeletal element at NBC and HRC. ..	102
Table 4.19: Percentages of each skeletal type with one or more cut marks at NBC and HRC.	104
Table 4.20: Numbers of cut marks (CM) per skeletal element at NBC.....	105
Table 4.21: Numbers and percentages of cut marks (CM) for each skeletal element type at NBC.	107
Table 4.22: Numbers of cut marks per skeletal element from HRC.....	108
Table 4.23: Numbers and percentages of cut marks (CM) for each skeletal element type at HRC.	110
Table 4.24: Numbers and percentages of burnt skeletal elements at NBC and HRC.....	115
Table 4.25: Percentages of skeletal element types showing burning at NBC and HRC.	118
Table 4.26: Numbers of bones from NBC and HRC classified according to Stiner et al.'s (1995) stages of burning.	119
Table 4.27: Numbers of skeletal element types from NBC and HRC that were carbonised (Stage 1-3) and calcined (Stage 4-6).....	119

Chapter 1: Introduction

Seals were a major item of diet for coastal hunter-gatherers and herders in South Africa. At Nelson Bay Cave (NBC) on the Robberg Peninsula at Plettenberg Bay, Western Cape, South Africa, more than half of the Holocene mammal bones are from Cape fur seals (*Arctocephalus pusillus*) (Inskeep 1987a; Klein 1972a). At other South African Holocene coastal sites such as Die Kelders (Klein 1975; Klein & Cruz-Urbe 1996,2000; Schweitzer 1979), Elands Bay Cave (Klein & Cruz-Urbe 1987,1996; Parkington 1976), Dune Field Midden (Klein & Cruz-Urbe 1996; Parkington 2006; Parkington et al. 1992) and Kasteelberg (Cruz-Urbe & Klein 1994; Klein & Cruz-Urbe 1996; Smith 2006b) seals were also key food items.

Seal harvesting is the oldest commercial fishing industry in South Africa (Shaughnessy 1984). Seals supply meat, blubber, organs and skins in considerable quantities (Rand 1956,1959). The meat and blubber contain valuable nutrients such as protein and omega-3 fatty acids that help fuel brain function (Brunborg et al. 2006).

Of the seal remains from NBC, certain skeletal elements have already been studied by Klein and Parkington (Klein 1972). These researchers focussed on the humeri, femora (Inskeep 1987a; Klein & Cruz-Urbe 2016) and mandibles (Inskeep 1987a) respectively, to infer size range and age at death, and hence season of site occupation. Results indicate a wide range of seal sizes, indicating that animals of various ages were exploited. This age profile is consistent with active hunting of seals at a rookery (Inskeep 1987).

There have, however, been no previous studies on the entire NBC seal assemblage. The aim of this study is to analyse all of the seal remains from selected archaeological levels at Nelson Bay Cave and from the 2007/2008 excavations at the nearby site of Hoffmans/Robberg Cave to gain a better understanding of the role of Cape fur seals in the lives of Holocene hunter-gatherers and pastoralists at Robberg. The principal objectives are as follows:

- To create a skeletal template for Cape fur seals, which will be digitally captured on the GIS-based program ArcMap10.2. The locations of cut-marks, as well as other surface modifications, will be accurately recorded on the digital template of the relevant skeletal element.
- To establish what body parts are represented and in what frequencies

- To assess pre- and post-depositional bone modifications to investigate butchery patterns, and the possible contribution of non-human agents to the accumulation of the seal assemblage
- To contribute, if possible, to debates about the ages of the seals and what we can learn from this

The remainder of this thesis is divided into five chapters:

- Chapter Two provides background information on the economic, social and spiritual significance of seals. It also provides information on the history of sealing in South Africa as well as Cape fur seal ecology and distribution. This chapter also discusses the history of faunal analysis and current seal coding methodologies. To provide context for the Robberg seal assemblage the excavation histories of NBC and HRC are outlined.
- Chapter Three describes the sample selection and methods used to analyse seal bones from NBC and HRC.
- Chapter Four reports the results.
- Chapter Five reviews the results and contextualises them in terms of the literature reviewed in Chapter Two. It also highlights the limitations of this study and provides some suggestions for future research.
- Chapter Six summarises the conclusions of the study.

Chapter 2: Background

2.1 Marine resources: brainfood for modern humans

2.1.1 Early human origins on the South African coast

The lifeways of coastal hunter-gatherers are of considerable interest to archaeologists around the world. It has been hypothesized that the southern coast of South Africa with its high plant diversity, abundant coastal resources and moderate climate would have been the ideal environment for early humans during the cold Marine Isotope Stage 6 (Marean 2010,2011).

The earliest securely dated evidence of a diversified marine diet comes from Pinnacle Point Cave 13B at 164 kya (Marean 2011). Other South African MSA sites such as Klasies River (KRM) (Deacon 2001; Singer & Wymer 1982; Thackeray 1988; Wurz 2000,2012,2016), Die Kelders cave (DK) (Avery et al. 1997; Klein & Cruz-Urbe 2000; Marean et al. 2000a; Marean et al. 2000b; Tankard & Schweitzer 1974), Sea Harvest and Hoedjies Punt archaeological sites (Kyriacou et al. 2015; Stynder 1997; Volman 1978; Will et al. 2013), Herolds Bay cave (Brink & Deacon 1982), Boegoeberg 2 rock shelter (Klein et al. 1999) and Blombos cave (Henshilwood & Sealy 1997; Henshilwood et al. 2001a; Henshilwood et al. 2001b; Langejans et al. 2012) also contain evidence of diversified marine diets.

After 90 kya there is an increase in the level of coastal adaption with the expansion of shellfish gathering to the Cochlear Zone and regular production of shell middens. Marine mammal exploitation also becomes more prominent within the archaeological record (Marean 2011). At about this time, anatomically modern humans (AMH) expanded out of Africa following coastal routes across Eurasia and Australasia (Oppenheimer 2009). Modern human activity on the South African coast continued, so that by 70 kya, we find the earliest evidence of fishing in South Africa (Henshilwood et al. 2001b; Van Niekerk 2011).

Researchers do not consider MSA coastal sites to be evidence of fully developed marine adaptations (Will et al. 2016) while others (Bar-Matthews et al. 2010; Deacon & Wurz 2001; Deacon 2001) do.

During the Early Holocene, a large accumulation of shell deposits on coastal sites such as the Matjes River Rock Shelter reflect specialized coastal adaptations (Döckel 1998; Jerardino 2016; Sealy et al. 2006). During the Late Holocene (3.5 kya) the first “mega middens” appear as the extensive exploitation of various marine resources increase. For many, these “mega middens” reflect an increased Holocene coastal population, followed by higher levels of

sedentism (Erlandson 2001). Larger group sizes would have added pressure on AMH to develop more efficient cultural techniques for intergroup diplomacy (Marean 2011). According to Erlandson (2001), marine resources provide the economic foundation for the existence of semi-complex societies that possess significant population numbers and intricate material culture. Shellfish, fish and marine mammals are high in protein, omega-3 fatty acids vitamins and minerals (Broadhurst et al. 2002; Sidwell 1981). Marine mammals also provide large amounts of fat and calories. It has been argued for many years that shellfish gathering has a low-calorie return rate, but recent studies have shown that shellfish gathering under average tidal conditions can yield higher caloric returns than terrestrial hunting (De Vynck et al. 2016).

According to Marean (2015), extreme glacial periods in the Pleistocene isolated specific hominid populations. Isolated groups, specifically in South Africa, began to exploit dense and predictable resources that were immune to the Pleistocene glacial cycles. On the South African coast, marine resources occurred in dense patches. These resources were dense, nutritious and available all year round. The result of coastal foraging was active boundary defence (territoriality), increase in intergroup conflict/cooperation as well as social and economic variation among groups. Archaeological evidence of hyperprosociality, advanced cognition and social learning are present from 200-100 kya (Henshilwood et al. 2011; Jerardino & Marean 2010; Marean et al. 2007; Watts 2010). This would suggest the existence of ethnolinguistic structures and exchange networks. Between 100-50 kya, the modern human population spreads from Africa encountering various archaic groups. By 40 kya modern human species are present in Africa, Eurasia, Australasia and the Sahul with other archaic groups nearly extinct. This biological and archaeological evidence suggests rapid dispersal of modern humans throughout the continents. In possession of technologically advanced systems and excellent group organisation skills, modern humans globally displace all archaic hominid groups (Marean 2015). However, some interbreeding between modern and archaic humans also happen. This is seen most clearly in the incorporation of Neanderthal genes in modern Europeans (Wang et al. 2013).

It would seem that marine resource exploitation had a significant effect on early human diet, nutritional levels, technological advances and their mobility. The end product was socially and culturally more complex human beings migrating from Africa into the Middle East, Europe and Asia gradually displacing all archaic hominid groups. Marean's (2015) model rates the importance of marine foraging in the development of modern humans especially

highly, but others have also written about the importance of marine adaptations, e.g. in facilitating the spread of humans across and between continents via coastal routes of dispersal (Erlandson 2001) and with watercraft across the sea (Roberts et al. 1990; Thorne et al. 1999). Regardless of the merits of these arguments, a better understanding of coastal hunting and gathering is of more than just local significance.

2.1.2 The nutritional value of seals

Coastal hunting and gathering for early modern humans required constant access to reliable and predictable seafood rich in calories and nutrients. Numerous coastal resources such as shellfish, fish, birds, seals and whales would have assisted to early human brain development (Cunnane 2010). The focus of this dissertation, however, is on the importance of seals in the diet and culture of South African hunter-gatherers frequenting the Robberg Peninsula on the southern Cape coast of South Africa during the Holocene.

Research has shown that Cape fur seals supply meat, blubber, organs and skin in considerable amounts (Rand 1956,1959). The most important of these were seal blubber which is a thick layer of fat located underneath the skin of the seal and other marine animals. Fat would have played an essential role in hunter-gatherer diet and culture (Speth & Spielmann 1983). Fat in the form of lipids have double the energy value of protein and carbohydrates (Saint-Germain 2005). It also contains calories, fatty acids and fat-soluble vitamins that protects against protein poisoning (Erasmus 1986; Mead et al. 1986). Fat is also an essential fuel for the body and brain and thus a crucial resource for survival in the wild (Saint-Germain 2005).

The nutritional value (fatty acids and minerals) of seal blubber and oil in relation to other mammal fat are unsurpassed (Bailey 1952; Brunborg et al. 2006; Koep et al. 2007; Marean 1986). Seal oil is rich in omega-3 fatty acids (Dubey et al. 2011; Shahidi 2012) and low in toxins (Koep et al. 2007). The nutritional value of seal meat is also significantly higher than that of land-mammals providing higher levels of protein, iron and vitamin A, B₁₂, D₃ and E (Brunborg et al. 2006). Cape fur seal meat is also considered the aquatic version of venison; being lean, high in protein, amino acids and minerals and also low in toxins (Koep et al. 2007).

2.2 Seal taxonomy and ecology

2.2.1 Appearance

In South Africa, the most common seal found on the coast or neighbouring islands is *Arctocephalus pusillus pusillus* (Cape fur seal). The Cape fur seal belongs to the clade of Pinnipedia (pinnipeds), the family of Otariidae (eared seals) and the subfamily of *Arctocephalinae* (fur seals). There are two genera of fur seal, namely *Callorhinus* (northern fur seal) and *Arctocephalus* (southern fur seal). The Cape fur seal and *Arctocephalus pusillus doriferus* (Australian fur seal) are both subspecies of *Arctocephalus pusillus* (brown fur seal). The remaining seven southern fur seal groups are *A. australis* (South American fur seal), *A. philippi* (Juan Fernandez fur seal), *A. galapagoensis* (Galapagos fur seal), *A. townsendi* (Guadalupe fur seal), *A. forsteri* (New Zealand fur seal), *A. tropicalis* (Subarctic fur seal) and *A. gazelle* (Antarctic fur seal). All nine southern fur seal species, except for the Guadalupe fur seal, occur in the southern hemisphere (Bonner 1994).

All fur seals are similar in appearance and behaviour. Fur seals possess thick fur coats consisting of a thick undercoat of short brown hair that is protected from the external elements by long guard hair. It is this thick undercoat that makes fur sealskins highly sought after in the garment industry (David 1989). Cape fur seal pups are born in November-December with a very dark brown to black natal coat. After four months, during March and April, the pups shed their natal coats for a new silver-grey to olive-grey yearling coat present in all pups by July. After twelve to fifteen months the yearlings shed their olive-grey coats for a silver-grey coat that gradually darkens over time with each moult. Moulting takes place on an annual basis in the late summer between January and March. Moulting takes five to seven weeks to complete, in which time the old and faded winter coats are shed and replaced by fresh and shiny ones. The new coats of adult females are neutral grey in the summer months, turning a yellowish-beige colour in the winter months (Rand 1956). Adult males tend to have a grey-brown colour that becomes darker and more grizzled in appearance after the moult (Bonner 1994). Almost all pinnipeds have a polygynous mating system which correlates directly to sexual dimorphism. In some pinniped species, males can reach sizes four to ten times larger than their female counterparts (Ralls & Mesnick 2009). The size range of southern fur seals can also vary greatly. Cape fur seal males, for instance, can reach a total length of 2.73m while a male Galapagos fur seal only measures up to 1.54 m (Bonner 1994).

Table 2.1: The mean length and weight values of Cape fur seals. After Rand (1956).

<u>Classification</u>	<u>Age (months)</u>	<u>Length (meters)</u>	<u>Weight (kilograms)</u>
Newborn	0-30days	0.7 (F & M)	6 (F & M)
Yearling	30days -12	1.1 (F) 1.17 (M)	20-23 (F) 34 (M)
Second-year	12-24	1.2 (F) 1.34 (M)	29 (F) 44 (M)
Sub-adult to adult	24<	1.3-1.6 (F) 1.6-2.1 (M)	42-72 (F) 73-187 (M)

As seen in Table 1, all Cape fur seal juveniles (younger than two years) are similar in mean length and weight. Male juveniles are, however, slightly larger than their female counterparts during the first to second year (11-15 kg). After two years, the sexual dimorphism between males and females becomes more prominent, making it more challenging to estimate the exact ages of older individuals (Shaughnessy 1987).

2.2.2 Seasonal blubber and hide variation

Seals store energy in the form of subcutaneous fat called blubber. Blubber thickness is known to fluctuate seasonally. Seals undergo an annual cycle of breeding, pupping and moulting. These activities are exclusively done on land and within the summer months. During pupping and breeding seals live off their fat reserves. In the winter, seals spend more time at sea feeding and rebuilding their blubber supply. In the winter months, a seal's blubber content can be up to 40% of their body weight while in summer, it can drop as low as 23% (Marean 1986). It is important to note that pelt quality also varies among seasons. Nelson (1969) notes that among Inuit groups, summer-caught seals' fur is considered useless as it sheds easily and is customarily thrown away.

2.2.3 Diet

Seals occupy a high trophic position in the marine food cycle (Riedman 1990). Fur seals are carnivorous and opportunistic predators that will eat any prey that is abundant if their preferred resources are scarce. About 74% of the diet of the Cape fur seal consists of fish. They also consume squid (cephalopod), which can contribute up to 17% of their diet. The rest of the diet is made up of crustaceans (5%), rock lobsters (3%) and cartilaginous fish (1%) (David 1989).

On the south coast of South Africa, Cape fur seals mostly consume anchovy, pilchard, horse mackerel and hake (David 1989). This is consistent with modern studies of the diet of Cape

fur seals frequenting the Robberg Peninsula and surrounding Plettenberg Bay area in which anchovy, sardine, horse mackerel, sand tongue-fish and shallow-water hake is most commonly consumed (Huisamen, J et al. 2012).

2.2.4 Breeding

Fur seals are polygynous with Cape fur seal males being territorial and establishing harems of 10-30 females during the breeding season. Breeding season for Cape fur seals takes place annually between late October and early January (Kirkman 2010). The earliest recorded ages of pregnancy in fur seals vary between 2-4 years of age. The mean breeding age of females is between 7-11 years. Male fur seals establish harems only between 7-13 years of age.

Males haul-out in October/November to establish their harems. They stay in their established territories for 6 – 8 weeks, living off their fat reserves (Kirkman 2010; Woodborne 1996).

Pregnant females arrive at the breeding colony in November and give birth to a single pup in November/December. Females have a gestation period of twelve months, which includes four-month delay in implantation. A week after birth, the females start mating. Males will leave the breeding colony after mating with all the females in their harems, returning only for the next breeding season. Females will leave the colony to feed for 3-4 days, returning to the breeding colony to feed their pups for 2-3 days (Kirkman 2010).

It is during November – December that pup mortality rates are at their highest (De Villiers & Roux 1992). Deaths can occur through trampling, starvation, predation, drowning (Mattlin 1978) or overheating. After December pup mortality gradually decreases to an ultimate low in September (De Villiers & Roux 1992). Pups are nursed for 8-11 months. After this period, the mothers leave the breeding colony and abandon the juveniles, leaving them to fend for themselves (Kirkman 2010). Weaning occurs typically between July and October (Huisamen 2012). The weaned juveniles do not put on weight during their second year as they still struggle to fend for themselves. This continues for the next few years as they wander from colony to colony, aggregating with their age groups (Huisamen 2012).

2.2.5 Cape fur seal demography at haul-out and breeding colonies

As fur seals breed on an annual basis, their age group distribution will be in yearly cohorts. What this means is that the first-year cohort consists of pups less than 12 months old born in the last breeding season. Second-year cohorts include seals between the ages 12-24 months born during the previous breeding season, etc. The difference between each age cohort is

always 12 months. Physical characteristics of the different age cohorts are not easily noticeable at two years and older (Woodborne 1996).

The demography of Cape fur seal breeding and haul-out colonies are very different, notably the demography of breeding colonies, which varies throughout the year. Haul-out colonies consist of juvenile seals which are still too young to breed. After they are weaned, juveniles will haul-out with older cohorts which are also not old enough to breed. When males and females reach sexual and social maturity, they start to form part of breeding colonies (Woodborne 1996). Haul-out population size varies throughout the year. In winter haul-out colonies are small as most seals are foraging at sea. In the summer months, between January and February, the haul-out population is at its biggest (Oosthuizen & David 1988).

By November, breeding colonies consist of bulls between ages 8-10 and cows aged 4-10. Some first-year seals, born the previous season, will also still be hauling out at the breeding colony along with sexually mature bulls which are not able to establish harems. By January the newborns have been born, the bulls and cows have mated, and the bulls returned to the sea. Between January and July, the breeding colony consists of cows and their pups, gradually decreasing in number over time as the pups are weaned. During August to September, most of the cows have returned to sea, and the breeding colony takes on the characteristics of a haul-out colony (Woodborne 1996).

2.2.6 Distribution

Cape fur seal breeding colonies are located all along the southern African coast from Algoa Bay in South Africa to Baia dos Tigres in Angola (Kirkman 2010). If 100 pups or more are born in a specific location on an annual basis, the colony is recognised as a breeding colony (Oosthuizen & David 1988). According to Conry & Van der Vyver (2017), there are currently 41 (24 island and 17 mainland) breeding colonies located along the southern African coast.

The majority of these breeding colonies are located west of Cape Agulhas, forming part of the cold Benguela current system. Only three breeding colonies exist east of Cape Agulhas in the warm Agulhas current system. These are Black Rocks in Algoa Bay, Seal Island in Mossel Bay (Kirkman et al. 2011; Kirkman 2010) and Robberg in Plettenberg Bay (Conry & Van der Vyver 2017). The most prominent breeding colonies west of Cape Agulhas, within South Africa, include Geyser Rock, Seal Island in False Bay, Vondeling Island and Kleinsee (Huisamen et al. 2011; Kirkman et al. 2011). Kleinsee (Huisamen et al. 2011; Kirkman et al.

2011) and Robberg (Conry & Van der Vyver 2017) are the only two land-based breeding colonies located within South Africa.

2.3 The history of sealing in Southern Africa.

2.3.1 Seal harvesting at the Cape of Good Hope (16th-19th century)

The harvesting of seals, primarily for their hide and blubber, is the oldest commercial fishing industry in South Africa (Shaughnessy 1984). The earliest written record of seal and bird harvesting in South Africa comes from Edmund Barker, the lieutenant of a British ship which anchored at Table Bay in 1591 to resupply. He wrote that 15 to 20 days after their arrival at the Cape, malnourished and starving, the admiral rowed to Robben Island in pursuit of food. He returned with many seals and birds (Raven-Hart 1967).

Records show that seals were extensively hunted on Robben Island, Dassen Island and Saldanha Bay in the 16th and 17th centuries (Raven-Hart 1967; Thom 1952,1954,1958). In 1610 alone, 45 000 Cape fur seals were killed at the Cape. Seals were hunted for their meat, blubber and hides. By 1652, with the arrival of Dutch settlers, the majority of the seal colonies around Table Bay at the Cape were driven to extinction (David 1989; Shaughnessy 1984). Seal meat was used to feed the Dutch East Indian Company (DEIC) community and slaves (Raven-Hart 1971a; Schoeman 2001) and the blubber was used to make train-oil (Raven-Hart 1971a). Train-oil was very cheap but did not provide much light, smelled terrible and caused vapour. Large amounts of train oil were consumed in the kitchens of households as well as the company barracks, hospital, slave lodge, outposts and ships (Mentzel 1944; Schoeman 2001). Seal hides were used to make camp beds for the garrison (Mentzel 1919; Schoeman 2001), pillows and storage bags for tobacco. The majority of the seal pup hides were exported to Europe to manufacture clothing items (Schoeman 2001). Calculations based on historical accounts show that approximately 1 276 747 seals were killed at the Cape between 1652 -1752 (David & Van Sittert 2008).

The sealing industry would relocate, during the late 18th to early 19th century, from the Cape to the West Coast. By the end of the 19th century 23 island-based seal colonies, between Plettenberg Bay on the southern Cape coast to Namibia on the north-western coast of southern Africa, would be extinct (Best & Shaughnessy 1979; David 1989; Shaughnessy 1984). Only 20 000 seals are thought to have been left on the islands that formed part of the Cape Colony (Shaughnessy 1984). In an attempt to prevent the extinction of Cape fur seals, new legislation was introduced in 1893 in the form of the Cape Fish Protection Act, which

stipulated that all sealers required a sealing permit from the government. Other acts introduced in 1909 and 1936 prohibited hunting of seals during the breeding season. The 1973 act also stipulated that a permit is required from the Minister of Environmental Affairs to hunt birds and seals. The Minister has the right to prescribe the age, size and sex of the hunted seals as well as the season and location where sealing is allowed (David 1989).

Hides from seals, aged between seven to ten months old, were and still are an essential product of the sealing industry. According to the 1973 act, females up to two years old and males up to three years old are defined as “pups”. From November to mid-December, adult males (bulls) were also harvested. It is estimated that over 2,5 million pups and bulls were harvested between 1900 to 1983 (David 1989). In 1990 seal harvesting was suspended in South Africa (David 1989; Wickens et al. 1991). However, the sealing industry continues in Namibia (David & Van Sittert 2008; Stewardson 1999).

2.3.2 Seal harvesting in Namibia (20th – 21st century)

In the 20th century seal meat and bone was processed at Cape Cross into bone- and meat-meal for stock. The industry, however, came to a stop after not turning a profit. The seal blubber was boiled down to oil and used to manufacture soap, rubber and calcium grease (David 1989).

Today the Cape fur seal industry in Namibia is still profiting from seal exploitation. About 80 000 Cape fur seal pups and 6 000 bulls are killed at Cape Cross on an annual basis. In the past ten years, 400 000 seal hides have been shipped internationally (mostly to Turkey) to produce fur coats. In the past decade, 124 919 litres of seal oil was shipped to China as a nutritional Omega-3 supplement. Cape fur seal bull genitalia, considered an aphrodisiac in China, are also sold in dried, liquefied or powdered form as a sexual performance enhancement (Nowak 2016).

2.4 Ethnographic studies of pinniped exploitation by coastal hunter-gatherers

Human behaviour and the interaction of hunters with prey are best understood by looking at ethnographic accounts of similar cultures. Unfortunately, ethnographic studies of marine-oriented hunter-gatherers in South-Africa are extremely limited (Raven-Hart 1967,1971a,b; Schapera & Farrington 1933; Thom 1952,1954,1958).

There are many ethnographic accounts of coastal hunter-gatherers from the Inuit culture in Alaska, Canada and Greenland (Binford 1978,1980; Birket-Smith 1936; Nansen 1893;

Nelson 1969). These far northern hemisphere climates differ dramatically from that of South-Africa, but the in-depth studies of seal exploitation within these bands are invaluable in better understanding the importance of seals within coastal hunter-gatherer cultures.

2.4.1 The different methods of seal hunting

In the South African ethnographic record, there is a shortage of in-depth accounts of Cape fur seal hunting and scavenging. From the available records, it is established that hauled out seals were hunted on the beach (Raven-Hart 1967; Schapera & Farrington 1933) with sticks and clubbed to death, while washed up seal carcasses were also scavenged when encountered (Schapera & Farrington 1933). European ethnographic accounts from the Cape record seals hauling up, by the thousands, onto the beaches at night (Schapera & Farrington 1933).

Records from the 1620s state that the seals were inquisitive and not afraid to approach the men who would then, without difficulty, kill hundreds at a time (Raven-Hart 1971b). By 1652 Van Riebeeck noted that the bigger seals on Dassen Island were more aggressive and chased the sealers. Even with this increased hostility, seals were still killed by the thousands. Van Riebeeck noted a shortage of wooden sticks due to the sheer number that broke in the clubbing process. The younger seals were preferred because they were less dangerous, and their pelts also a prettier colour (Thom 1952).

Seals have predictable behavioural traits that hunters can utilise to kill them. In Inuit culture, seals can be hunted on foot by waiting at a seal breathing hole or sneaking up behind a sleeping seal that has hauled out on land to rest. When using the breathing hole technique, a hunter waits at a breathing hole for a seal to put its head out of the water to breathe, then shoots or harpoons it. Alternatively, seal nets are used. These nets are vertically cast underneath the water in open areas where seals aggregate or close to breathing holes to catch and drown seals (Birket-Smith 1936).

When seals are hunted on land, the hunter may disguise himself as a seal by wearing a sealskin. He will then slowly crawl up towards the unsuspecting seals, and if noticed, will mimic seal movements and noises. When he is close enough, the hunter uses a harpoon, rifle or club to kill the seal (Birket-Smith 1936). Seals, being more comfortable in water than on land, will retreat into the water when an enemy is seen. Once in the water, they will be inquisitive, lifting their heads out the water to observe the hunter. Hunters know this behavioural trait very well and patiently wait for this moment before shooting (Nelson 1969).

Seals are generally not very noisy except when they fight or play. Noises generally heard in colonies are yearlings calling their mothers to feed, and if close by, the mothers will always respond (Rand 1956). By mimicking either the yearling or adult female's noises it is possible to attract the opposite party. Once these individuals are lured, it is easy to corner and club them. Nelson (1969) also notes that seals are drawn to almost any kind of sound, especially mechanical noises such as pounding and scratching.

In Inuit culture, a more productive manner of seal hunting is with a harpoon and lance from a kayak (Nansen 1893). The hunter stuffs a sealskin, puts it in the water and mimics seal noises, attracting nearby seals who come closer to investigate. Once close enough, they are harpooned and dragged behind the boat back to the land where they are clubbed to death (Nelson 1969).

Alternatively, from their kayak, hunters will harpoon unsuspecting seals on land or in water. After the harpooned seal has tired, it is pulled closer to the kayak and stabbed to death with a lance. A towing-bladder (seal bladder) and -line is then attached to the dead seal before the hunter continues with his hunt. A hunter can attach as many as four seals to a kayak. When the kayak arrives back at the home base, the hunter loosens the dead seals, and the women pull them in onto the land (Nansen 1893).

2.4.2 Field butchery, storage and transport of seal remains to the consumption site

Ethnographic accounts of seal transportation and field processing by local inhabitants are almost non-existent. All that we know is that the Khoekhoen at the Cape Colony, in the 17th century, would cut pieces of meat from washed-up whale carcasses and bury them under the sand to preserve them for a later date (Raven-Hart 1971a; Schapera & Farrington 1933; Thom 1952). Studies indicate that seal meat and blubber could also have been safely stored for ten days on the beach if buried underneath the sand in the intertidal zone (Smith 2006b; Smith et al. 1992; Woodborne 1996). It is still uncertain which areas of the seal carcass would be stored for later use. In the Inuit culture, similar storage practices would also be utilised. Hunters hunting on foot would limit themselves to one or two seals per trip. One of the two seals would be stored beneath the snow for later use while the other is pulled back to the site using a rope. The one end of the rope is strapped across a hunter's shoulders like a harness, and the other end is threaded through a cut inside the lower mandible which is looped over the snout. The end is then attached to the harness. To lighten the load, blubber would be removed from the ventral half of the seal and sewn back up (Nelson 1969).

Alternative methods include field butchering the seal by removing the pelt, blubber and meat and leaving the skeletal remains behind. Another method also utilised is putting the remains of the second seal into the cavity of the first seal by removing the first seal's ribs, after which the first seal is sewn up and dragged back to the home base (Nelson 1969).

Although no ethnographic accounts exist of seal transport in South Africa, coastal hunter-gatherers may have used similar land-based transport techniques. However, unlike the northern hemisphere climate, there is no snow on the South African coast to facilitate the dragging of the seal carcass back to the site. Alternatively, seals may have been "hogtied" onto a wooden framework to facilitate transport over the rough terrain. If the seal was extensively field butchered, various body parts might have been carried back to site by hand or strapped onto the hunter's back.

2.4.3 Seal butchery and carcass disarticulation at the consumption site

In the Inuit culture, it is the responsibility of the women to skin and butcher the seals (Lantis 1946; Nelson 1969). In Alaska, Nunivak women would skin smaller seals while the bigger seals are left for the men to process (Lantis 1946). Inuit women are known to have immense butchering skill and knowledge of seal anatomy. They can cut up the seal carcass into smaller sections without sawing or breaking any bone. The woman starts the butchering process by cutting open the seal along the belly from the chin to the anus. The skin of the seal is removed along with the attached blubber which is later scraped off. The skin from the front flippers is not removed during the skinning process. The thoracic cavity is opened by removing the sternum and cartilaginous portions of the ribs. The flesh protecting the internal organs are cut open and the organs removed. Meat is cut away during the removal of the ribs, front and hind limbs and the sectioning of the vertebral column. The removed elements are then butchered into smaller pieces at various joints (Nelson 1969). Seals are butchered with an ulu, a crescent-shaped blade (Birket-Smith 1936).

2.4.4 Seal meat and blubber use

In 1497 Vasco Da Gama noted that the local inhabitants of St Helena Bay ate only seals, whales, gazelles and the roots of plants. They also owned many dogs. The Khoekhoen delighted in the taste of seals of which the meat would be consumed unwashed and raw or slightly roasted on the fire. If whales and any other washed up "sea monsters" were encountered, they were also exploited (Raven-Hart 1967).

Accounts from 1608 state that the local inhabitants from Saldanha feasted on fifteen-day old seal carcasses left by European sealers. They would choose the most rotten parts and lay them unwashed on the coals to scorch for a short while before eating. Another account from 1620-1622 mentioned European sealers moving their camp to get away from the stench of the discarded eight-day-old seal remains. The smell was so bad that no wild animals approached. The local inhabitants (Khoekhoen) however did approach the seal carcasses taking some of the rotten meat, placing it on the coals of the fire. Afterwards, they would squeeze the seal meat between two stones and eat it (Raven-Hart 1967).

Numerous accounts of feasting on whale blubber at the Cape also exist. In one account the Khoekhoen encountered a stranded whale. They scooped handfuls of blubber from the carcass and drank it down eagerly (Raven-Hart 1971a; Schapera & Farrington 1933). Seal blubber would most likely also have been consumed in such a fashion.

At the Cape, Jan Van Riebeeck reported the blubber of a whale was boiled down and stored and drunk out of dried kelp (Thom 1952). The boiling down of seal blubber into oil has been observed in the archaeological record at Kasteelberg, a Khoekhoen site near Saldanha. Residue tests on pottery fragments from Kasteelberg show that seal blubber was boiled in these vessels to render oil for consumption and body paint (Smith 2006b).

Whale and seal blubber may also have had social significance in Khoekhoen culture. The smearing of animal fat on the entire body was a common practice, believed to have been a reflection of wealth (Raven-Hart 1971a). Johan Albrecht von Mandelslo, in 1639, noted that the people who lived on Robben Island gave off a nasty smell as they smeared their body with “fish-oil” so much so that they shone (Raven-Hart 1967:152).

Ethnographic accounts from Greenland and Alaska indicate that Inuit groups enjoyed seal meat (Lantis 1946; Nansen 1893; Weyer 1932). They would eat the meat raw, cooked, frozen, dried and fermented (Nansen 1893). Nansen (1893:89-90) reflected on the experience of eating fresh whale and seal blubber as having a sweet taste, reminding him of cream. Only after the blubber had been boiled, roasted or turned stale did he note an oily fish-like taste. A highly esteemed dish was fermented seal head (Nansen 1893). In other Inuit groups, such as the Wainwright people, seal meat was not consumed but instead used as dog food. However, in times of need, the meat of young seals would be eaten raw, frozen or cooked by boiling it in water and eating it off the bones. The legs (flippers), shoulder joints, ribs and vertebrae were the preferred body parts for consumption (Nelson 1969).

The Nunivak people also utilised seal meat and blubber. Seal meat would be cut in strips and hung up on racks to dry or buried in pits under the ground where it preserved well. In fall many dead seals would wash up. If the seal was too decomposed, the meat would be used as dog food. If still in good condition the meat would be stored in underground pits. The seal blubber, on the other hand, would be cut up and put into pokes (sealskin bags). The pokes were put in a water spring, the gentle movement of water breaking down the blubber to oil. Blubber was also melted on a hollowed-out stone (Lantis 1946). Seal blubber was used to make oil for consumption (Nelson 1969), cooking, lighting, heat as well as waterproofing (Fenton 1978), tanning and softening leather (Bailey 1952; Woodborne 1996). Historically seal oil was burnt in lamps, pottery and shallow stones (Weyer 1932).

2.4.5 Seal viscera use

It is known from numerous European accounts that the Khoekhoen wore raw or dried animal intestines around their necks and legs (Raven-Hart 1967, 1971a). The purpose of this might be decoration, consumption or protection from the elements. Unfortunately, the accounts do not specify from which animals these intestines originate. Considering observations of the Cape Khoekhoen wearing cloaks/“karosse” made from seal skin, it is possible that they also utilised seal intestines.

Seal viscera were utilised in Inuit culture for consumption and other utilitarian purposes (Lantis 1946; Nelson 1969; Weyer 1932). In Alaska, Nunivak women would remove the seals' stomachs and intestines to clean and dry. Seal eyes and brains would also be eaten (Lantis 1946). In Greenland, the Inuit people would use intestines as waterproof clothing and windows (Weyer 1932). The Wainwright Inuit would consume the liver, intestines and kidneys, either frozen or cooked (Nelson 1969). The dried sinews of seals and whales, as well as the oesophagus of seals and cormorants, would be used as thread for sewing (Nansen 1893). Ethnographic data from Frobisher Bay, Canada indicate that hunter-gatherer groups utilised the entire seal. The seal carcass was opened, the blood scooped out, the liver cut out and divided into four sections and distributed among the hunters involved, the ribs were then cut out and distributed based on “social picking”, while the brain was used to make pâté and the tongue consumed (Henshaw 2000).

2.4.6 Sealskin use

Seal skins would also have played an essential role in hunter-gatherer economies. From ethnographic accounts, we know that seal skin was worn by the Khoekhoen as clothing in the

form of cloaks or as hats (Raven-Hart 1967,1971a; Schapera & Farrington 1933). Seal teeth (Raven-Hart 1967) and skin were also used as a trading commodity with the Europeans (Raven-Hart 1971b). Sealskin has a water-resistant quality, making it a good source for the manufacture of clothing, shelter, footwear (Birket-Smith 1936; Johnson 2005; Nansen 1893; Nelson 1969; Weyer 1932), bags/containers (Lantis 1946; Weyer 1932), seal fishing nets (Lantis 1946; Weyer 1932) and kayaks (Nansen 1893).

Inuit women would soften, stretch and sew sealskin for boats and clothing as follows: The blubber would be scraped off the sealskin while fresh. Black sealskin would be left to lie in stale urine for a few days. The hair was removed with a knife, and the skin rinsed with seawater and dried in the shade. If used for kayaks, the freshly rinsed black sealskin was placed over the wooden framework of the boat to dry. When using white sealskin, the freshly scraped skin was rolled up and stored in a warm place until the hair could easily be scraped off with a mussel shell or the woman's teeth. The women preferred to use their teeth as this provided the opportunity also to suck out some of the blubber left within the skin. In Inuit culture, women's teeth functioned as a third hand. The front teeth were used to scrape, stretch and hold animal skin during tanning process, leading to extreme tooth wear. After scraping, white sealskins were also hung up and left to dry in the shade (Nansen 1893).

2.4.7 Seal bone use

Seal bones were sometimes used for grease extraction, although accounts of this are uncommon. Seal bone structure is different from that of terrestrial mammals, lacking a marrow cavity. Marrow is evenly distributed throughout the cancellous bone, making it more challenging to extract. The high fat yield of seal blubber would have reduced the need for bone grease extraction (see section 2.6.3.3). This seems to be the case in the literature for southern hemisphere Holocene coastal sites (Cruz-Urbe & Klein 1994; Marean 1985; Martinoli 2015; Martinoli & Vázquez 2017; Nagaoka 2006; Piana et al. 2008; Smith 1985,2004,2005) as well as northern hemisphere coastal sites (Boyle 2005; Erwin 1996; Henshaw 1999,2000; Hodgetts 2005; Hodgetts et al. 2003; Jourdan & Le Mouel 1987; Lyman 2016).

2.5 The spiritual significance of seals

Marine animals play an essential role in the social and economic wellbeing of coastal groups. In many cases, marine animals also fulfil a spiritual role. For instance, in the Baikal region seals have an active ontological and cosmological role in hunter-gatherer cultures in the past and still today. The value of seals is based not so much on their size but on their taste, lack of odour, quality of skin and level of alertness when being hunted.

Hunting success is considered to be highly dependent on a good relationship and standing with the gods and spirits. The bodies of the hunted Baikal seals are to be treated with respect as this will aid in the regeneration of the seal colony. The seal scapula, for instance, would be used to determine the outcome and location of the hunt. The scapula would be tossed like a coin, or burnt over a fire, and the cracks read afterwards (Nomokonova et al. 2013).

Depictions of seals are rare but are present in coastal hunter-gatherer cultures. In Baikal, Russia, depictions of seals start to appear 7 000 years ago. Seals are depicted on rock art at the Upper Lena River, 130km away from Lake Baikal. A seal sculpted out of bone was also found at the Angara River, 90km away from Lake Baikal. These depictions and their distance away from the lake would suggest that seals had some significance even for people living far away from the seal colony. The depictions of seals occur in various settings such as graves, cave and occupation sites. Depictions of seals are rare to absent at the hunting site itself (Zagan-Zaba II) but more common at sites located far from the hunting site (Nomokonova et al. 2013).

2.5.1 Archaeological depictions of marine animals on the southern coast of South Africa

It is argued that the burials on the southern Cape coast are strongly associated with water symbolism. The feeling experienced while going underwater is associated with the spirit world. Artefacts found in southern Cape graves such as seashells, zosteria grass and water-worn stone all have strong symbology associated with the spirit world and water (Pearce 2008). Numerous excavations on the southern Cape coast at archaeological sites such as the Knysna Eastern Head Cave, Robberg Caves D, F & G, Matjies River Rock Shelter, Tsitsikamma Cave and Klasies River Cave 5 have revealed painted stones associated with Holocene hunter-gatherer burials (Rudner 1971). Of the 46 recorded painted stones, 18 came from the Robberg Peninsula (Pearce 2008). In general, these painted stones depict humans in postures associated with the ethnographic San trance dance. It is argued that other images depicted on these stones are also associated with trance or other San religious beliefs (Lewis-

Williams 1984; Pearce 2005,2008). The painting of water animals can be interpreted as a metaphor for the San trance experience of being underwater. Like being underwater, the trance experience involves difficulty in breathing, weightlessness, blurry vision, hearing noises and unconsciousness (Lewis-Williams & Dowson 1999). In San rock art, depictions of water animals such as fish and eels are thought to reflect the underwater trance experience (Lewis-Williams & Dowson 1999).

On the southern Cape coast, depictions of marine animals are found on painted stones. A painted stone from Klasies River Mouth Cave 5 (Figure 2.1a) depicts a man most likely in a trance state next to four dolphins. Another painted stone from Tsitsikamma Cave depicts a whale (Figure 2.1b). The depiction of marine animals on painted stones from these coastal sites should be considered the coastal version of the San trance underwater experience. If these were burial stones, they might have aided the deceased enter the spirit world by “going underwater” (Pearce 2008).

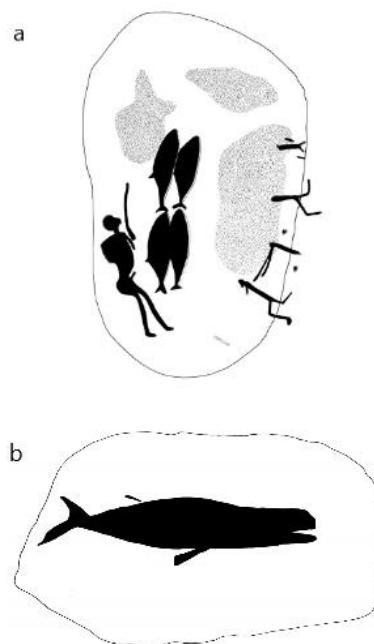


Figure 2.1: Painted burial stones from (a) Klasies River Mouth Cave 5 (SAM-29350) and (b) Tsitsikamma Cave. Images from Pearce (2008) (a&b) Rudner & Rudner (1970) (b).

2.5.2 The Knysna seal scapula

The Knysna seal scapula is a unique artefact (Figure 2.2). It is the only painted bone artefact that has thus far been found in South Africa (Deacon & Deacon 1998). The scapula, with four painted figures in black, is currently housed in the British Museum. It was sold to the museum on 30 November 1886 by a Mr Thomas Hadley. A note found with the scapula mentions that it came from the “Knysna caves” and that the central figure looks like a bird (British Museum Collection Database, 2019).

The scapula was initially discovered by George Rex junior and presented to Thomas Bain (Bain 1880). It is believed that the scapula came from a small cave on the Knysna Eastern Head. It is located ± 37 meters above sea level and contained deposits 3 meters in depth. In 1880 Bain used a stick to scratch out several archaeological artefacts which included grindstones along with faunal and human remains. The most significant find was, however, the “lion” blade bone with paintings on it (Bain 1880; Goodwin 1935). Goodwin (1935) confirmed that this scapula was sent to England and was stolen on the return voyage.

Initially, the scapula was thought to belong to an antelope or lion (cite references here that refer to it as a lion bone). However, Graham Avery from Iziko Museums, South Africa, pointed out that the scapula is in fact that of a seal (Sealy 2006).



Figure 2.2: The Knysna scapula currently housed at the British Museum (image courtesy of © Trustees of the British Museum). Height 17.1 cm, width 20 cm (British Museum Collection Database, 2019).

The first figure seems to be that of a seal (Leggatt 2010; Sealy 2006; Storrar & Komnick 1984), most likely a Cape fur seal. The fur seal is captured during a mid-air jump (Figure 2.3 & 2.4a). The central figure seems to be a bird (Leggatt 2010; Storrar & Komnick 1984), superimposed creatures or a birdlike being (Sealy 2006:583). I believe that this may be a depiction of one or multiple *Spheniscus demersus* (South African penguins) (Figure 2.3 & 2.4b). The third figure is faded, and it is unclear what this figure is supposed to represent (Figure 2.2 & 2.4b). It has been argued that the fourth figure is that of a fish (Leggatt 2010). I believe it is an image of a whale carcass on its back, either floating on the sea or stranded on the beach. The shape matches that of a *Megaptera novaeangliae* (humpback whale) (Figure 2.3 & 2.4c).

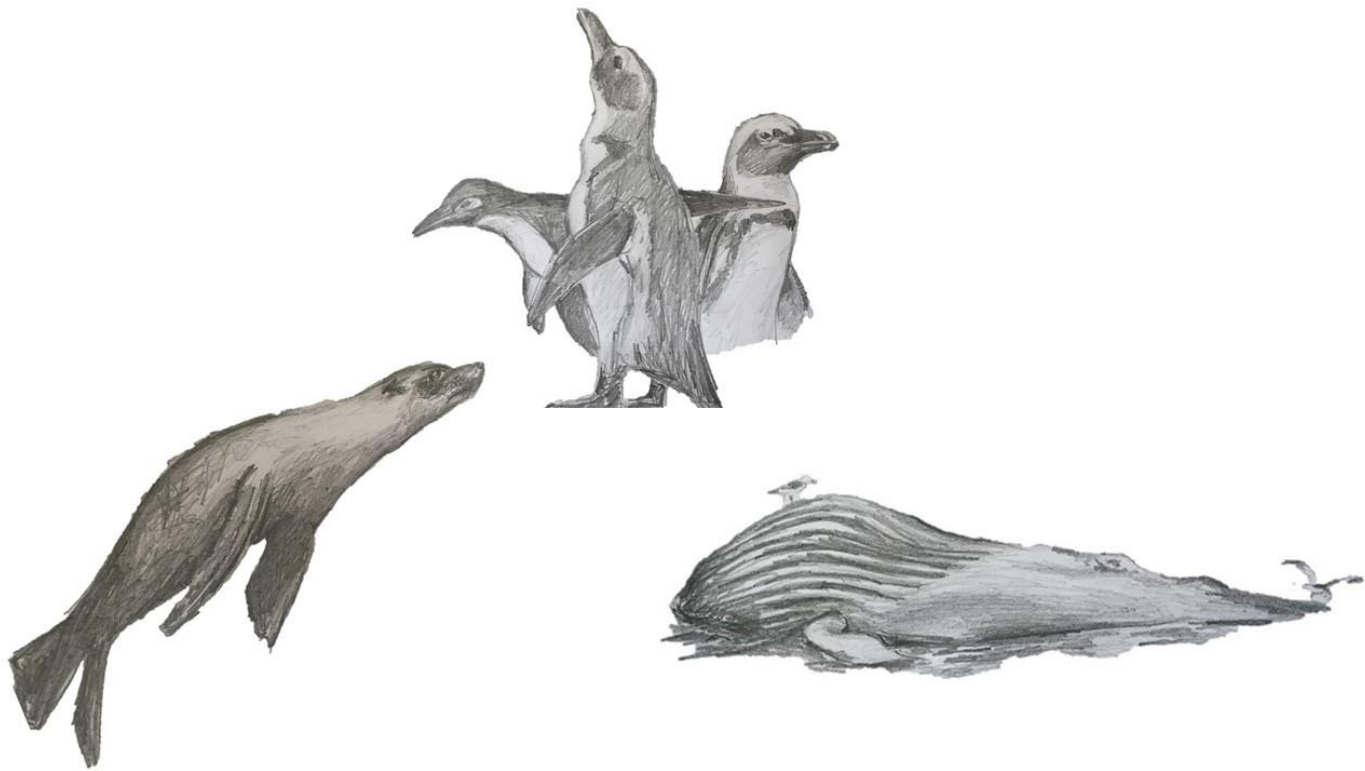


Figure 2.3: Drawings of animals possibly depicted on the Knysna seal scapula. Left to right: a Cape fur seal, South African penguins and a humpback whale (drawn by Lenél Richardson).

Closer inspection of the figures on the Knysna scapula shows (Figure 2.4 a-b) that the flippers of the seal and the outline of the birdlike being/s have been drawn and retraced with a different coloured ink. The painted images also seem to have also been “touched-up” with black ink, as the cracks present on the scapula are filled with black staining (Figure 2.4 a & c). It is interesting to note that the unknown third figure is more faded than the other three (Figure 2.2). It may be that the images on this scapula were modified after its discovery in the 19th century. It is recommended that residue tests be conducted on the ink of this artwork to determine the legitimacy or the level of tampering.

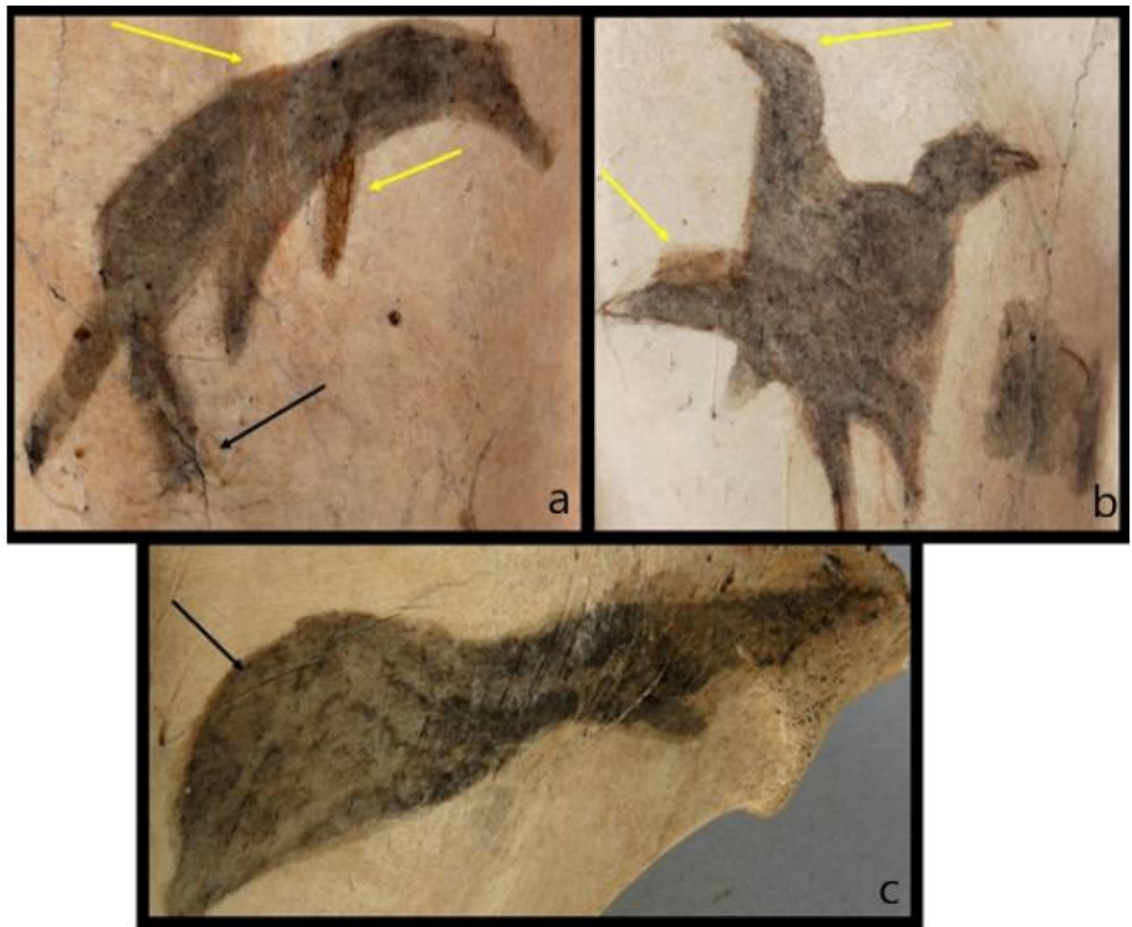


Figure 2.4a-c: Close-ups of the Knysna scapula images. The yellow arrows depict brown ink used to outline and colour the flippers of the seal and outline the birdlike being/s. The black arrows indicate cracks that appear to have been filled with black ink (images courtesy of © Trustees of the British Museum).

2.5.3 The spiritual significance of the Knysna seal scapula

The depiction of painted marine animals on the Knysna seal scapula might also serve as a metaphor for the underwater trance experience such as the painted “burial” stones found along the southern Cape coast. However, unlike other water animals depicted in San rock art, marine animals such as the seal, dolphin, whale and penguin are abnormal (anomalous) creatures (Pearce 2008). This abnormality may have also given them symbolic power in coastal hunter-gatherer culture (Sealy 2006).

Seals, dolphins and whales share characteristics associated with both land mammals and fish. They are fish-like in their appearance, but unlike fish, they breathe air, are warm-blooded and give birth to young that have to go through an extended period of nursing (Pearce 2008; Sealy 2006). Penguins are unlike other birds in that they are flightless and swim in water.

These characteristics mark them out as animals that cross over from one realm to another (land to water, water to air, etc.) Arguably, this echoes the way that shamans move from the material to the spiritual world. Underground and underwater imagery plays a vital role in San shaman thought. The /Xam San of the Cape Province shamans go into a “waterpit” to enter the spirit world. The spirit world is where the dead live with God (Lewis-Williams & Dowson 1990). Using marine animals’ bones such as the Knysna seal scapula would have aided the deceased enter the spirit world. The depiction of anomalous marine animals on the Knysna seal scapula may reflect that the people on the southern Cape coast respected these animals not only as a resource for food and clothing but also as animals with anomalous power.

2.6 Analyses of archaeological faunal assemblages

2.6.1 The history of faunal analysis in South Africa.

Bogan and Robison (1987) suggest that in North America, there were three phases of development of the field of zooarchaeology: the Formative period (the 1860s to 1950s), the Systemization Period (1950s to 1960s) and lastly the Integration Period (1970s to present). It is during the Systemization Period that professional zooarchaeologists came into being. During the Integration Period of the 1970s, increased interest in historical archaeology and its attempt to reconstruct historical lifeways, in particular diet, sparked the growth and expansion of zooarchaeology across the entire world (Landon 2005; Reitz & Wing 2008).

In South Africa, a Zooarchaeology department was established at the Transvaal Museum (now the Ditsong National Museum of Natural History) in 1976. Charles Brain, a palaeontologist, pioneered the zooarchaeological movement in South Africa in the 1970s. He was accompanied by Elizabeth Voigt, Ina Plug and Richard Klein, who analysed faunal remains from numerous archaeological sites to better understand animal use throughout South African prehistory (Hutten 2005). While Voigt and Plug’s research focused on animal remains from inland Iron Age sites (Plug 1999; Plug & Voigt 1985), Klein studied animal remains from Early, Middle and Later Stone Age sites, many along the coast (Klein & Cruz-Uribe 1984).

Faunal studies of numerous coastal MSA and Holocene sites have revealed large quantities of seal remains. MSA levels at Klasies River Mouth (KRM) (Klein 1975, 1976b; Klein & Cruz-Uribe 1996) and Die Kelders (DK) (Klein 1975; Klein & Cruz-Uribe 1996, 2000) as well as Holocene levels at NBC (Deacon 1984; Inskeep 1987a; Klein 1972a), DK (Klein 1975; Klein

& Cruz-Urbe 1996,2000; Schweitzer 1979), Elands Bay Cave (EBC) (Klein & Cruz-Urbe 1987,1996; Parkington 1976), Dune Field Midden (DFM) (Klein & Cruz-Urbe 1996; Parkington 2006; Parkington et al. 1992) and Kasteelberg (KB) (Cruz-Urbe & Klein 1994; Klein & Cruz-Urbe 1996; Smith 2006b) all contain significant assemblages of seals. South African sites with smaller numbers of seal bones include shell middens at Paternoster (Robertshaw 1977), Duiker Eiland (Robertshaw 1979) and Smitswinkelbaai (Marean 1985,1986).

2.6.2 Skeletal frequency and representation: human utilisation and transport of animal remains

Carcass transport decisions play a vital role in the skeletal representation of different taxa in the archaeological record. Hunting or scavenging for animals takes time and energy. For optimal hunting and foraging, hunter-gatherers tend to look for resources which lead to a high post-encounter caloric return rate (Cannon 2003). This means the hunter-gatherer's ultimate goal is to maximize the nutritional benefit relative to the costs involved in field processing and transporting the carcass back to site (O'Connell et al. 1988).

Zooarchaeologists have long been interested in explaining the variability in the skeletal representation of particular taxa within the archaeological record. One of the first concepts to account for this variability was the "schlepp effect" (Lyman 1994b). The "schlepp effect", from the German word "to drag", was initially developed by White (1952,1953a,1954) and popularised by Perkins & Daly (1968) to explain the presence of low utility elements such as the lower limbs in the archaeological record. According to White, there was an inverse relationship between the skeletal element representation and the animal size. The larger the animal, the fewer skeletal elements were present in the archaeological record and vice versa. He argued that the meat of large animals killed a distance away from the home base would be stripped from the skeleton and dragged back to the base in the skin to reduce transport costs. Similarly, he argued that limb bones are more likely to return to the site than the axial skeleton as they have more edible tissue relative to the total element weight. These arguments would later also be used by Perkins and Daly, who called it the "schlepp effect" (O'Connell et al. 1988). Klein has also used the "schlepp effect" to explain the dominance of the skull and lower limb bones of large bovids in the KRM, MSA record. Klein argued that the skull and the lower limb bones of large bovids were preferentially returned to the site

while smaller bovids, to which the “schlepp effect” does not apply, were returned more or less whole (Klein 1976a).

Ethnographic studies among the Hadza in Tanzania contradict the “schlepp effect.” There, axial skeletal elements such as the vertebrae, scapulae, pelvis and the upper-forelimb bones are the most likely to be present in the campsite with lower limb bones more likely to be absent (O'Connell et al. 1988). The number of animal parts returning to the home base will also vary with the size of the hunting party, the distance between home and kill site and the size of the animal (O'Connell et al. 1990). The Hadza, on average, carry loads of 10-20 kg per person but can carry up 45 kg (O'Connell et al. 1988). Animals weighing more than 45 kg would have to be field butchered into smaller sections before being transported back to the home base to optimize the energy return rate.

Binford (1978) identified factors that determine what happens to animal bones between the time that the animal was hunted/scavenged to the point in time where the bones were discarded. Archaeological and ethnographic studies of Inuit people in northern Alaska showed that different anatomical parts of the animal are treated differently based on their food value.

The fat, meat and grease value of each anatomical unit was calculated to determine their food (utility) value. These values were normalised on a scale from 1-100 known as the GUI (general utility index). According to Binford, the GUI values could be used to determine which skeletal elements would return to the site. His studies showed that elements with a high utility value are usually returned to the home base while low utility elements are left at the kill and butchery sites. However, the presence of low-utility index elements in the archaeological record led to the development of an alternative index known as the MGUI (modified general utility index). Binford argued that low-utility elements would have returned to the site only as “riders” or attachments to skeletal elements with a higher utility index (Binford 1978).

In some cases, the dominance of lower limbs and the skull in the archaeological record may have nothing to do with their function as “riders” (Binford 1978) or to the “schlepp effect” (Klein 1976a; Perkins & Daly 1968). Baxter and Hamilton-Dyer (2003) have argued that the dominance of foot and tail bones of fur-bearing mammals in the Saxo-Norman (10th-12th century AD) archaeological record at Hertford, Hertfordshire, U.K. may be indicators of a fur or hide trade. Lower limb bones can also be used for non-dietary purposes such as tool

manufacturing, ornaments, gaming pieces, talismans etc. They may also be considered delicacies, such as pickled pigs feet (Reitz & Wing 2008) or fermented seal flippers (Spray 2002). Skulls yield little meat but may be returned to the site for the valuable by-products of the brain and tongue. These can be eaten, and/or the brain used for treating leather (Reitz & Wing 2008).

When analysing seal hunting and scavenging strategies, it is essential to consider the foraging location and prey size. Seals can be found on land or in the water. These locations require different hunting technologies and strategies. When large seals are caught on land, they usually undergo primary disarticulation at the kill site, and skeletal parts of marginal value are likely to be abandoned at the kill site. On the other hand, smaller seals are likely to be transported whole to the consumption site, regardless of distance. When a seal is captured on water, with the help of watercraft, the complete carcass (regardless of size) will return to the consumption area (Binford 1978).

2.6.3 Bone fragmentation and surface modification

Fragmentation patterns and other bone surface modifications are products of cultural and non-cultural processes and should always be studied together. Identifying these patterns will help interpret food processing, skeletal part distribution, as well as help identify site formation processes (Bunn & Kroll 1986).

2.6.3.1 Butchering marks

Cut marks on bones are mostly associated with the disarticulation or defleshing of the animal. When analysing the types and frequencies of cut marks, and their locations on the skeleton, the underlying causes of the cut marks need to be considered: the anatomy of the animal, the type of lithic technology, transport decisions, the availability of cooking implements and whether the bones are going to be used for marrow extraction (Cruz-Urbe & Klein 1994).

Cut marks may result from disarticulation, skinning and/or filleting. According to Binford, disarticulation and skinning marks will be concentrated at the joints of the animal. These cuts will be relatively deep and in general, oriented at an acute angle to the axes of long bone shaft. Filleting marks will occur on the shaft and in general, they will be shallow and orientated nearly parallel with the long-bone shaft axes (Binford 1981).

In the case of seals, numerous factors such as carcass size, distance from the site, type of butchering tool, and carcass condition (fresh or dried) (Cruz-Urbe & Klein 1994) can

influence cut mark frequency and placement (Cruz-Urbe & Klein 1994; Lyman 1992). Large adult Cape fur seal carcasses (57-250 kg), tend to have higher frequencies of cutmarks because they need to be disarticulated into smaller sections before being transported back to the site. Smaller individuals such as 9-month-old yearlings (24-31 kg) are usually not disarticulated and are returned to the site without being field butchered (Cruz-Urbe & Klein 1994).

This was the case at Zagan-Zaba II, a Holocene site located close to Lake Baikal, Russia. The seal bone assemblage was dominated by yearling and juvenile (sub-adult) Baikal seals with a low frequency of cut marks (Early- to Middle Holocene: 0.2-0.8% and Late Holocene: 2.7%-5.2%). According to Nomokonova et al. (2015), the small size and weight of juvenile (34-58 kg) and yearling Baikal seals (31 kg) mean that extensive field butchery is not required for transportation back to the consumption site, nor is much disarticulation needed before cooking.

The following cutmark distributions are diagnostic of specific butchery activities on seals. Cut marks on the mandible reflect the removal of the tongue while cut marks on the vertebrae and ribs result from the opening of the carcass and the removal of the ribs. Cuts on the proximal epiphysis of the radius, the distal ends of the radius/ulna/tibia, carpals/tarsals, metapodials and phalanges indicate disarticulation of the limbs (Boyle 2005). Cut marks on the long-bone shafts are associated with skinning (Cruz-Urbe & Klein 1994) or filleting (Lyman 1992).

2.6.3.2 Evidence of burning

Burnt material, including burnt bone, is often common in archaeological sites. Various purposeful or accidental human activities can cause bone to end up in the fire: bone grease extraction (Outram 2001,2002), cooking activities, use as fuel or hygienic practices. Bone can also fall into the fire accidentally when dropped close to the hearth (Costamagno et al. 2005; Nomokonova et al. 2015; Spennemann & Colley 1989). The most common scenarios for burnt seal bone are cooking activities, adding fuel to the fire and accidental placement (Nomokonova et al. 2015).

According to the classification system developed by Stiner et al. (1995), bones can show 7 stages of burning: 0 = unburnt, 1 = <50% carbonised, 2 = >50% carbonised, 3 = fully carbonised (burnt black), 4 = <50% calcined, 5 = >50% calcined and 6 = fully calcined (burnt white). Experiments have shown that bones lying close to or underneath the fire typically

show burn stages 0-3 (carbonised) while those directly exposed to fire show burn stages 3-6 (calcined) (Stiner et al. 1995).

Burnt seal bones do appear at Holocene archaeological sites, but in low frequencies. For instance, at Zagan Zaba II, Lake Baikal region Russia, the burning frequency ranged between 1.2% to 14.9% for various occupation phases (Nomokonova et al. 2015). In Tierra del Fuego, Argentina (Martinoli & Vázquez 2017) only 4% of the seal bones at Ajei I (Piana et al. 2008) and 1.2% at Imiwaia I, were burnt (Martinoli 2015). At Ajei I, it is of interest that 25% of the burnt seal skeletal elements were sternum and flipper bones (Piana et al. 2008).

2.6.3.3 Bone nutrient extraction

Bone fat plays a vital role in the subsistence economy of many hunter-gatherer groups (Blumenshine & Madrigal 1993; Brink 1997; Marshall & Pilgram 1991; Outram 1998,1999,2001,2003). Defined criteria have been developed by Villa & Mahieu (1991) to identify intentional (humans and carnivores) and unintentional (taphonomic processes) bone breakage in the archaeological record. It should be noted that the following bone fracturing studies were done on terrestrial mammal bones.

Bone breaks can be categorised into nutritive versus non-nutritive breaks. An oblique angle or a curved outline break is categorised as a nutritive bone break. These types of breaks appear when the bone is broken while still fresh and nutrient-rich. A right angle or transverse outline break is categorised as a non-nutritive break. This kind of break occurs when the bone is dried out and no longer contains nutrients (Villa & Mahieu 1991).

In cases where humans and carnivores are actively trying to remove marrow from terrestrial mammal bones, they tend to leave a large percentage of nutritive oblique (approx. 85-95%) or curved (approx. 80-90%) angled breaks with only a small percentage of non-nutritive transverse (approx. 5-15%) and right (<6%) angle breaks. Higher frequencies of non-nutritive breaks are generally attributed to post-depositional taphonomic activity such as trampling and sediment compaction (Marean et al. 2000a; Villa & Mahieu 1991).

Rendering bone grease is another method to extract fat from animal bones. This is labour-intensive and done mainly in colder climates (Binford 1978). Bone grease is rendered by breaking bones into small pieces and boiling them up (Outram 2005).

Outram (1999) notes that marine mammal bone is very different from terrestrial mammals. The different architecture (Figure 2.5) of seal bones means that one needs to be cautious

about using these studies to interpret seal bone fracturing patterns. No fracturing studies on seal bones could be found. Also, no ethnographic accounts have been found of seal bone exploitation for fat/marrow rendering, even from the Arctic. This may be partly because seal oil has a low melting point, making it difficult to extract (Shahidi et al. 1994). Given the low nutritional yield of seal bones in relation to the high yield of seal meat, blubber, blood and organs it is not surprising that hunter-gatherers usually discard complete seal bones (Boyle 2005; Outram 2005).



Figure 2.5: Seal bones do not have a marrow cavity as seen in this cross-section of a juvenile Cape fur seal radius. Maximum length is 80.3 mm (Photo: Leesha Richardson).

2.6.3.4 Carnivore ecology

Carnivore activity on seal bones is not common in the LSA archaeological assemblages from South Africa, but canid activity was recorded at KBB, DFM (Cruz-Urbe & Klein 1994; Stynder 2008; Woodborne 1996) and Smitswinkelbaai (Marean 1985). What makes seal bones so attractive to carnivores is that the digestible organic matter is distributed throughout the entire bone and not limited to a marrow cavity as in terrestrial mammals. At both KBB and DFM, canid chew marks were mostly found on the long bones of seals, which are especially rich in grease and marrow (Cruz-Urbe & Klein 1994). At Smitswinkelbaai canid chewing occurred on the flipper bones and the scapula (Marean 1985).

The above-mentioned sites were occupied after the introduction of pastoralism (approx. 2 000 BP) in South Africa. The earliest remains of domesticated dogs in the Western Cape Province comes from KBB and dates back to 1100 years ago (Cruz-Urbe & Klein 1994). DNA analyses on canid bones from DFM (Horsburgh 2008) indicate that dogs are present there too, and were probably the cause of the extensive chewing found on the seal long bones.

At Smitswinkelsbaai, Marean attributed gnawing of seal flipper bones to jackals (Marean 1985), but dogs may have been responsible.

HRC and NBC (except for unit 22 – 30 of Inskeep's excavation) were occupied before the introduction of pastoralism and domestic dogs to South Africa. *Hyaena brunnea* (brown hyena) and *Canis mesomelas* (black-backed jackal) are known to frequent the Southern African coast and prey on seals (David 1989). Of these, only black-backed jackals have been noted in the Holocene archaeological record at NBC (Inskeep 1987a; Klein 1972b).

Jackals are omnivores – opportunistic feeders that will eat any small animal they are able to overpower. Larger prey is generally obtained by scavenging carcasses left behind by larger predators (Rowe-Rowe 1983). Jackal and dog gnawing patterns are very similar and far less destructive than hyaena gnawing (Cruz-Urbe & Klein 1994; Woodborne 1996). According to Stynder (2008) the gnawing patterns of small carnivores such as jackals and indigenous dogs on seal bone are influenced by the variation of bone density across the bone, the shape of the bone and the distance of the midshaft from the epiphyseal ends.

Observations have been conducted by Woodborne (1996) on jackals scavenging washed-up seals on the western coast of South Africa. Jackals approach carcasses by first trying to penetrate the neck by biting through the skin at the neck. Their primary goal is to remove all flesh from the bones as well as the stomach and chest contents. They avoid eating the blubber, skin and bones of the seal. They are so good at defleshing carcasses that they rarely leave any marks behind. The only bones that are destroyed in the scavenging process are the sternum, the distal cartilage of the ribs and the proximal margin of the scapula when they try to open the chest cavity.

Analyses of jackal middens from the North Cliff Midden and the East Rock Midden on the West Coast show that jackals tend to gnaw on smaller bones such as the femur, long bone epiphyses, sternum, ribs, carpals and phalanges. Jackals feed on the axial skeleton and the hind limbs only when they are nutritionally stressed and mostly prefer to feed on the easily removable forelimbs (Woodborne 1996).

2.6.3.5 Other taphonomic processes.

Other post-depositional factors such as weathering (Behrensmeyer 1978), trampling (Behrensmeyer et al. 1986; Fiorillo 1989; Klein 1989; Reynard 2014) exfoliation, leaching (Klein 1989; Lyman 1994b), fluvial transport (Behrensmeyer 1975; Boaz & Behrensmeyer 1976), sediment compaction (Klein 1989) and root etching (Behrensmeyer 1978; Lyman

1994b) also need to be considered when examining bone surfaces for human or carnivore activity. Many of these post-depositional processes can remove the outer cortical surface of the bone, removing all evidence of surface modification left behind by humans or carnivores.

2.6.3.6 Bone preservation (Hardness index)

According to Lyman (1994b) the preservation of bone in the archaeological record is also related to its density. A dataset for *Phoca spp.* (North American seal) bone density has been constructed by Chambers (1992). Chamber's seal bone mineral density values are commonly compared with the percentages of minimal animal units (%MAU) from an archaeological record (Boyle 2005; Moody & Hodgetts 2013; Nomokonova et al. 2015). The comparison of the skeletal frequency to bone density enables one to assess the influence of destructive processes in the zooarchaeological record (Lam et al. 2003).

Bone density values are highly variable between species (Lam et al. 2003). The seals from Chambers' (1992) study belong to the family Phocidae while Cape fur seals belong to the family Otariidae. Phocids are more aquatic than otariids and thus not morphologically comparable. For this reason, it is not advisable to use Chambers' dataset on Cape fur seal analyses (Stynder 2008).

Fortunately, a hardness index for Cape fur seal bones was generated by Woodborne (1996). The Cape fur seal dataset indicates the mid-shafts of long bones, followed by the proximal and distal shafts, to be the hardest throughout the entire skeleton. The long bones of the front limbs are harder than the back limbs. The seal mandible, atlas vertebrae and middle parts of the ribs were also found to be hard, while the second and third phalanges and innominates were the softest.

2.6.4 The completeness of the archaeological record.

It is of great importance to determine if the skeletal representation in the archaeological record is biased in any way by excavation or curation practices. During field seasons, faunal material may be sorted by students at the site; a zooarcheologist may not be present to oversee the sorting activities. The material is often sorted into two groups, identifiable vs non-identifiable faunal remains. In some cases, the non-identifiable material may be discarded, leading to the loss of valuable information. Many of the bones that end up in this discard pile are the middle shaft fragments, cortical and/or trabecular bone fragments. These biases can be detected by the zooarchaeologist by implementing two methods, namely the circumference method and the shaft to epiphyses ratio (Marean et al. 2004).

Initially, the circumference method was developed to determine the completeness of shaft fragments, as well as what activities caused their breaks (Bunn 1983). However, this method is also helpful in identifying whether shaft fragments of a particular circumference type (groups 1-3) are missing in the record (Marean et al. 2004). This method groups bone shaft fragments into three groups according to how much of the circumference they preserve; 1: the long bone shaft is less than 50% in circumference, 2: the long bone shaft is more than 50% in circumference and lastly 3: the long bone shaft 100% in circumference (Bunn 1983). Studies have shown an incompletely retained faunal assemblage will have a high frequency of complete bone shafts (Type 3) while a completely retained assemblage does not (Marean et al. 2004).

Studies have shown that long bone shafts tend to preserve better than epiphyses because they are harder (Marean et al. 2004). Measuring the ratio of shafts to epiphyses and comparing with a control sample should, therefore, provide a good indication of the preservation of the archaeological material. Control samples from Blumenshine and Marean (Marean et al. 2004:Figure 7) indicate the epiphyses versus shaft ratios will be reasonably consistent, with shaft fragments always dominating the epiphyses fragments. In a biased collection, the frequency of epiphyses will be closer to that of shafts and sometimes even higher if excavation biases have taken place (Marean et al. 2004).

Many zooarchaeological studies of seals (and other fauna) focus on the identification of the articular ends of skeletal elements, ignoring shaft fragments (Chase 1986; Cruz-Urbe & Klein 1986; Klein 1976b,1989; Klein & Cruz-Urbe 1984; Klein & Scott 1986; Stiner 1991,2002). Such studies are usually focussed on establishing which species were present, and their relative proportions. Additional information can be obtained by studying the remains of the shafts as well, e.g. biotic and abiotic post-depositional processes and excavation and identification decisions (first and second-order changes) as well as exchange networks (Marean & Spencer 1991; Outram 2001,2002; Reitz & Wing 2008; Todd & Rapson 1988). It is argued that only when mid shaft fragments of long bones are included in the analyses of bones that an accurate view of specimen count (NISP) and the resulting minimum number of individuals (MNI) can be seen (Marean & Frey, 1997, Marean & Kim, 1998, Marean et al., 2004, Pickering et al., 2003).

2.7 Quantifying animal and seal remains

Information on the relative abundance of different skeletal parts is essential for understanding the butchering, transport, processing, disposal and nutritional value of animals found in the archaeological record. It also helps to identify activity areas, economic institutions and social organisation of the research site (Reitz & Wing 2008).

2.7.1 Calculating taxonomic abundance: NISP and MNI

Number of identified specimens (NISP) and the minimum number of individuals (MNI) are the quantitative units most commonly used in zooarchaeology to determine the relative frequencies of animal taxa (Lyman 1994c). While NISP is merely an observational unit that identifies the number of specimens present in the collection, the MNI is a derived unit, defined as: “the smallest number of individuals that is necessary to account for all the skeletal elements (specimens) of a particular species found in the site” (Reitz & Wing 2008:205). MNI is estimated by selecting the most abundant skeletal element present in the archaeological collection. This element is then separated into left and right components, where appropriate. The highest number is the MNI (White 1953b). Another standard method, used by Binford (1978), is to divide the number of specimens identified for each element by the number that element is present in a single skeleton.

Additional steps to White’s (1953b) MNI calculation method have been suggested by Klein and Cruz-Urbe (1984). In addition to sorting skeletal elements into left and right, the sorted bones should also be “matched” by looking at the bone size. A distinct trait such as the fusion and nonfusion of epiphyses can be used as a matching criterion. “Matching”, however, does require fairly complete bones. It is also essential to decide if fragmented bones will be incorporated in the MNI calculations. Three options are available: 1) ignore fragmented bones; 2) treat fragmented bones as whole bones; 3) or record as fractions of complete bones. Ideally, fragmented bones should be incorporated into the MNI calculations by using the fraction method (option 3). See section 2.7.2 for a description of the fraction method. After the components have been separated according to these criteria, the skeletal element with the highest number is used as the MNI.

Since the 1970s, there has been a debate on the merits and shortcomings of using NISP compared with MNI to quantify taxonomic abundance (Grayson 1984; Grayson 1973; Klein & Cruz-Urbe 1984; Marshall & Pilgram 1993). NISP is an easier measure for the faunal analyst to obtain, but suffers from several problems. NISPs are higher for more easily

identifiable species, such as seals. They are also influenced by degree of fragmentation of the assemblage, with even a small amount of fragmentation leading to substantially increased NISPs. MNI was developed partly to deal with this problem, but subsequent studies have shown that it, too, is sensitive to fragmentation, decreasing with increasing fragmentation, i.e. greater difficulty of identification (Marshall & Pilgram 1993). MNI is also very sensitive to sample size.

2.7.2 Bone completeness and taxa representation: MNE and MAU

The minimum number of elements (MNE) is used to determine skeletal completeness or representation of various taxa in the archaeological record. Unlike MNI, MNE does not consider age, sex, size variability and left/right element designation (Lyman 2019). There are several ways to calculate MNE and it is for this reason essential to define “elements” when calculating MNE (Lyman 1994c). “Elements” can be defined as skeletal elements (e.g. humeri), specified portions of skeletal elements (e.g. distal humeri) or portions of the skeleton (e.g. pelvis).

One approach to calculating MNE for fragmented long bones is by measuring the percent of complete circumference represented by the long bone shaft fragment and then adding up the percentages of each measured portion of the skeletal element (Marean & Spencer 1991).

This method is simplified by using the GIS-based approach of Marean and colleagues (Abe et al. 2002; Fisher et al. 2017; Marean et al. 2004; Marean et al. 2001), that runs on Faunalyze 2.1. This is faunal coding software written in Python 3.4 and runs within ArcMap (an ESRI ArcGIS 10.x software) (Fisher et al. 2017). All identifiable specimen fragments are drawn onto a digital template of the characteristic skeletal element. Faunalyze counts overlapping fragments to calculate the MNE.

Another method by which MNE can be calculated is by using the fraction method, which records the fraction of the identified skeletal element that remains. The fractions of each skeletal element zone are added up and rounded off to the nearest round number to calculate the MNE. For example: a complete proximal phalanx + half a proximal phalanx + a third of a proximal phalanx ($1.0 + 0.5 + 0.33 = 1.83 \sim 2$ (MNE) (Klein & Cruz-Urbe 1984). This method is less precise than the GIS method because the fractions are recorded only for the epiphyseal ends and not the long bone shaft fragments (Lyman 1994c).

Minimum animal units (MAU) are calculated by using the MNE (Binford 1978; Binford & Bertram 1977; Lyman 1994c) or NISP (Binford 1984) count of each skeletal element, divided

by the number of times the skeletal element occurs in a complete skeleton. The highest MAU value is used as the standard. All other MAU elements are divided by the standard and multiplied by 100. This will give a derived %MAU for each element. MAU can be used to determine the preservation of specific skeletal elements as well as determining patterns involving differential dismemberment and transport of carcasses.

%MAU can be compared to the food utility index (FUI) (Binford 1984). FUI is defined as: “the gross weight of a part minus the dry bone weight of that part, where gross weight is the weight of bone, meat, marrow, and bone grease of each body part” (Metcalf & Jones 1988:489). The FUI and the modified food utility index (MFUI) is commonly used today to indicate the food value of skeletal units (Metcalf & Jones 1988).

A utility index for phocid seals, developed by Lyman et al. (1992), was used by Woodborne (1996) as a basis for his Cape fur seal studies. According to Woodborne’s standardised modified bulk utility index (%SMBUI) for Cape fur seals, skeletal elements such as the ribs/thoracic vertebrae, cervical and lumbar vertebrae should be abundant (51-100%) in the archaeological record. The head, pelvis/sacrum/femora, scapula, humerus and radius/ulna should be less abundant (11-50%). The tibia, fibula and front and back flippers should be least abundant (0.1-10%).

2.8 Determining the season of death: Determining the age and sex of animals in the archaeological record

2.8.1 Assigning relative age to mammals in the archaeological record

In general zooarchaeological studies, the stages of bone ossification (epiphyseal fusion) and the stages of tooth calcification (sometimes extending to examination of dental growth annuli), eruption and wear are used to determine the age at death of animals.

The epiphyses and diaphyses of immature animals undergo fusion at predictable times. To determine age at death, the sequence of long bone epiphyseal fusion for that species needs to be known, by collecting modern data from animals with known ages at death (O'Connor 2004).

The third method of determining the age of animals at death is looking at the level of tooth eruption and wear. As for epiphyseal fusion, this requires knowledge of the ages of tooth eruption for the species in question. Tooth eruption can be used to age individuals who have not yet fully matured. After the last permanent teeth have erupted, tooth wear analyses can

be used. These consist of measuring the crown height and estimating the proportion of the crown that has been worn away. The drawback of using tooth wear is that it is subjective and might reflect aspects not correlated with age, such as the nature of the animal's diet or its nutritional well-being (Reitz & Wing 2008).

The third method of determining the age at death is by studying the incremental growth annuli of tooth enamel and cementum. This method is not widely used as it is destructive (teeth have to be sectioned), labour-intensive and somewhat subjective (O'Connor 2004; Reitz & Wing 2008).

2.8.2 Assigning sex to mammals in the archaeological record

It is not recommended to assign sex to animals unless diagnostic features such as the bacula, spurs or medullary bones are used. However, subjective observations such as larger canines, robusticity/gracility of muscle attachments on the crania and long bones, can be used to establish the sex of an animal if suitable comparative measurement data are available (Reitz & Wing 2008).

2.8.3 Assigning age and sex to pinnipeds from the archaeological record

Marine mammals have very different morphology from terrestrial mammals. It is therefore essential to develop methods specifically for ageing and sexing seals, rather than trying to generalize from studies of terrestrial mammals.

2.8.3. Ageing seals in the archaeological record

Following general principles for mammal ageing and sexing, there are currently three methods to determine the age and thus the season of death in seals. The first method is the measuring of long bone growth (Parkington 1972; Parkington 1976; Storå 2002; Woodborne et al. 1995). The second method is recording the level of epiphyseal fusion (Storå 2001) and the third method is the analyses of dentinal annuli in canine teeth of seals (Bowen et al. 1983; Fletemeyer 1974,1977; Weber et al. 1993; 1998).

The first method seems to have more advantages than the other two methods. Seals give birth only at a specific time of year, which leads to distinct age cohorts separated by 12 month intervals. Long bone measurements of juveniles can determine to which cohort an individual belongs, and help to determine the season of death. The long bone measurements of yearlings (0-12 months) show high inter-individual consistency and little sexual dimorphism, making these measurements relatively reliable as a means of estimating age

(and season of death) (Storå 2002). However, as the animals age, these measurements show greater inter-individual variation and more sexual dimorphism, making it more challenging to determine age and season of death.

Similar studies have been conducted on Cape fur seals from coastal Later Stone Age sites in South Africa. Measurements of distal humeri shafts (Inskeep 1987a; Klein & Cruz-Urbe 1989,1996,2000,2016; Klein et al. 1999) and mandibles (Inskeep 1987a; Parkington 1972; Parkington 1976; Woodborne et al. 1995; Woodborne 1996) have been used to determine age of death (with implications for seasonality of site occupation). The modern comparative database for both humeri and mandibles was constructed mostly from measurements of yearlings ca. 9 months. There is currently no substantial comparative dataset similar to that of Ericson & Storå (1999) for the ageing of older or younger Cape fur seals. Ericson & Storå's (1999) manual provides extensive measurements of the mandible, temporal bone and postcranial bones for *Halichoerus grypus* (grey seal), *Phoca hispida* (ringed seal), *Phoca vitulina* (harbour seal) and *Phoca groenlandica* (harp seal). Crania were not measured as these are often fragmented due to taphonomic factors. Storå's (2001) observations on the sequence of epiphyseal fusion of harp seal long bones should also be replicated for Cape fur seals. Storå identifies four age classes based on the epiphyseal fusion of the scapula, humerus, radius, ulna, metacarpal 1, innominate, femur tibia-fibula and metatarsal 1. The age classes are yearlings (0-12 months), juveniles (10-22 months to 5 years), young adults (5 to 7 years) and old adults (6-9 years and older). This information needs to be collected in order estimate the relative ages of Cape fur seals from coastal LSA archaeological sites.

According to Storå (2002), the pinniped data set for age determination should preferably be obtained from an environmental setting similar to that of the archaeological record. If seals are available at a locale all year round such as a breeding colony it is slightly more difficult to determine the age of the seals. This is because a breeding colony will have a larger variety of age cohorts which varies throughout the year (See section 2.2.5). In such a case, more long bone measurements are required to determine the season of death.

In the scenario where there is no database of long bone measurements and ages of epiphyseal fusion for a particular species (the current predicament with the Cape fur seal assemblage), remains can be assigned to broad age categories based on overall sizes of the bones and stages of epiphyseal fusion. Unfused epiphyses and bones that are clearly smaller than adult size should be classified as a juvenile. Partially fused epiphyses or those that are fused but

with visible suture lines, and close to or equal to adult size should be classified as sub-adult. Lastly, fused epiphyses with no visible suture lines, and skeletal elements of adult size should be classified as an adult (Crockford & Frederick 2011).

Difficulties in using annuli to estimate age were mentioned above. In addition, in seals the annuli in older individuals become thinner and more crowded, which makes it very difficult to distinguish the most recent annuli (Dudley 1999; Hiseler 1997). There was an early attempt to use this method on Cape fur seals (Fletemeyer 1974,1977) which provided a means to determine the season of death. Similarly, Weber et al. (1993) were able to determine the season of death of Baikal seals. It was, however, noted that this method becomes less reliable when individuals are older (6-8 year) as it is more difficult to count the inner dental annuli.

2.8.3.2 Assigning sex to seals in the archaeological record

Little attention is given in the literature to assigning sex to seal remains, probably because this is, to a large extent, based on subjective observations (Reitz & Wing 2008). The following morphological features are noted to be diagnostic of sex: the shape of the innominate bone (King 1983), the width of the canine crown (Schiavini 1990), and the lengths of the long bones (humerus, ulna, femur and tibia) (Orquera 2000).

The work of Martinoli et al. (2015; 2017) in Argentina is among the few that have attempted to determine the sex of archaeological seal remains. Their approaches might be helpful in assigning sex to Cape fur seals in the future. However, this was considered to be beyond the scope of this project.

2.9 Archaeological seal remains and seasonality on the South African coast

2.9.1 Seasonal seal availability

Coastal hunter-gatherers in South Africa foraged and hunted in the intertidal and perhaps in the shallow subtidal zones. There is no evidence that they had access to watercraft. Their access to seals would thus have been limited to the scavenging of washed-up carcasses or hunting land-based breeding and haul-out colonies located within the foraging radius of their home base. The availability of seal carcass wash-ups is highly seasonal. Mortality rates of Cape fur seal pups are highest during the first 30 days after birth (20-40%) (De Villiers & Roux 1992; Wickens & York 1997) as well as during the weaning period, when they are about 9 months old (Marean 1986; Marean & Binford 1986). Newborn pups wash up

between December-January while the 8 to 12-month-olds wash up between July and October. The December breeding and moulting process leads to the depletion of adult seals' fat reserves, leaving them weak and vulnerable, which in many cases also leads to their deaths. Mortality rates and wash-ups of adults are noted to be high between January to March (Marean & Binford 1986). The demography of haul-out and breeding colonies are also seasonally variable, as discussed earlier (see section 2.2.5).

According to Parkington (1972; 2001), Holocene hunter-gatherers on the western coast of South Africa visited the coast on a seasonal basis. This hypothesis is based on the abundances of seasonally available plant and animal remains at EBC and De Hangen (DH). Seal mandible and distal humeri measurements from both DFM and EBC also indicate that hunter-gatherers were at the coast during the winter months. The Cape fur seal record at DFM and EBC consists mostly out of yearling (± 9 -month-old) seals which frequently wash up in large numbers during the winter months (Klein & Cruz-Urbe 2016; Parkington 1972; Parkington 2006).

According to Marean (1986), LSA hunter-gatherers living on the southwestern coast would have followed a similar mobility pattern to the hunter-gatherers frequenting the West Coast. Marean argues that hunter-gatherers would have been at the coastal site of Smitswinkelbaai in the winter season to exploit seals, after which they would return inland in the summer to exploit ungulates and starchy plant underground storage organs. The low fat content of ungulates in the winter season would have forced hunter-gatherers to the coast to look for alternative fat resources. At other LSA sites on the southwestern and southern Cape coast such as Kasteelberg A (KBA) and B (KBB) (Cruz-Urbe & Klein 1994; Klein & Cruz-Urbe 1989, 2016), Die Kelders 1 (DK1) (Avery et al. 1997; Klein & Cruz-Urbe 2000) and NBC (Inskeep 1987a; Klein & Cruz-Urbe 2016), measurements of distal humeri indicate that yearling seals (approx. 9 months old) dominate the seal assemblages. The results seem to indicate that seasonal visits to southwestern and southern Cape LSA sites were also scheduled for winter months (Klein & Cruz-Urbe 2016).

Although Klein and Cruz-Urbe's (1989) analysis of the Kasteelberg seal assemblage was based on comparative material with known date at death, there is uncertainty about the ontogenetic ages. Subsequent study of known-age seals has shown that distal humeri of older animals may fall into the size range proposed for the 9 month olds (Woodborne 2006).

Woodborne et al. (1995) therefore preferred to use the ‘short length’ of the mandible (from the mandibular condyle to the back of the tooth row) to assess size/age. This part of the mandible is frequently preserved in archaeological assemblages. Their comparative sample included a larger proportion of known-age animals. The regression of short length on age for seals up to 36 months (3 years) was associated with acceptable confidence ranges, but for seals older than 36 months, the confidence ranges were too large to be useful. Thus the age (and season of death) of seals up to 3 years old can be accurately determined using the mandible regression method (Woodborne et al. 1995; Woodborne 1996).

Woodborne’s mandibular measurements and age estimates of the EBC Upper, DFM and KBB seals confirmed that the sites on the West Coast were occupied during the winter to summer months (Woodborne et al. 1995; Woodborne 1996). At EBC Lower, there was no seasonal focus of seal exploitation. Second years dominated the assemblage indicating the exploitation of hauling out colonies (Woodborne et al. 1995). At KBB on the southwestern coast, the seal mandible measurements showed that seal exploitation peaked in autumn (May) and spring (October) with some exploitation also present in the summer and winter months. A large number of adult females and the shortage of mature bulls and pups (first cohort) suggest that a breeding colony was being exploited, and that the people of KBB practised selective cropping during their hunting expeditions (Smith 2006a; Woodborne 1996). The large number of seals (MNI 216) found at KBB (Cruz-Urbe & Klein 1994) suggests that sealing was a major activity for the inhabitants of this site. Large scale hunting expeditions are less of a disruption to breeding colonies than ongoing small scale expeditions. It would seem that the KBB people were practising sustainable sealing at a land-based seal colony (Woodborne 1996,2006).

At NBC, distal humeri (Klein 1972b), mandibles and femora (Inskeep 1987a; Klein & Cruz-Urbe 1996) were measured to infer age of death and seasonality of occupation. There is a wide range of measurements, indicating that seals of various ages were exploited at NBC during the Early- to Middle Holocene. After 3 300 BP, there seems to be a shift towards procuring younger seals. A full analysis of age/season of death has not yet been published for seals from NBC. The wide range of ages, however, seems to be consistent with active hunting at a rookery (breeding colony) (Inskeep 1987a).

The MSA seal record at KRM and DK is small but there is a clear absence of young seals within the assemblage. The MSA record does not show the same focus on the exploitation of

9 month old seals as the LSA assemblages at NBC, EBC and DFM do. Therefore MSA people weren't targeting the shore at the time that the weanlings were washing up in the same way as LSA people did (Klein & Cruz-Urbe 1996).

2.9.2 Stable isotope analyses and the interpretation of seasonality at NBC.

Based on the excavated residues from NBC, Inskeep (1987a:303-311) proposed several alternative scenarios for the settlements patterns of hunter-gatherers who used NBC, but could not tell which was the most likely. Subsequent work has focused largely around stable isotope analyses, which have shown the Robberg hunter-gatherers followed a high trophic level marine-based diet. Analyses of the food remains found at Nelson Bay Cave (NBC) suggest the occupants depended on high trophic level fish such as yellowtail and seals as major components of their diet.

By contrast, stable isotope analyses of Holocene human remains found at Matjes River Rock Shelter (MR), 14 km east of the Robberg Peninsula, indicate that the occupants followed a mixed diet (terrestrial and marine). This suggests there was a clear economic separation between the sites and that the occupants of MR had no direct access to the seal colonies on Beacon Island and the Robberg Peninsula. It is believed the Keurbooms River estuary would have served as a natural barrier between the two groups (Figure 2.6). For this territoriality to have been maintained, people would have had to be settled on the coast throughout the year (Sealy 2006).



Figure 2.6: The Holocene archaeological sites (white/plain balloon) separated by the Keurbooms River estuary, which would have served as a natural barrier between the people of Robberg/Plettenberg Bay and Matjes River Rock Shelter. Beacon Island and Cape Seal Point (starred balloons) are the two seal colonies present during the Holocene. The location of Nelson Bay Cave and Hoffman's/Robberg Cave relative to the current Cape fur seal breeding colony distributed along the coastal area between points A and B, known as Rondeklipe and the historical colony, at point C, known as Seal Point

Monks (2005) gives examples of the distribution of hunter-gatherer groups and the frequency and duration with which they occupy a site. Their frequency and duration of stay is heavily influenced by the localised and periodic abundance of an individual marine mammal species. Sea mammals and the resources they supply can have a remarkable impact on human social organisation. The abundance of marine mammals will influence group aggregation size, the composition as well as the size of hunter groups, the type of activities undertaken at the site, the establishment and maintenance of social rank within the group, as well as the establishment and maintenance of redistributive relationships between nearby located groups.

The relative inaccessibility of the Robberg Peninsula to large terrestrial predators (Dusseldorp & Langejans 2013) likely contributed to the establishment of a land-based seal colony (Huisamen et al. 2011; Huisamen, J. et al. 2012; Rand 1959; Schutte-Vlok et al. 2012) on the peninsula. It is uncertain when this breeding colony was established. This seal colony

offered hunter-gatherers a rich and reliable source of meat, fatty acids and minerals. This resource might be expected to reduce the need to be mobile and lead to an increase in population as well as territoriality (Binford 1980). This may have been the fact when looking at NBC and HRC.

This is a unique phenomenon for the South African coast and not yet universally accepted (Parkington 2007). Parkington (2001:3) argues: "...isotopes cannot tell us anything about either mobility or seasonality, though they can test hypotheses derived from evidence that can". Marean (2006) suggests that a more in-depth study needs to be conducted on the seal remains, to support (or otherwise) Sealy's findings. The aim of this project is thus to conduct an in-depth study of the seal remains from NBC and HRC to determine their role in the hunter-gatherer economy and to contribute to debates about settlement patterns.

2.10 The Robberg Peninsula: environment and climate during the Holocene

2.10.1 Change in sea level at Robberg during the terminal Pleistocene and Holocene

During the Last Glacial Maximum, approximately 18 000 BP, sea level was at its lowest on the southern Cape coast (-130 m) (Deacon 1982). Robberg would have been 30 km away from the coast and quite a prominent feature on the landscape (Carr et al. 2019). Grasslands with large grazing bovids such as the now-extinct *Syncerus antiquus* (giant buffalo), *Megalotragus priscus* (giant hartebeest) and *Equus quagga quagga* (quagga) would have been commonplace on the Robberg landscape (Deacon & Deacon 1999; Klein 1972b).

From 18 - 7 kya continental ice sheets started to melt, leading to a 120 (Compton 2001) to 130 m rise in sea level to its present-day position (Deacon 1982). As a result, there was a gradual transition in the landscape from grasslands to shrublands as the coast gradually crept closer. Large grazing bovids disappeared from the archaeological record as small to medium browsers become more abundant (Klein 1972a,b). Coldwater shellfish such as *Choromytilus meridionalis* (black mussel) start to appear in the archaeological record at NBC around 12 kya and are gradually replaced by warm water shellfish such as *Perna perna* (brown mussel) by 10 kya. Other marine resources such as the Cape fur seal and shallow water fish such as *Sparodon durbanensis* (white musselcracker), *Diplodus capensis* (dassie) and *Lithognathus lithognathus* (white steenbras) also appear in the archaeological record at NBC by 10 kya (Deacon 1984; Klein 1972a).

At HRC occupation was interrupted by a sizeable aeolian sand dune, more than 5.5 m deep, which accumulated within the cave between 9.3 -7 kya. The raised sea level seems to have stimulated dune activity on the Robberg Peninsula (Carr et al. 2019). Occupation at NBC, however, was not interrupted by the slight rise in sea level (Klein 1972a; Loftus et al. 2016). During the Middle Holocene, from 7 – 5 kya, there was a small rise in sea-level (Compton 2001). Evidence from the Keurbooms Estuary, less than 10 km away from the Robberg Peninsula, indicate that the sea-level was 2.7 m higher than it is today (Reddering 1988). More estuarine fauna such as the hippopotamus appeared at NBC (Klein 1972a).

Between 5 – 4 kya, the sea levels dropped, staying within 1-2 m of current sea-level throughout the remainder of the Holocene (Compton 2001). The first post-sand dune occupation layers at HRC date to 4.3 kya (Kyriacou 2009). Large amounts of marine food resources such as shellfish, seals and fish accumulate within a brief time period (Kyriacou 2009; Sealy 2006). Research has shown that the climate of the South African Holocene was similar to that of today (Barham 2008; Deacon & Deacon 1999; Mitchell 2002).

2.10.2 Physical environment

The Robberg Peninsula, located on the southern Cape coast, west of Plettenberg Bay, is 185.3 ha in size and surrounded by sea except where it adjoins with the mainland (Figure 2.7). The coastline is altogether 9.5 km long with 8.5 km consisting of rocky shoreline and 1km of sandy beaches (Schutte-Vlok et al. 2012). The geology of the peninsula consists mainly of quartzitic sandstones of the Robberg Formation, which date to the Early Cretaceous, and younger Cretaceous conglomerates (Reddering 1993).



Figure 2.7: The Robberg Peninsula, as seen from the town of Plettenberg Bay (image courtesy of Louisa Hutten).

2.10.3 Rainfall, temperatures and biological environment.

The mean temperature on the peninsula between 1998 and 2010 averaged 19.3 °C. The warmest temperatures are reached between November and March (hottest month: February) and the coldest between April and September (coldest month: July). Rainfall measurements since 1995 indicate an all year rainfall pattern (Wettest months: July to November) with an average rainfall of 555 mm per year (Schutte-Vlok et al. 2012).

The following three vegetation types occur on the peninsula: Cape Seashore Vegetation, Garden Route Shale Fynbos and Knysna Sand Fynbos (Mucina & Rutherford 2006). The peninsula forms part of the Cape Floristic Region (CFR), one of the smallest but richest of six floral kingdoms found throughout the world. With the most diverse biological and endemic ecosystems, 70% of the plant species and 20% of the genera are found nowhere else.

The Robberg Peninsula coastline forms part of the warm temperate south coast marine zone. The rocky and sandy beaches, along with subtidal rocky reefs and sandy benthos, support various warm water marine species, most of which are endemic to the south coast. The offshore reefs are a natural habitat for *Petrus rupestris* (red steenbras) and *Cymatoceps nasutus* (black mussel cracker). The sandy banks between these reefs support *Austroglossus pectoralis* (East Coast sole), *Argyrosomus* spp. (silver kob) and *Merluccius* spp. (hake) (Schutte-Vlok et al. 2012). The rocky shores are also home to the brown mussel and several limpet species (including *Patella cochlear*, *P. granularis*, and *P. oculus*) (Deacon 1982).

The peninsula itself also functions as a breeding colony for *Haematopus moquini* (African black oystercatcher), *Phalacrocorax lucidus* (white-breasted cormorant) (Schutte-Vlok et al. 2012) and the Cape fur seal (Harding 2015). Sea turtles, whales and dolphins are also regularly sighted. Due to the peninsula's rich biodiversity, the Robberg Nature Reserve Complex (RNRC) was established in 1980 and the Robberg Marine Protected Area in 1998 to protect the peninsula and the surrounding marine life (Schutte-Vlok et al. 2012).

2.10.4 The Robberg Cape fur seal colony

“Robberg” translated from Afrikaans means “seal mountain”. The name, along with archaeological records, indicate that the Robberg Peninsula has been home to the Cape fur seal for thousands of years (Inskeep 1987a; Klein 1972a,b).

The Robberg Peninsula and Beacon Island (now joined to the Plettenberg Bay mainland) were two of nine fur seal colonies east of Cape Agulhas during the 19th century. Early accounts of Plettenberg Bay have been interpreted to indicate that Cape fur seals occupied the

furthermost point of the Robberg Peninsula, known as Cape Seal or Seal Point (Figure 2.6 & 2.8) (Huisamen 2012; Stewardson 1999). The earliest estimation of the size of the Robberg seal colony comes from the accounts of George Rex. In 1833 Rex noted that Captain Harker, the government resident at Plettenberg Bay, estimated that about 3 000 seals were living on the Robberg Peninsula. It was suggested that half of the seals should be killed and the other half left to breed. Rex, however, noted that thus far only males had been caught, suggesting that the Robberg colony was a haul-out colony (Metelerkamp 1955). The number of seals killed on the Robberg Peninsula and Beacon Island during the 18th and 19th centuries is unknown. The Beacon Island seal colony ceased to exist by 1881 while the Robberg seal colony was driven to extinction somewhere between 1857 and 1890 (Stewardson 1999).

In 1990 all sealing was suspended in South Africa. The 1990s saw the gradual return of Cape fur seals to the Robberg Peninsula. Rather than returning to Seal Point, seals recolonised the eastern side of the Robberg Peninsula between Grasnek and Witsand in an area called Rondeklippe (Figure 2.6 & 2.9). In 1996, a non-breeding colony of 48-67 seals were recorded at Rondeklippe (Stewardson 1999). In the 1996/1997 breeding season, several pups were also observed on the peninsula (Huisamen 2012). Between 2003 and 2008 the colony size varied between 1514 and 2300 seals (Huisamen, J. et al. 2012). By 2009 Robberg was still considered a non-breeding colony as less than 100 pups were born during the breeding season (Huisamen 2012). By 2017 the Robberg seal colony was reclassified as a breeding colony. 6000 Cape fur seals with 160-200 pups were recorded during the 2016/2017 breeding season (Conry & Van der Vyver 2017). The most recent counts for the 2017/2018 breeding season were approximately 838 pups (Conry et al. 2019a).



Figure 2.8: The historical and probable Holocene location of the Cape fur seal colony on the eastern stretch of the Robberg Peninsula known as Cape Seal Point. (Photo: Leesha Richardson).

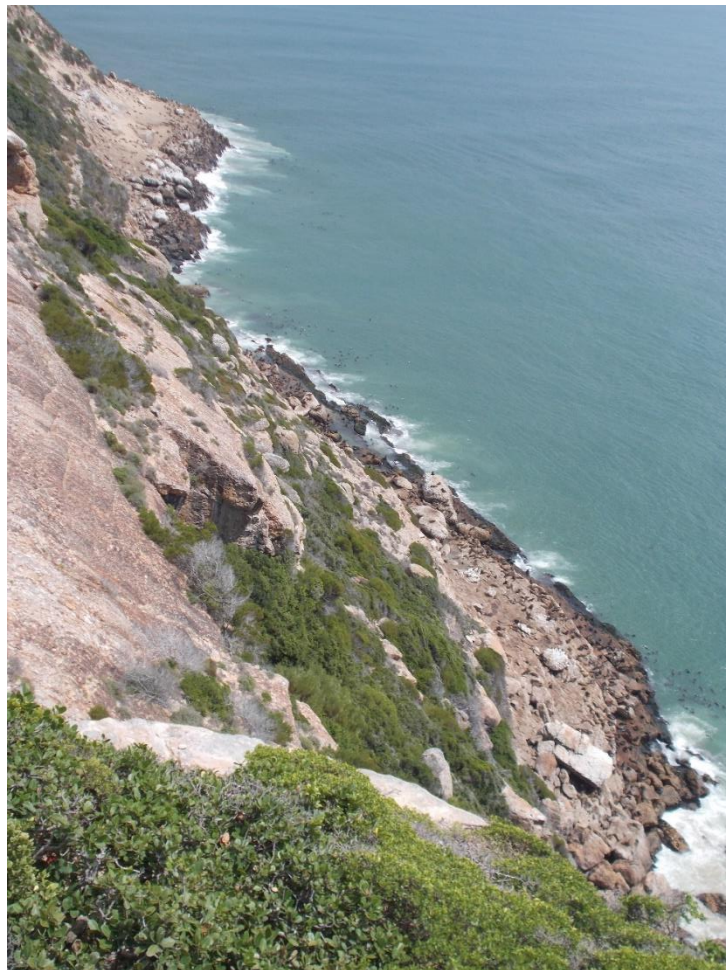


Figure 2.9: The current location of the Cape fur seal colony on the northern stretch of the Robberg Peninsula known as Rondeklippe (image courtesy of Patricia Groenewald).

2.10.5 Other seals found on the Robberg Peninsula.

Other seal species such as the *Mirounga leonina* (southern elephant seal), *Arctocephalus gazella* (Antarctic fur seal) and the *Arctocephalus tropicalis* (sub-Antarctic fur seal) have been observed on the Robberg Peninsula. Only one or two are found hauled out on the peninsula throughout the year. Their closest breeding colony is Marion Island, 2200 km away. It is believed that they come ashore to rest, moult or die (disease or sickness) (Conry et al. 2018; Conry et al. 2019b).

2.11 Excavation history at Robberg.

2.11.1 The archaeological history of Robberg.

Many archaeological sites have been identified on the Robberg Peninsula. Rudner and Rudner (1973) recorded nineteen archaeological sites in rock shelters or caves; there are also a number of open sites. Many of the caves and shelters were disturbed by residents and farmers in the 19th and 20th century. Farmers would collect guano within the caves to use as fertiliser on their lands. Residents would frequent the archaeological sites, digging for human remains and artefacts to sell.

In the 1910s representatives of the South African Museum “excavated” some of the Robberg cave sites. These contractors had no archaeological training and reports were limited. Forty-eight adult and child burials were discovered and collected for the museum from various caves on the peninsula. The grave goods included ostrich eggshell beads, bone and stone tools as well as painted stones. These “burial stones” had human and animal figures painted on them with several depicting hunting scenes. On the reverse side, there was evidence of some of these stones also being used as grinders. Some of these finds are known to have come from HRC (Cave F) (Rudner & Rudner 1973).

2.11.2 Excavations at Nelson Bay Cave.

NBC is located on the south-eastern side of the Robberg Peninsula (34°6'5" S and 23°22'30" E) (Figure 2.10). The cave is 35 m long and 18 m wide and located approximately 18-20 m above sea level (Deacon 1982). It was formed during periods of high sea levels, as wave action eroded the breccia at the contact between the Table Mountain Group (Silurian) quartzite and the Uitenhage Group (Cretaceous) quartzitic sandstone (Butzer 1973).



Figure 2.10: The mouth of Nelson Bay Cave located on the southern stretch of the Robberg Peninsula (Photo: Leesha Richardson).

The first systematic excavations at NBC were conducted in the 1960s and 1970s by R.R. Inskeep (Inskeep & Vogel 1985; Inskeep 1987a) and R.G. Klein (Klein 1972a,b). Before excavations started numerous depressions and associated deposits (dumps), were identified throughout the cave. These dumps were left by people from the recent past who were in search of human remains and artefacts (Figure 2.11) (Inskeep 1987a).

NBC is rich in archaeological deposits which varied in depth throughout the cave. At the mouth of the cave, the deposits were 6 m deep, in the central cave area about 5 m deep and in the back of the cave only 1m deep. On average, the cave ceiling was 3-4 m above the deposits (Figure 2.12). It is estimated that from bedrock to the cave ceiling would have been a maximum height of 10 m (Deacon 1982).

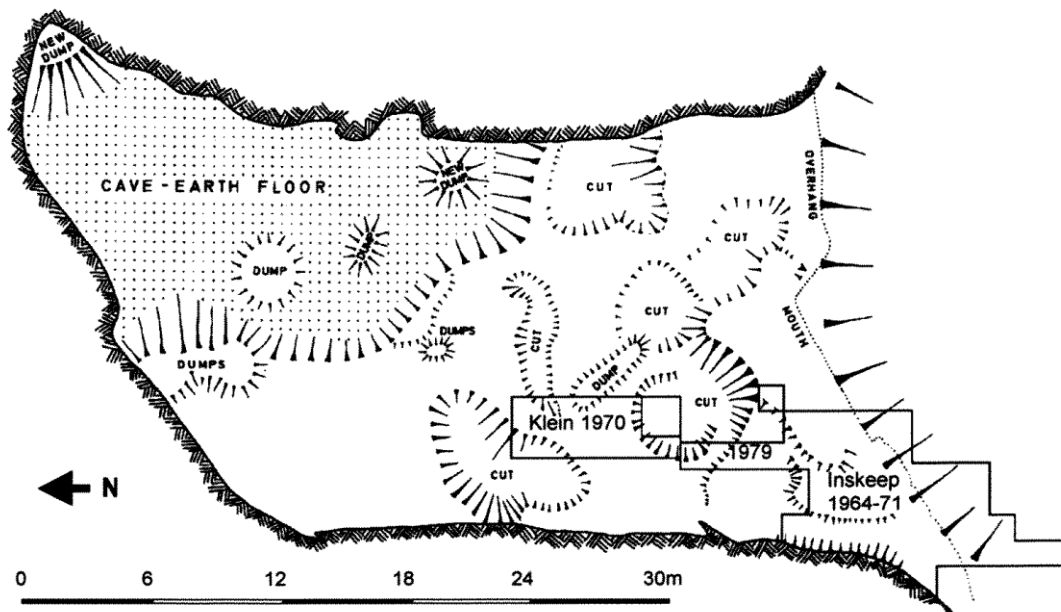


Figure 2.11 Plan of Nelson Bay Cave showing the location of R. Inskeep and R.G. Klein's excavations as well as the location of the disturbances (dumps and cuts) found throughout the cave. From (Deacon & Deacon 1998) after Inskeep (1987).



Figure 2.12: Facing north towards the interior of Nelson Bay Cave. The corrugated iron roof, as seen in the bottom right corner, covers the area excavated in Richard Klein's 1970 field season. This roof was erected in 1992 and serves to protect a museum display of Nelson Bay Cave's archaeological history (Photo: Leesha Richardson).

To create more natural light and enlarge the entrance at NBC, initial excavations by Inskeep (1964–1966) focused on the removal of the uppermost archaeological deposits at the western mouth of NBC (Deacon & Deacon 1998; Deacon & Brett 1993). Inskeep also moved all disturbed (dump) deposits, located throughout the cave, to the farthest point at the back and along the western wall of NBC (Inskeep 1987a). The deposits from the mouth of the cave dated from 3 270 to 500 BP (Inskeep & Vogel 1985; Inskeep 1987a). In search of older deposits, Inskeep dug a 2m² test pit in the central area of NBC in 1964/65 (Deacon 1982,1984; Inskeep 1987a; Klein 1972a,b). Radiocarbon dates from this test pit yielded ages from 3 600 to 5 890 BP (Inskeep & Vogel 1985; Inskeep 1987a).

From Inskeep's excavations, 148 stratigraphic units were identified (Figure 2.13). The radiocarbon dates from Inskeep's excavations range from 455 to 5890 BP (Table 2.2) (Inskeep & Vogel 1985; Inskeep 1987a). From Klein's excavations, 11 LSA stratigraphic units were identified (Figure 2.14). The radiocarbon dates from Klein's excavations date from 5590 to 23 355 BP (Table 2.3) (Loftus et al. 2016)

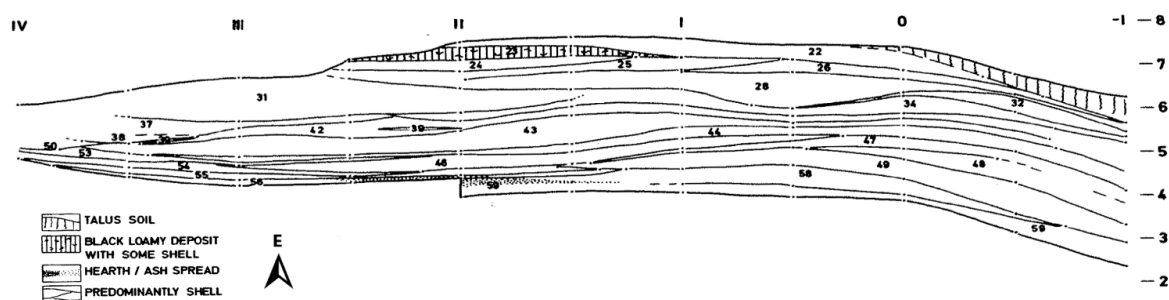


Figure 2.13: Section drawing of the Late Holocene stratigraphic units 22-59 from squares B IV to -1 at NBC. From Inskeep (1987).

Table 2.2: Radiocarbon dates from the Middle- to Late Holocene deposits at Nelson Bay Cave. After Inskeep & Vogel (1985) and Inskeep (1987).

Stratigraphic Unit	Reference No.	Material	$\delta^{13}\text{C}$	Conventional C14 Age (BP)	Calibrated BC/AD (2 sigma calibration)
NBC Unit 22 (a)	Pta - 1361	Charcoal	-24.95 ‰	455±30	-
NBC Unit 22 (b)	Pta - 1360	Charcoal	-25.55 ‰	1500±35	-
NBC Unit 23	Pta - 3361	Charcoal	-25.0 ‰	850±50	-
NBC Unit 24	Pta - 3362	Charcoal	-24.7 ‰	650±50	-
NBC Unit 28	Pta - 3363	Charcoal	-24.4 ‰	2560±60	-
NBC Unit 29	GrN - 5703	Ostrich Eggshell	-24.2 ‰	1930±60	20 AD
NBC Unit 29	OxA - 873	Sheep Bone	-	1100±80	-
NBC Unit 30	Pta - 1363	Charcoal	-24.65 ‰	2085±35	-
NBC Unit 6	Pta - 2921	Charcoal	-24.0 ‰	2450±60	-
NBC Unit 18	GrN - 5715	Ostrich Eggshell	-	2540±50	590 BC
Ribs of Burial 1	Lv - 217	Human Bone	-	2660±150	710 BC
NBC Unit 31	Pta - 1485	Charcoal	-24.5 ‰	2950±80	-
NBC Unit 42	GrN - 5702	Ostrich Eggshell	-24.2 ‰	2925±35	975 BC
NBC Unit 43	Pta - 2913	Charcoal	-24.5 ‰	2970±60	-
NBC Unit 49	Pta - 2920	Charcoal	-25.3 ‰	3020±35	-
NBC Unit 59	Pta - 3095	Charcoal	-24.4 ‰	3190±50	-
NBC Unit 62	Pta - 3097	Charcoal	-24.6 ‰	3270±70	-
NBC Unit 63	Pta - 2919	Charcoal	-25.1 ‰	3600±50	-
NBC Unit 64	Pta - 2910	Charcoal	-24.9 ‰	3350±60	-
NBC Unit 78	Pta - 2916	Charcoal	-25.2 ‰	4520±60	-
NBC Unit 105	Pta - 2933	Charcoal	-25.9 ‰	5320±220	-
NBC Unit 129	Pta - 2915	Charcoal	-25.4 ‰	5860±70	-
NBC Unit 148	Pta - 2909	Charcoal	-24.7 ‰	5890±70	-

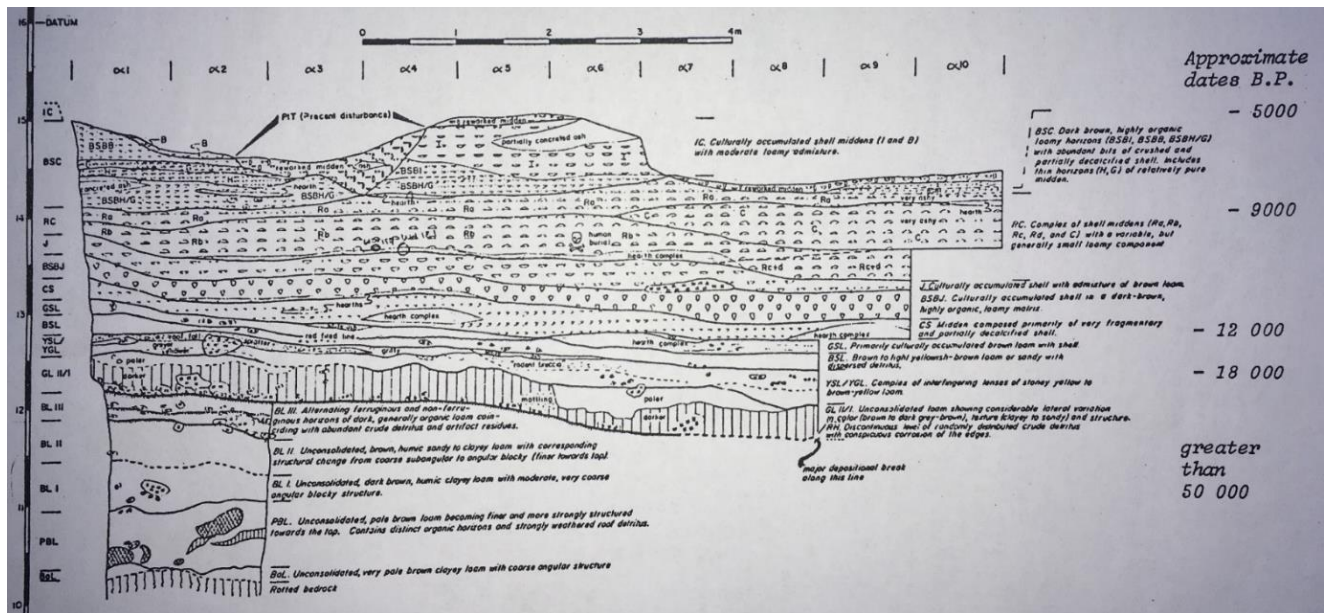


Figure 2.14: The western long section profile of the 1970/71 excavations by R.G. Klein. From J. Deacon (1984) after R.G. Klein (1972b) and unpublished.

Table 2.3: Accelerator mass spectrometry (AMS) dates from the Late- Pleistocene and Early- to Middle Holocene layers at Nelson Bay Cave. After Loftus et al. (2016).

Stratigraphic Unit	Reference No.	Material	$\delta^{13}\text{C}$	Conventional C14 Age (BP)	Calibrated BC/AD (2 sigma calibration)
Ivan	OxA-32448	Bovid Bone	-11.2 ‰	4968±31	5730 - 5590 BC
Ivan	OxA-32449	Bovid Bone	-22.1 ‰	4860±45	5655 - 5330 BC
Rice A	OxA-32450	Bovid Bone	-11.6 ‰	8281±38	9400 - 9030 BC
Rice B	OxA-32451	Bovid Bone	-10.2 ‰	8550±37	9545 - 9460 BC
Rice B	OxA-32452	Bovid Bone	-11.7 ‰	8447±39	9520 - 9305 BC
Jake	OxA-32453	Bovid Bone	-19.0 ‰	9325±45	10,590 - 10,275 BC
BSBJ	OxA-32454	Bovid Bone	-12.2 ‰	10,155±45	11,975 - 11,405 BC
CS	OxA-32455	Bovid Bone	-19.7 ‰	10,340±50	12,400 - 11,825 BC
GSL	OxA-32456	Bovid Bone	-8.7 ‰	12,425±55	14,810 - 14,125 BC
BSL	OxA-32606	Bovid Bone	-10.3 ‰	12,155±55	14,135 - 13,775 BC
BSL	OxA-32457	Bovid Bone	-19.7 ‰	10,450±50	12,515 - 12,020 BC
YSL	OxA-32458	Bovid Bone	-13.8 ‰	14,715±65	18,050 - 17,645 BC
YGL	OxA-32607	Bovid Bone	-21.9 ‰	18,450±100	22,485 - 21,960 BC
YGL	OxA-32608	Bovid Bone	-14.3 ‰	19,110±110	23,355 - 22,615 BC

In 1970 and 1971 Klein started excavations at NBC. Looking for MSA deposits, Klein dug a 30m² trench that continued north from Inskeep's first 1964/65 test pit in the central area of NBC (Figure 2.12) (Deacon 1982,1984; Klein 1972a,b). The majority of the squares reached the base of the LSA deposits (2.5-3m deep) and several reached MSA deposits before encountering bedrock (3-4m deep) (Deacon 1984; Klein 1972b). The LSA deposits from Klein's excavations dated from 5 590 to 23 355 BP (Loftus et al. 2016). The MSA deposits are estimated to date to 60 - 120 kya (Deacon & Deacon 1998). These older deposits were waterlogged, destroying all organic material (Deacon & Brett 1993).

It is estimated that NBC was occupied during the MSA from about 125 - 50 kya and again during the LSA from about 18 kya to a few hundred years ago (Deacon & Brett 1993).

2.11.2.1. Post-Wilton and herders levels at NBC

Units 2-30, dating from 455 to 2085 BP, were shell middens containing sheep and pottery remains. A total of 10 sheep were identified in the uppermost deposits at NBC. AMS dating of a sheep mandible (from Y-I. Unit 29) resulted in a date of 1 100 ± 80 BP (OxA-873) (Gowlett et al. 1987:148). Units 31-63, dating from 2950 to 3 270 BP, consisted of shell deposits with a few ash and hearth lenses.

In units 2-63, dating from 455 to 3270 BP, informal stone tools were abundant with some formal tools (scrapers) also present. The raw material used to manufacture stone tools was mostly quartzite. These technological features are constant with the Post-Wilton industry. Decorative artefacts found within the Post-Wilton layers at NBC include pendants and beads manufactured from *Haliotis midae* (abalone), *Turbo sarmaticus* (alikeurekel) and *Glymeris queketti*, ostrich eggshell, tortoise carapace and bone. Engraved bone, a variety of polished bone tools, tortoise bowls, stone sinkers, grindstones, rubbing stones and palettes were also present. (Deacon & Deacon 1999; Inskeep & Vogel 1985; Inskeep 1987a).

Marine food resources such as shellfish, fish, birds and seals dominated the uppermost deposits. The most common shellfish were brown mussel, and the limpet species *Patella cochlear*. Both would have been readily available from the rocky shoreline along the Robberg Peninsula. Fourteen different fish species were identified from the Holocene levels. The appearance of sinkers at 4 500 BP along with a marked increase in fish remains after 3 500 BP suggests the introduction of new fishing methods during the Post-Wilton. It is noted that within units 31-64, the weight of fish bone per square meter is double that in the

underlying Wilton levels. The presence of larger fish species such as *Seriola lalandi* (Cape yellowtail) and *Dichistius capensis* (galjoen) indicate angling from the gullies located throughout the Robberg Peninsula (Deacon & Deacon 1998; Inskeep 1987a). Smaller fish such as *Lithognathus lithognathus* and *L. mormyrus* (white and sand steenbras) and *Liza richardsonii* (southern mullet) could have been caught with fish traps, nets or spearfishing. It is important to note that 11 out of the 14 fish species identified are considered angling fish.

Cape fur seals dominated the mammal assemblage in the Post-Wilton, mostly yearlings and second-year seals (Inskeep 1987a). Terrestrial mammals contributed only a small amount to the faunal collection. The most common land mammals were rock hyrax (dassie), small to medium browsing bovids such as the duiker, grysbok and grey rhebok as well as occasional Cape buffalo (Deacon & Deacon 1998,1999; Inskeep 1987a). According to Deacon and Deacon (1998) the decreased hunting of small browsing bovids and the apparent increase in reliance on seals and rock hyraxes during the Post-Wilton indicates an intensification of locally available food resources. This would be consistent with population increase and restriction in movement after 3 300 BP at Robberg.

2.11.2.2. The Wilton levels at NBC.

1979 Excavations by Inskeep in the central area of NBC focused on the Middle Holocene deposits designated layers 63 – 148 (3 350 – 5 890 BP). These levels yielded microlithic stone artefacts made mostly from fine grained raw materials such as chalcedony and quartz. There is a high degree of retouch, with small scrapers and backed pieces prominent. This is known as the ‘Wilton’ industry. Ash and hearth features dominate the deposits with shellfish decreasing in numbers. Decorative artefacts such as shell pendants possibly made from *Oxysteles* (sea snails) also become prominent (Inskeep & Vogel 1985; Inskeep 1987a; Kyriacou 2009). Faunal remains were similar to the Post-Wilton layers except for the decrease in seal and fish exploitation as well as the appearance of the white mussel (*Donax serra*) from units 100 -144 (Inskeep 1987a).

Below Unit 148 (> 6 000 BP), Inskeep (1987a:38) noted that shell deposits increased again. Klein’s stratigraphic units Ivan Complex (IC), Brown Soil Complex (BSC) and Rice A (RA) also yielded material characteristic of the Wilton industry. IC and RA were shell middens, while BSC consisted of brown, highly organic sediments (Deacon & Deacon 1998; Klein 1972b). AMS dates from IC to RA were 4860 – 8281 BP (Table 2).

Marine food resources were still dominant with shellfish, fish, seals and birds the most abundant food resources. Terrestrial mammals such as small browsing bovids from the genus *Raphicerus* and rock hyraxes were also abundant. It is important to note that small browsers such as the grysbok prefer bushy environments with scattered grassy patches. This would indicate that the Middle Holocene environment was very similar to current climate conditions on the Robberg Peninsula (Klein 1972a,b).

2.11.2.3. *The Albany levels at NBC.*

The underlying stratigraphic units Rice B-D and Chris (Rice Complex), Jake (J), Brown Soil Below Jake (BSBJ), Crushed Shell (CS) and Grey-brown Shelly Loam (GSL) dating from 8 447 to 12 425 BP and yielded artefact assemblages of the Albany industry (Deacon 1984).

RC and J were both large shell middens. RC contained small lenses of brown soil with a large burnt shell lens. J contained sandy clay loam and various burnt shell lenses. BSBJ was a transition between a midden and brown occupation deposits. CS was a crushed shell midden that had been decalcified. GSL consisted of grey-brown loam deposits with hearths, ash and decalcified shell deposits. Artefact density was low in all five stratigraphic units (Deacon 1984; Klein 1972b).

These five units contained a bone tools, large scrapers and retouched pieces made from quartzite. No backed stone tools were present within the Albany deposits (Deacon & Deacon 1998; Deacon 1978). The most prominent artefacts in the Albany deposits included small double-pointed polished bone fragments, believed to have been used as fish gorges.

Faunal remains continued to be dominated by marine resources such as shellfish, fish, birds and seals, however in decreasing frequency. Terrestrial mammals were similar to those found in the Wilton except for the addition of the eland (*Taurotragus oryx*) and the warthog (*Phacochoerus africanus*) (Deacon & Deacon 1998; Klein 1972a,b). This suggest the environment at NBC was relatively open and grassy (Klein 1972a).

Klein's excavations of the deeper deposits at NBC, yielding the Robberg industry and the MSA, will not be discussed here. Discussions of these levels are available from field reports (Deacon & Deacon 1998,1999; Deacon 1978,1982,1984; Deacon & Brett 1993; Klein 1972a,b; Klein & Cruz-Urbe 1996). Since these levels did not contain marine fauna, including seals, they are not relevant to this thesis.

2.11.3 Excavations at Hoffman's/Robberg Cave.

Approximately 650 m east of NBC is HRC ($34^{\circ}6'10''$ S and $23^{\circ}23'3''$ E) (Figure 2.15 - 2.16). This south-facing cave, located 12m above sea level, is approximately 40 m² and contains enormous mounded-up shell middens stretching from the front to the back of the cave.

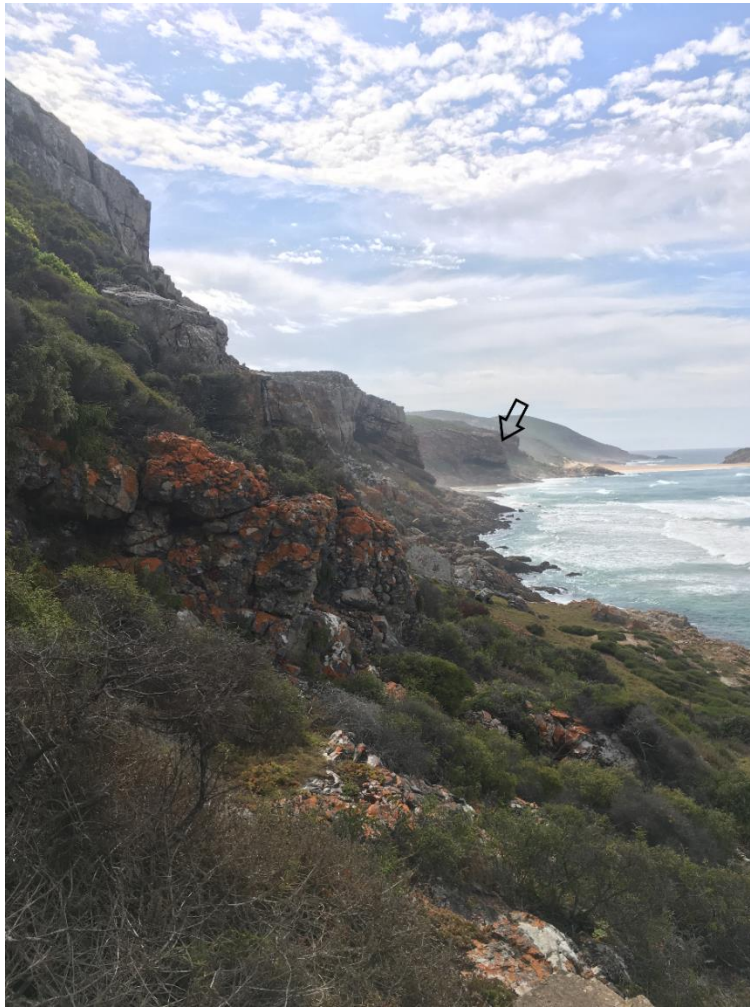


Figure 2.15: Hoffman's/Robberg Cave (black arrow) as seen from Nelson Bay Cave (Photo: Leesha Richardson).



Figure 2.16: Hoffman's/Robberg cave as seen from the Robberg hiking trail (image courtesy of Louisa Hutten).

Systematic excavations at HRC started in the 1950s by A.C. Hoffman. A trench approximately 2 m deep in an LSA midden revealed human remains as well as numerous artefacts and food remains (Figure 2.17) (Fairhall et al. 1976). Hoffman did not leave any description of his excavation methods, but it is clear that he kept only a selection of the finds. These were not described until many decades later (Kyriacou & Sealy 2009). Samples for radiocarbon dating were collected by H.J. Deacon and R.G. Klein in 1970, and yielded uncorrected dates of 3190 ± 110 BP (from the top of the midden) and 3770 ± 100 BP (from the base) (Fairhall et al. 1976). Both dates were on marine shell.

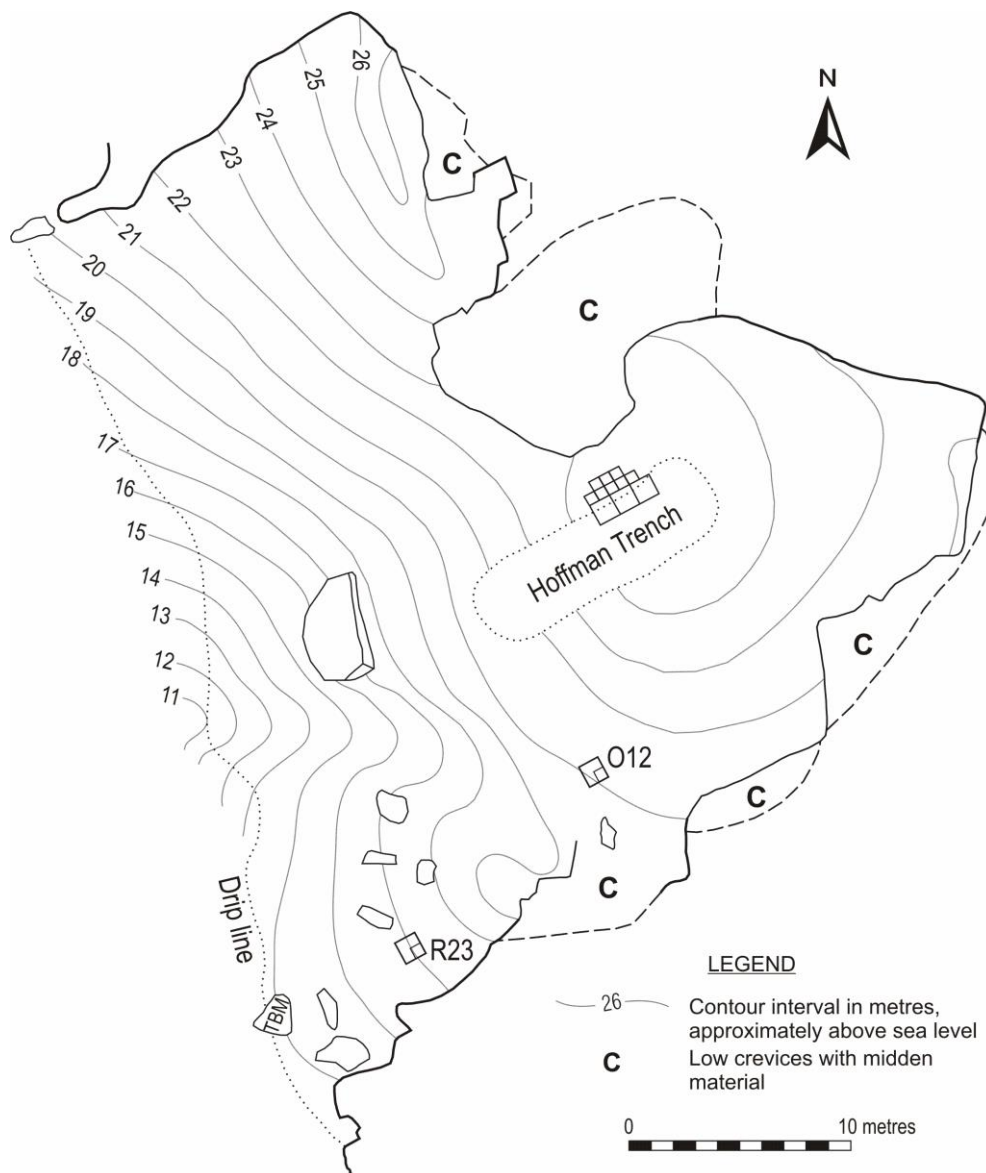


Figure 2.17: Site plan of Hoffman's/Robberg Cave, Hoffman's trench and the squares excavated in 2007-8: E- (from left to right E6a-c, E5a-d and E4a) and D-squares (from left to right D6, D5 and D4) (image courtesy of Judith Sealy).

Renewed excavations at HRC started in 2007 by J. Sealy. The aim of the excavation was to obtain an unselected sample of material for comparison with NBC, and to gain a better understanding of the age. The approach taken was to extend Hoffman's trench by excavating back from the standing section. Three 1 x 1 m squares, E4, E5, and E6 and an additional two 0.25 x 0.25 m quadrants, D4a and D5b, were excavated. An additional season in 2008 focused on the removal of the remainder of the unexcavated quadrants of squares D4 and D5 from 2007 as well as the excavation of square D6 (Figure 2.17). Standard excavation and recording methods were implemented. All material was sieved through 3 mm and 1.5 mm mesh trays. Artefacts were sorted into shell, bone, charcoal and stone in the field and later

curated and housed at the University of Cape Town. In total, 35 stratigraphic units were identified (Figure 2.18 - 2.19) (Kyriacou 2009).

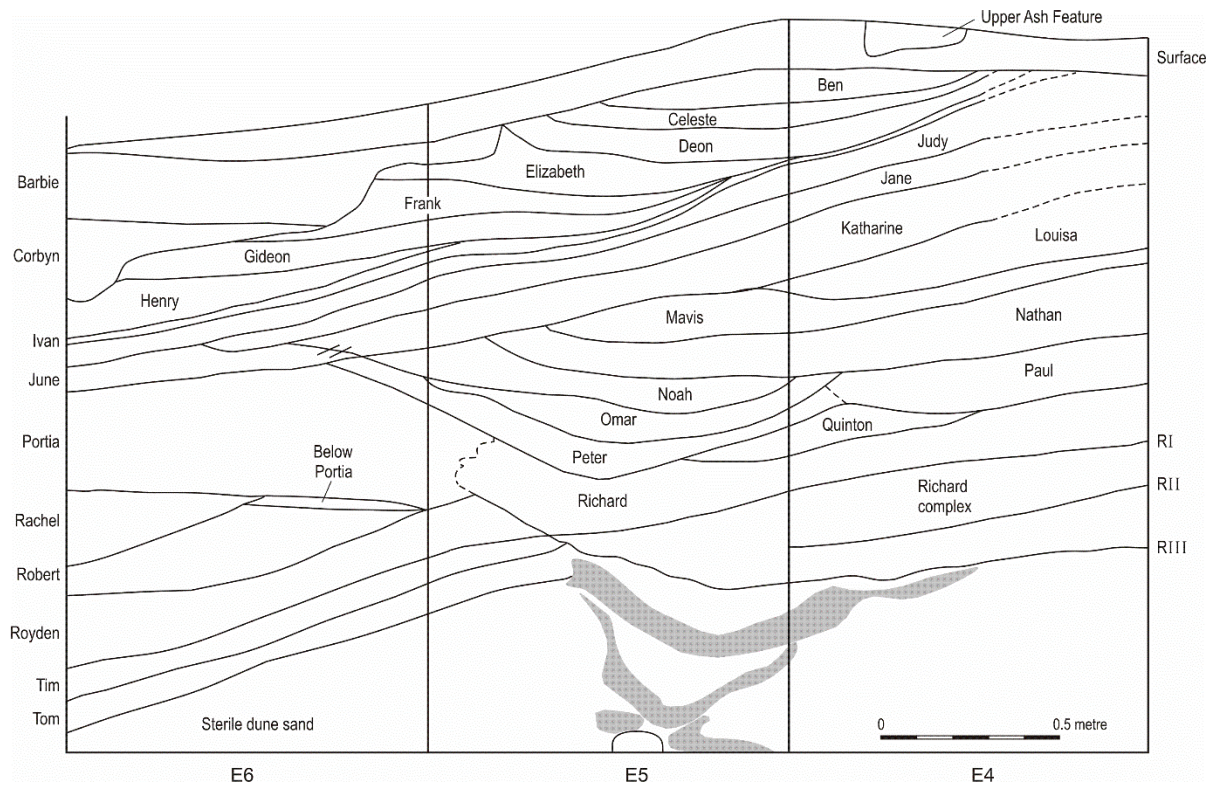


Figure 2.18: Section drawing of the Late Holocene stratigraphic units from squares E4 to E6 at Hoffman's/Robberg Cave (image courtesy of Judith Sealy).



Figure 2.19: Northern profile wall of J.Sealy's excavations at Hoffman's/Robberg cave by the end of the 2008 field season (image courtesy of Louisa Hutten).

Radiocarbon dates from the 2007 field season were measured on charcoal and shell samples. The dates show a 1,360 year occupation span from 2620 to 1260 BC between the layers Ben (top) and Richard III (bottom) at HRC (Table 2.4).

Table 2.4: Radiocarbon dates from Hoffman's/Robberg Cave. After Kyriacou (2009).

Square and Layer	Reference No.	Material	$\delta^{13}\text{C}$	Conventional C14 Age	Calibrated BC (2 sigma calibration)
D5b Ben	Beta - 241142	Charcoal	-24.3 ‰	3370±40BP	1750 - 1590 BC & 1590 - 1530 BC
D5b Ben	Beta - 241143	Shell	+2.3 ‰	3640±40BP	1430 - 1260 BC
E6 Henry	Beta - 241149	Charcoal	-24.8 ‰	3310±40BP	1690 - 1500 BC
E6 Henry	Beta - 241150	Shell	+0.6 ‰	3750±60BP	1610 - 1360 BC
E4 Judy	Beta - 241144	Charcoal	-24.2 ‰	3760±40BP	2290 - 2110 BC & 2100 - 2040 BC
E4 Judy	Beta - 241145	Shell	+2.0 ‰	4100±40BP	2000 - 1780 BC
E5 Tom	Beta - 241147	Charcoal	-22.9 ‰	3920±40BP	2550 - 2540 BC & 2490 - 2290 BC
E5 Tom	Beta - 241148	Shell	+1.7 ‰	4330±60BP	2400 - 2030 BC
E4 Richard III	Beta - 241146	Charcoal	-26.5 ‰	3990±50BP	2620 - 2440 BC, 2420 - 2400 BC & 2380 - 2350 BC

2.11.3.1. Post Wilton levels at HRC.

All of the deposits excavated at HRC contained post-Wilton stone artefacts similar to the Post-Wilton assemblage at NBC. The HRC lithic assemblage was dominated by quartzite flakes and chunks. Some quartzite grinding equipment and hammerstones, shale palettes as well as ochre stained lithics were also recovered. Quartzite scrapers and stone sinkers were rare finds.

Other artefacts included bone tools, rings, beads and pendants, ostrich eggshell beads and shell pendants. A *Scutellastra cochlear* and an *S. tabularis* shell both have ochre staining on the inner surface, suggesting that these shells were used for ochre containers (Kyriacou 2009).

The faunal assemblage at HRC is dominated by fish, seal and birds (Judith Sealy, personal communication). Over twenty-nine fish species were identified from the Post-Wilton deposits. The most common fish species present were *Distichius capensis* (galjoen), *Diplodus capensis* (Cape white seabream), *Liza richardsonii* (southern mullet), *Seriola lalandi* (Cape yellowtail) and *Sarpa salpa* (dreamfish). The majority of the species are shallow water fish, all of which still occur at the Robberg Peninsula today (Van Niekerk 2011). The analyses of the HRC seal assemblage forms part of this thesis and the findings will be presented in Chapter 4. The remainder of the HRC faunal assemblage, including the bird bones, are currently being studied at UCT under the supervision of Judith Sealy.

Chapter 3: Materials and Methods

3.1 Curation of the NBC and HRC seal assemblages

The NBC seal assemblages from both Inskeep's (1987a) and Klein's (1972b) excavations were housed at the IZIKO Museums in Cape Town. At the time of the request, the museum collection was being audited, resulting in limited specialist access to the archaeological material and a long waiting list. After a waiting period of seven months, the material became accessible. The HRC seal assemblage was, however, housed at the University of Cape Town (UCT) and readily available.

Upon receiving the NBC seal collection, the content of the boxes was examined to determine the state of bone preservation and the curation methods implemented by Inskeep and Klein. The seal bones from Inskeep's excavations were unwashed and covered in dark brown sediment which made the identification of surface modification very difficult. The bones were stored in boxes labelled with the relevant information such as the name of the site and the stratigraphic layer. Each seal bone was also individually marked (black and blue ink) with the square number and layer. In some cases, the ink had already rubbed off the grime-covered bones. As a result, only the stratigraphic layer could be recorded (from the label on the box). On other occasions, the square and layer were not inked on to the bone, but other information such as the bone type or side were.

The seal bone assemblage from Klein's excavations was clearly marked and grouped according to the skeletal element or stratigraphic layer. The bones also seem to have been cleaned, making the identification of surface modification easier. The bones were stored in brown paper bags labelled with the skeletal element, the layer and the square. Individual bones were also labelled with the square and layer information. In some cases, one or two bones in larger bags were not labelled.

The seal bones from the 2007-2008 excavations at HRC had to be separated from the other excavated faunal material. This was done by Dolores Jacobs, the Archaeology Department lab assistant at UCT, under my supervision. All the faunal material was stored in plastic ziplock bags by the 2007-2008 excavation team. The bones were not individually labelled, but the square, layer and the date of excavation were written with a permanent marker on the outside of the bag or on a piece of paper stored within the plastic bag. The HRC faunal material was unwashed but relatively clear of dirt, making the identification of surface modification possible.

3.2 Sample selection

Due to time restrictions and the very large size of the seal bone assemblage at NBC, only selected layers could be examined. Layers dating from the Early, Middle and Late Holocene, as well as transition periods, were chosen for study, with preference given to those with the largest assemblages of seal bones.

The following layers from units 22 to 62 of Inskeep's excavations were selected for analysis:

1 930 - 455 BP

- Betty
- Bonnie
- Bonnie/Brett
- Brett

3 000 – 2 000 BP

- Cedric
- Chris
- Clara
- Derek
- Desmond
- Edward
- Esther
- Garth
- Jill
- Luke
- Upper Geoff

* Note: Units 1 to 21 (2 660 – 2 450 BP) and 63 to 112 (5 890 – 3 350 BP) could not be selected for study because material from these units was not present in the boxes made available to me.

The following layers from Klein's excavations were selected for analysis:

Ivan Complex - 4 968 ± 31 BP

- Ivan,
- Ivan/Betsy

- Betsy

Rice Complex - 8 550 ± 37 BP to 8281 ± 38 BP

- Rice A
- Rice B
- Rice C
- Rice D
- Chris

Brown Soil Complex – (only upper section -10 155 ± 45 BP)

- BSBJ

The entire seal assemblage from *in situ* stratigraphic units from 2007-2008 excavations at HRC was analysed. Layers containing seal remains were:

HRC – 4 330 ± 60 BP to 3370 ± 40 BP

- Upper Ash feature
- Ben
- Celeste
- Corbyn
- Deon
- Elizabeth
- Frank
- Gideon
- Henry
- Jane
- Judy
- Katharine
- Louisa
- Mavis
- Nathan
- Paul
- Below Peter
- Portia
- Richard

- Robert
- Royden
- Susan
- Tim
- Tom

*Note: Ivan, June, Noah, Omar, Peter, Quinton and Rachel did not contain any seal remains.

For a more comprehensive view of the skeletal representation and bone modification at NBC and HRC, stratigraphic units/layers were grouped according to their dates into stratigraphic aggregates.

1. The sampled units from Inskeep's excavations were grouped into two stratigraphic aggregates:
 - Units 22 to 29 = Inskeep 1 (I1) - 2 000 BP to 500 AD
 - Units 30 to 62 = Inskeep 2 (I2) - 3 000 BP to 2 000 BP
2. The stratigraphic aggregates assigned by Klein for the NBC Middle- to Late Holocene layers were not modified and replicated as follows for this study:
 - Ivan Complex (IC) ~ 5 000 BP
 - Rice Complex (RC) ~ 6 000 – 9 000 BP
 - Brown soil below Jake (BSBJ) ~ 10 000 BP
3. The seal assemblage at HRC was too small to assign stratigraphic aggregates and as such was labelled as follows:
 - Hoffman's/Robberg Cave (HRC) - $4\,330 \pm 60$ BP to 3370 ± 40 BP

3.3 Cataloguing the seal bones

The seal bones from NBC and HRC included in this study were catalogued and coded as follows:

1. Each specimen was placed in its own individual plastic ziplock bag.
2. A unique specimen number was assigned to each seal specimen. The coder's initials (LR) were included as a prefix to each specimen number for reference purposes.

3. A paper label which gives the site name, stratigraphic unit (layer and square), date of excavation (where applicable), specimen number and seal species were included in each specimen bag.
4. Other information such as skeletal element and side, as determined in this study, along with the information given on the box, was copied on to the outside of the specimen bag with a permanent marker.

3.4 Taxonomic assessment

At the start of this research project, the taxonomy of the pinnipeds from NBC had already been assessed. This was done for HRC as part of this research.

The Department of Archaeology at UCT has a mammalian osteological reference collection which includes six relatively complete Cape fur seal skeletons. These were utilized as comparative specimens for skeletal identification of the HRC collection. In South Africa, the most common seal found along the coast is the Cape fur seal (Section 2.2.1). Occasionally the southern elephant seal, Antarctic fur seal and the sub-Antarctic fur seal will visit the shores of South Africa (Section 2.10.5)

3.5 Assigning age and sex to the NBC and HRC seal assemblage

To assign ages to seals from the archaeological assemblages, long bone measurements of known-age individuals are required. Such a dataset for Cape fur seal does not exist and it is thus problematic to assign ages to the seals in this study. For the purposes of this thesis, bones of smaller than adult size with unfused epiphyses were classified as juvenile. Those close or equal to adult size, with recently fused and/or partially fused epiphyses with visible suture lines were classified as sub-adult. Lastly, those of adult size with fused epiphyses with no visible suture lines were classified as adult (Crockford & Frederick 2011).

Sexual dimorphism is more prominent in the Cape fur seal than in any other fur seal species (Bonner 1994). It is thus risky to assign sex to the NBC and HRC seals. An extensive morphometric dataset for known-age Cape fur seals needs to be constructed to be able to assign age and sex to the NBC and HRC seal assemblage. For this reason, no attempt was made to assign sex to these assemblages.

3.6 Faunal coding

The morphology, state of completeness and surface features of seal specimens from NBC and HRC were recorded using a GIS-based system and Access bone-entry system.

3.6.1 Designing a GIS-based system for Cape fur seals

At the start of this project, the seal bones from both sites were expected to be relatively fragmentary. This was later found not to be true. Previous research has shown that when a collection is highly fragmented, the NISP counts will be inflated, and as a result also the MNE counts (Abe et al. 2002) (Section 2.7.1 - 2.7.2). A newer GIS-based approach was designed to overcome this issue, producing more accurate MNE, surface-modification and frequency counts for fragmented faunal collections (Abe et al. 2002; Fisher et al. 2017; Marean et al. 2004; Marean et al. 2001). It was decided to implement this GIS-based approach, along with other standard fauna coding methods, for the NBC and HRC seal assemblages.

This was done using Faunalyze 2.1. This is a faunal coding software written in Python 3.4, running within ArcMap (an ESRI ArcGIS 10.x software) (Fisher et al. 2017). Faunalyze requires a digital template (based on a photograph) of each skeletal element from every animal species that may be present.

Six photographs were taken of each skeletal element in skeletons of modern seals (both adult and juvenile) from the faunal collections housed at the Munro cottages in Mossel Bay (Mossel Bay Archaeology Project) and the UCT Archaeology Department. This proved to be a time-consuming process with over two thousand RAW format photos taken. A great deal of trial and error was involved during this step of the process. The initial green background proved to be very time-consuming to remove from the photographed image, and all bones had to be photographed again using a black velvet cloth as background.

The six images of each skeletal element were combined into one image using Microsoft Powerpoint, and saved as a .jpeg file. For paired skeletal elements, this was done separately for right- and left-hand sides. The jpeg images were then edited and geo-rectified on ArcMap and saved as “image files”. The outline of each skeletal element was then traced and saved as a “shapefile”. The editing and geo-rectifying of the entire seal skeleton was a lengthy and laborious process.

The next step of the process was to trace the outline of all the archaeological specimens from NBC and HRC onto the relevant skeletal element templates, as well as any cut or bite marks, using ArcGIS. Upon completion, the data can be quantified to enable examination of the location and frequency of cut marks as well as MNI and skeletal abundance of the entire seal collection by using Faunalyze 2.1.

Six months after starting my project, the templates for adult seals were complete and those for juveniles in progress. Still awaiting the NBC bones from IZIKO, it was decided to start working on the HRC seal bone assemblage. Visual inspection of the NBC and HRC seal specimens showed that very few of the long bone mid-shafts were fragmented. Most fragmentation occurred on the proximal and distal ends of the long bones. Due to time restrictions, large sample size (± 5000 bones) and the high level of completeness of the long bone middle shafts, it was decided to code the seal bones from NBC and HRC using a simpler system that runs on Microsoft Access.

Although the seal templates were not, in the end, used for this study, they may be useful in future studies and are available in Appendix B. These images will also be useful as aids in the identification of Cape fur seal skeletal elements. Geo-rectified images can also be provided per request. Templates of the Cape fur seal phalanges and the teeth were not created because so many of these elements were incomplete in the modern seal skeletons.

3.6.2 Skeletal element analysis

A bone entry system designed to run on Microsoft Access was used to code the seal bones from NBC and HRC. The system is developed to ask standard questions relating to bone fragmentation, surface and post-depositional modification, taxonomic identification and skeletal identification (Abe et al. 2002; Marean et al. 2001).

The following aspects relating to surface modification and taphonomic processes of each specimen were recorded:

- The freshness of the break (e.g. new, old, indeterminate).
- Fracture outlines and angles (Villa & Mahieu 1991)
- Shaft circumference (Bunn 1983)
- Bone length and width
- Bone colour (e.g. beige, brown, grey)
- Burning intensity (Stiner et al. 1995)

- Level of fossilisation (e.g. none, light, heavy)
- Conjoined specimens (e.g. specimen LR 256 refits LR 289)
- Surface visibility (0-1) (e.g. 0.8 = 80%)
- Weathering (Behrensmeyer 1978)
- Gastric etching
- Percussion mark location and frequency * (Blumenschine & Selvaggio 1988; Blumenschine et al. 1996)
- Cut mark type and location and frequency (Binford 1981)
- Tooth mark type, location and frequency * (Blumenschine et al. 1996)
- Dendritic pocking (0-3)
(e.g. 0 = none, 1 = < 50%, 2 = > 50% and 3 = 100%)
- Exfoliation (0-3)
- Matrix cover (0-3)
- Sheen (0-3)
- Smoothing (0-3)

Aspects relating to the skeletal element and taxon were also recorded:

- Taxon
- Size (1-5)
- Age (adult, sub-adult, juvenile)
- Skeletal element (e.g. humerus, radius)
- Fragment type (e.g. shaft, epiphyses)
- State of fusion of the proximal and distal epiphysis (e.g. fused, unfused)
- Diagnostic landmark completeness (e.g. greater trochanter 50%)
- Tooth root fusion (open, closed, fusing)
- Tooth wear (early, middle, late)

* According to Blumenschine & Selvaggio (1988) percussion marks are defined as: “pits, grooves or isolated patches of micro-striations”. Similar to percussion marks, carnivore tooth marks can also cause pitting, grooving and micro-striations. Morphological and contextual criteria set out by Blumenschine et al. (1996) were used to differentiate between these two types of marks. According to the criteria, tooth marks of carnivores leave multiple pits and

grooves (u-shaped) which can penetrate the cortical and the medullary surface of bones. Micro-striations are rare but can occur in low-density patches. Percussion marks, on the other hand, cause very shallow micro-striations on the cortical surface of bones. These micro-striations, usually emanating from pits and grooves, occur in dense superficial patches close to a fractured bone edge.

3.6.3 Instruments used

All specimen measurements were taken with digital callipers. Bones were visually examined for surface modification under a digital microscope (Dino Light Edge AM4815ZT 20x-220x 1.3 MP). Due to the extensive collection of seal bones sampled, only bones with unambiguous surface modification were photographed with a camera (Sony Cyber-shot RX100 V (BSI 20.1MP sensor, ZEISS Vario-Sonnar T 24-70mm f/1.8-2.8 lens) and the Dino Light digital microscope.

3.7 Assessment of fragmentation

If there is no fragmentation, NISP and MNE values should be equal. The quantification of the specimens was performed using the number of identified specimens (NISP) and a minimum number of skeletal elements (MNE) values. By definition a *specimen* is “a bone or tooth, or fragments thereof” while a *skeletal element* is “a single complete bone or tooth in the skeleton of an animal” (Lyman 1994a:289).

The MNE was calculated using a method similar to Klein & Cruz Uribe’s (1984) fraction method (Section 2.7.2). Each skeletal element was assigned a specific number of diagnostic zones. For example, the rib had five diagnostic zones: rib head epiphysis, rib head metaphysis, tubercle facet, costal angle and costal cartilage facet. The fraction of each diagnostic zone was recorded and added up. For example, Sample 1 (Rib): $1.0 + 1.0 + 1.0 + 0.75 + 0 = 3.75$. This was done for all specimens that could be identified to a specific skeletal element. The fractions of each skeletal element (e.g. rib, humerus) were added up and divided by the number of diagnostic zones for that skeletal element. For example, 3 specimens (Rib) - $3.75 + 5.0 + 2.5 = 11.25/5 = 2.25$. The averaged fraction was then rounded off to the nearest whole number to determine the MNE ($2.25 \sim 2$ ribs). Factors such as the size and side of all the specimens were also taken into account before calculating the MNE (Bunn 1986). The issue of overlapping middle shaft fragments was not relevant. Unlike

terrestrial mammal bone, there were very few shaft fragments in the seal assemblage at both NBC and HRC.

The NISP values were compared to the MNE values to assess the level of fragmentation (NISP:MNE) (Klein & Cruz-Uribe 1984). The minimum number of animal units (MAU) and the percent MAU (%MAU) were calculated from the MNE values using principles set out by Binford (1984). The percent standardised modified bulk utility index (%SMBUI) for Cape fur seals (Woodborne 1996) were compared to the %MAU when exploring the relationship between the Cape fur seal bone utility value and transport strategies (Binford 1984) (Section 2.7.2).

MNI was calculated using methods discussed by Klein and Cruz Uribe (1984). Skeletal elements were sorted into left and right as well as “matched” by using the fusing and nonfusing epiphyses criteria (Section 2.7.1). Fragmented bones were also incorporated in the MNI calculations using a modified version of the fraction method (see MNE calculations above for a description of modified fraction method). After the elements were separated according to these criteria, the highest number was used as the MNI.

The results of the application of these methods is reported in the next chapter.

Chapter 4: Results

4.1 Specimen counts and identification

A total of 5008 seal specimens (NISP) were coded and analysed from Nelson Bay Cave (NBC) and Hoffman's/Robberg Cave (HRC) (Table 4.1). The most common species was *Arctocephalus pusillus* (Cape fur seal) of which there were 4518 specimens from NBC and 460 from HRC. *Mirounga leonina* (southern elephant seal) (23/4548) and *Arctocephalus gazella* (Antarctic fur seal) (4/4548) were also noted in the Early- to Middle Holocene layers at NBC. These specimens consisted only of canine and post-canines. Due to their small numbers and lack of post-cranial elements, these specimens were coded but not included in the data analyses of this thesis. All specimens could be identified to species while 99% (4545/4548) of the specimens from NBC and 98.7% (454/460) from HRC was identifiable to skeletal element. Approximate age could be assigned to 88% (4005/4548) and 86% (395/460) of the bones respectively, while in 65% (2946/4548) and 56% (256/460) of the paired skeletal elements, left and right could be distinguished.

Table 4.1: Numbers of identified seal specimens from selected stratigraphic units at NBC and HRC.

Species	NBC		HRC	
	NISP	Levels	NISP	Levels
<i>A. pusillus</i>	4518	All	460	All
<i>M. leonina</i>	23	IC, RC & BSBJ	0	None
<i>A. gazella</i>	4	RC & BSBJ	0	None
Pinnipedia	3	I1 & RC	0	None
Total	4548		460	

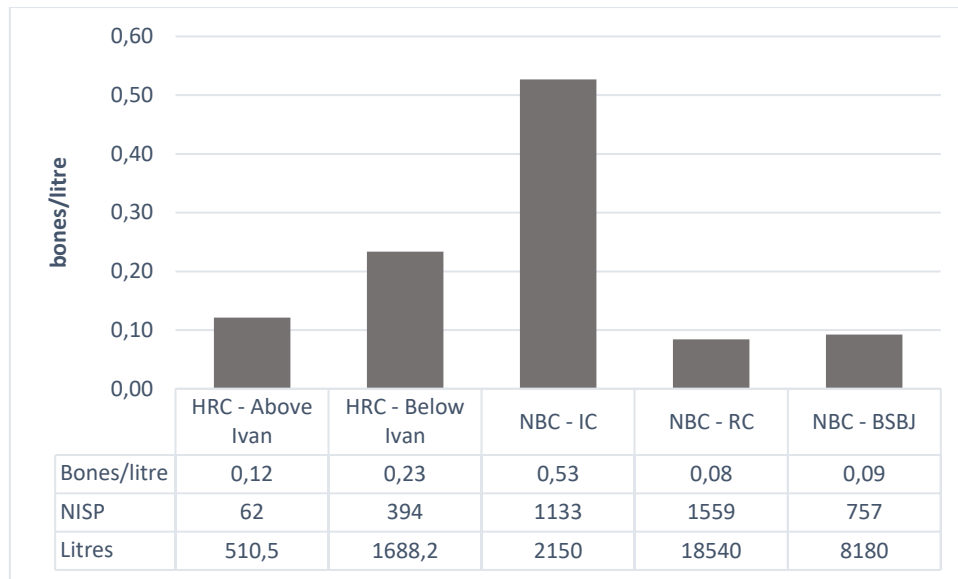


Figure 4.1: Numbers of seal bone per litre of sediment removed from BSBJ (~10 000 BP), RC (~6 000 – 9 000 BP) and IC (~5 000 BP) at NBC and deposits below (~4 000 BP) and above (~3 300BP) Ivan at HRC.

Figure 4.1 shows that the numbers of seal bones per litre of deposit (where this information was available) varied through the Holocene. During the Early Holocene the value was ~ 0.1 (BSBJ & RC), increasing to ~ 0.5 (IC) in the Middle Holocene and then falling to ~ 0.2 to 0.1 in the Middle- to Late Holocene (HRC). Due to taphonomic processes such as sediment compaction and trampling as well as the proportion of shell in the deposit, it was not possible to interpret the significance of the difference in bone per litre ratios.

4.2 Minimum numbers of individuals at NBC and HRC

Table 4.2: Minimum number of individuals (MNI) from I1, I2, HRC, IC, RC and BSBJ.

Level	skeletal element	MNI
I1	Radius/L	9
I2	Ulna/L	5
HRC	Radius/L	4
IC	Radius/L	17
RC	1st Metacarpal/L	45
BSBJ	Femur/R	14

*MNI calculated using White (1984)

Table 4.2 shows a minimum number of 94 Cape fur seals from the layers studied. 59 seals came from the Early Holocene layers BSBJ (~10 000 BP) and RC (~9 000 – 6 000 BP) and

17 from the Middle Holocene layer IC (~5 000 BP) at NBC. From the Late Holocene layers, 4 seals came from HRC (~4 000 – 3 000 BP) and 14 seals from I2 (~3 000 – 2 000 BP) and I1 (~2 000 - 500 BP) at NBC.

4.3 Skeletal element representation

4.3.1 Skeletal frequency: NISP versus MNE values

NISP and MNE values were used to determine the MAU and %MAU at NBC (Table 4.3 and Figure 4.2) and HRC (Table 4.4 and Figure 4.3).

Table 4.3: Calculated %MAU values for each skeletal element at NBC using NISP and MNE values.

Skeletal Element	NBC					
	NISP	MAU	%MAU	MNE	MAU	%MAU
Dentition (upper)	330	16.5	21.7	330	16.5	28.9
Dentition (lower)	286	17.9	16.7	285	17.8	22.2
Mandible †	60	30.0	66.7	52	26.0	77.8
Maxilla †	48	24.0	50.0	39	19.5	66.7
Hyoid †	10	1.1	11.7	10	1.1	15.6
Atlas •	13	13.0	16.7	12	12.0	22.2
Axis •	8	8.0	0.0	8	8.0	0.0
Cervical vertebrae •	35	7.0	5.0	27	5.4	8.9
Scapula †	26	13.0	33.3	19	9.5	44.4
Humerus ‡	92	46.0	83.3	48	24.0	100.0
Radius ‡	144	72.0	100.0	108	54.0	100.0
Ulna ‡	78	39.0	58.3	71	35.5	55.6
Carpal ◇	26	1.9	33.3	26	1.9	44.4
Metacarpal Ω	524	52.4	53.3	488	48.8	64.4
Phalanx (front) Ω	818	29.2	26.7	734	26.2	33.3
Thoracic vertebrae •	56	3.7	21.7	32	2.1	13.3
Rib †	58	1.9	36.7	44	1.5	28.9
Sternebra †	58	6.4	23.3	58	6.4	31.1
Lumbar vertebrae •	62	12.4	50.0	37	7.4	53.3
Sacrum •	5	5.0	0.0	5	5.0	0.0
Caudal vertebrae •	6	0.7	10.0	4	0.4	13.3
Innominate •	69	34.5	75.0	48	24.0	77.8
Femur ‡	126	63.0	25.0	94	47.0	33.3
Tibia ‡	133	66.5	66.7	89	44.5	44.4
Fibula ‡	59	29.5	41.7	46	23.0	55.6
Tarsal ◇	121	7.6	11.7	121	7.6	15.6
Metatarsal Ω	378	37.8	35.0	293	29.3	44.4
Phalanx (back) Ω	619	22.1	23.3	548	19.6	24.4

*Note this table does not include non-identified fragments. The following symbols were used to group skeletal elements: † = Flat bones, • = Irregular bones, ‡ = Long bones, Ω = digitopodia, ◇ = Short bones

Table 4.4: Calculated %MAU values for each skeletal element from HRC using NISP and MNE values.

Skeletal Element	HRC					
	NISP	MAU	%MAU	MNE	MAU	%MAU
Dentition (upper)	25	1.3	22.9	25	1.3	30.6
Dentition (lower)	16	1.0	24.8	16	1.0	33.0
Mandible †	8	4.0	41.7	7	3.5	48.2
Maxilla †	6	3.0	33.3	6	3.0	36.1
Hyoid †	6	0.7	1.5	6	0.7	2.1
Atlas •	1	1.0	18.1	1	1.0	22.2
Axis •	0	0.0	11.1	0	0.0	14.8
Cervical vertebrae •	2	0.3	9.7	2	0.4	10.0
Scapula †	4	2.0	18.1	4	2.0	17.6
Humerus ‡	10	5.0	63.9	9	4.5	44.4
Radius ‡	12	6.0	100.0	9	4.5	100.0
Ulna ‡	7	3.5	54.2	5	2.5	65.7
Carpal ◇	28	2.0	2.6	28	2.0	3.4
Metacarpal Ω	32	3.2	72.8	29	2.9	90.4
Phalanx (front) Ω	46	1.6	40.6	42	1.5	48.5
Thoracic vertebrae •	20	1.3	5.2	9	0.6	3.9
Rib †	65	2.2	2.7	38	1.3	2.7
Sternebra †	13	1.4	8.9	13	1.4	11.9
Lumbar vertebrae •	15	3.0	17.2	12	2.4	13.7
Sacrum •	0	0.0	6.9	0	0.0	9.3
Caudal vertebrae •	5	0.6	0.9	5	0.6	0.8
Innominate •	9	4.5	47.2	7	3.5	44.4
Femur ‡	3	1.5	87.5	3	1.5	87.0
Tibia ‡	8	4.0	92.4	4	2.0	82.4
Fibula ‡	5	2.5	41.0	5	2.5	42.6
Tarsal ◇	11	0.7	10.5	11	0.7	14.0
Metatarsal Ω	21	2.1	52.5	20	2.0	54.3
Phalanx (back) Ω	38	1.4	30.7	30	1.1	36.2

*Note this table does not include non-identified fragments. The following symbols were used to group skeletal elements: † = Flat bones, • = Irregular bones, ‡ = Long bones, Ω = digitopodia, ◇ = Short bones

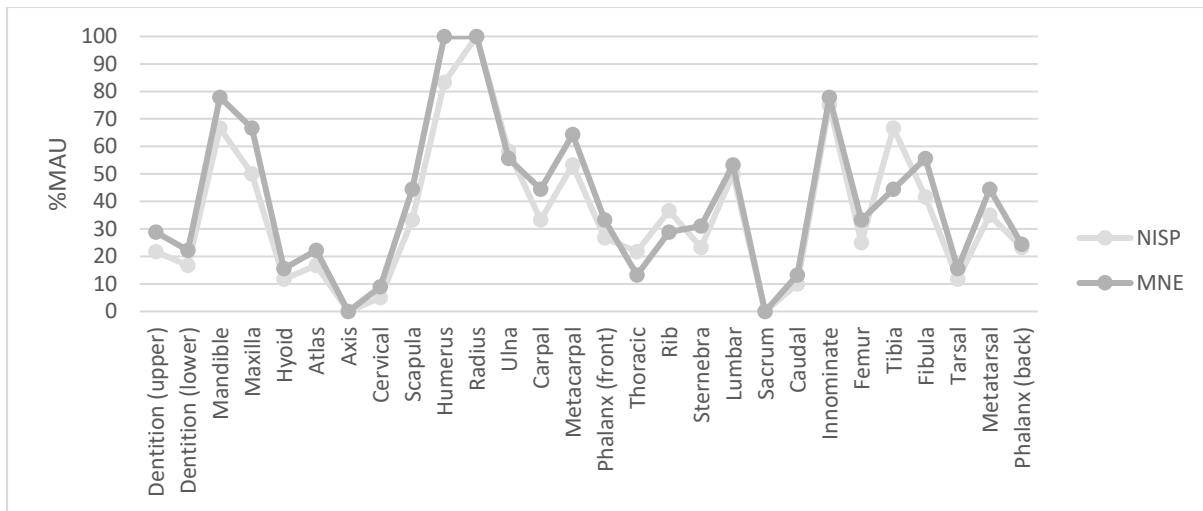


Figure 4.2: %MAU for each skeletal element at NBC using NISP and MNE values.

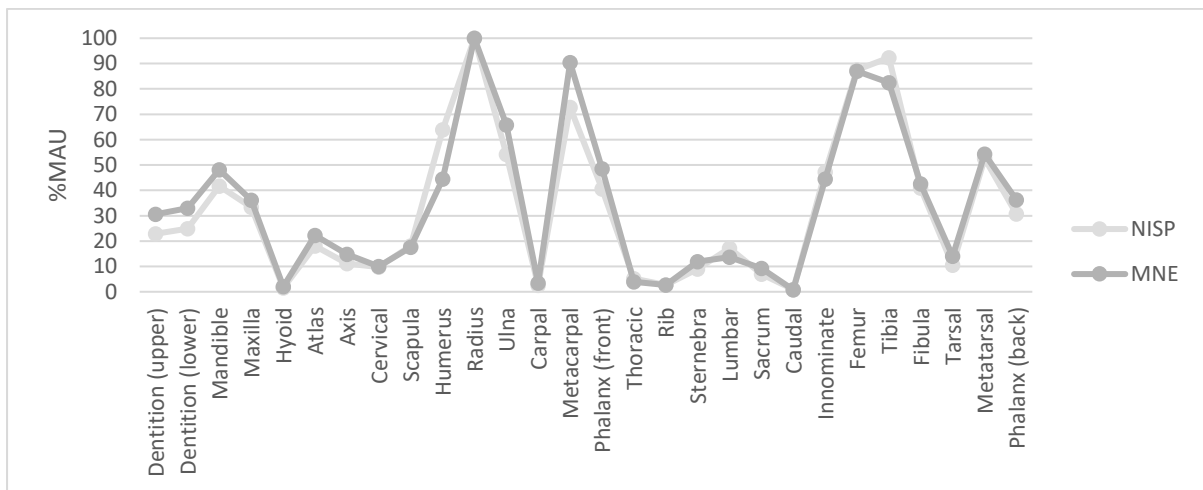


Figure 4.3: %MAU for each skeletal element at HRC using NISP and MNE values.

Figures 4.2 - 4.3 shows the distribution of the calculated %MAU values for each skeletal element were slightly irregular at NBC and relatively similar at HRC. At both sites, there was a 10-20% variation in %MAU values for certain skeletal elements. MNE values were always smaller than the NISP values. As MNE values are a more conservative estimate and less influenced by fragmentation, it was decided to use MNE rather than NISP values for skeletal element frequency calculations.

4.3.2 Skeletal element frequency

MAU and %MAU values for layers BSBJ, RC, IC, HRC, I2 and I1 were calculated (Tables 4.5 - 4.7) and are plotted in Figures 4.4 – 4.5 to assess changes in skeletal element frequency through the Holocene.

Table 4.5: %MAU for Early Holocene levels from RC and BSBJ at NBC using MNE values.

Skeletal Elements	RC				BSBJ			
	NISP	MNE	MAU	%MAU	NISP	MNE	MAU	%MAU
Dentition (upper)	34	34	1.7	5.7	122	122	6.1	33.0
Dentition (lower)	53	53	3.3	11.0	100	100	6.3	33.8
Mandible	11	9	4.5	15.0	19	17	8.5	45.9
Maxilla	2	2	1.0	3.3	18	12	6.0	32.4
Hyoid	0	0	0.0	0.0	1	1	0.1	0.6
Atlas	0	0	0.0	0.0	0	0	0.0	0.0
Axis	0	0	0.0	0.0	1	1	1.0	5.4
Other cervical vertebrae	0	0	0.0	0.0	0	0	0.0	0.0
Scapula	11	5	2.5	8.3	1	1	0.5	2.7
Humerus	14	4	2.0	6.7	22	9	4.5	24.3
Radius	21	16	8.0	26.7	29	20	10.0	54.1
Ulna	8	7	3.5	11.7	25	24	12.0	64.9
Carpal	0	0	0.0	0.0	0	0	0.0	0.0
Metacarpal	310	300	30.0	100.0	39	32	3.2	17.3
Phalanx (front)	512	456	16.3	54.3	50	37	1.3	7.1
Thoracic vertebrae	0	0	0.0	0.0	0	0	0.0	0.0
Rib	3	2	0.1	0.3	3	2	0.1	0.5
Sternebra	0	0	0.0	0.0	0	0	0.0	0.0
Lumbar vertebrae	0	0	0.0	0.0	1	1	0.2	1.1
Sacrum	0	0	0.0	0.0	0	0	0.0	0.0
Caudal vertebrae	0	0	0.0	0.0	0	0	0.0	0.0
Innominate	16	9	4.5	15.0	4	4	2.0	10.8
Femur	13	11	5.5	18.3	50	37	18.5	100.0
Tibia	6	6	3.0	10.0	65	37	18.5	100.0
Fibula	6	5	2.5	8.3	13	9	4.5	24.3
Tarsal	15	15	0.9	3.1	39	39	2.4	13.2
Metatarsal	160	134	13.4	44.7	55	36	3.6	19.5
Phalanx (back)	328	286	10.2	34.0	54	39	1.4	7.5
Total	1523	1354			711	580		

* Note: BSBJ = Brown Soil Below Jake and RC = Rice Complex.

Table 4.6: %MAU for Middle- to Late Holocene levels from HRC at Hoffman's/Robberg Cave and IC at NBC using MNE values.

Skeletal Elements	HRC				IC			
	NISP	MNE	MAU	%MAU	NISP	MNE	MAU	%MAU
Dentition (upper)	25	25	1.3	28.9	98	98	4.9	20.9
Dentition (lower)	16	16	1.0	22.2	61	61	3.8	16.2
Mandible	8	7	3.5	77.8	15	13	6.5	27.7
Maxilla	6	6	3.0	66.7	16	14	7.0	29.8
Hyoid	6	6	0.7	15.6	1	1	0.1	0.5
Atlas	1	1	1.0	22.2	2	2	2.0	8.5
Axis	0	0	0.0	0.0	2	2	2.0	8.5
Other cervical vertebrae	2	2	0.4	8.9	1	1	0.2	0.9
Scapula	4	4	2.0	44.4	4	4	2.0	8.5
Humerus	10	9	4.5	100.0	21	11	5.5	23.4
Radius	12	9	4.5	100.0	59	47	23.5	100.0
Ulna	7	5	2.5	55.6	22	19	9.5	40.4
Carpal	28	28	2.0	44.4	0	0	0.0	0.0
Metacarpal	32	29	2.9	64.4	100	87	8.7	37.0
Phalanx (front)	46	42	1.5	33.3	187	179	6.4	27.2
Thoracic vertebrae	20	9	0.6	13.3	1	1	0.1	0.4
Rib	65	38	1.3	28.9	4	3	0.1	0.4
Sternebra	13	13	1.4	31.1	21	21	2.3	9.9
Lumbar vertebrae	15	12	2.4	53.3	2	2	0.4	1.7
Sacrum	0	0	0.0	0.0	0	0	0.0	0.0
Caudal vertebrae	5	5	0.6	13.3	0	0	0.0	0.0
Innominate	9	7	3.5	77.8	20	14	7.0	29.8
Femur	3	3	1.5	33.3	35	25	12.5	53.2
Tibia	8	4	2.0	44.4	33	24	12.0	51.1
Fibula	5	5	2.5	55.6	21	15	7.5	31.9
Tarsal	11	11	0.7	15.6	31	31	1.9	8.3
Metatarsal	21	20	2.0	44.4	118	88	8.8	37.4
Phalanx (back)	38	30	1.1	24.4	175	172	6.1	26.1
Total	416	346			1050	935		

*Note: HRC = Hoffman's/Robberg Cave and IC = Ivan Complex.

Table 4.7: %MAU for Late Holocene levels I1 and I2 at NBC using MNE values.

Skeletal Elements	I1				I2			
	NISP	MNE	MAU	% MAU	NISP	MNE	MAU	%MAU
Dentition (upper)	54	54	2.7	27.0	22	22	1.1	20.0
Dentition (lower)	51	51	3.2	31.9	20	20	1.3	22.7
Mandible	9	8	4.0	40.0	8	5	2.5	45.5
Maxilla	8	8	4.0	40.0	4	3	1.5	27.3
Hyoid	5	5	0.6	5.6	3	3	0.3	6.0
Atlas	7	7	7.0	70.0	4	4	4.0	72.7
Axis	5	5	5.0	50.0	0	0	0.0	0.0
Other cervical vertebrae	26	20	4.0	40.0	8	7	1.4	25.5
Scapula	7	6	3.0	30.0	3	3	1.5	27.3
Humerus	17	15	7.5	75.0	13	9	4.5	81.8
Radius	29	20	10.0	100.0	6	5	2.5	45.5
Ulna	13	11	5.5	55.0	10	10	5.5	100.0
Carpal	16	16	1.1	11.4	11	10	0.7	12.9
Metacarpal	38	36	3.6	36.0	37	33	3.3	60.0
Phalanx (front)	43	37	1.3	13.2	26	25	0.9	16.2
Thoracic vertebrae	51	27	1.8	18.0	4	4	0.3	4.9
Rib	41	30	1.0	10.0	7	7	0.2	4.2
Sternebra	25	25	3.2	32.2	12	12	1.3	24.2
Lumbar vertebrae	55	30	6.0	60.0	4	4	0.8	14.6
Sacrum	5	5	5.0	50.0	0	0	0.0	0.0
Caudal vertebrae	6	4	0.4	4.4	0	0	0.0	0.0
Innominate	18	12	6.0	60.0	11	9	4.5	81.8
Femur	21	15	7.5	75.0	7	6	3.0	54.6
Tibia	19	15	7.5	75.0	10	7	3.5	63.6
Fibula	12	10	5.0	50.0	7	7	3.5	63.6
Tarsal	24	24	1.5	15.0	12	12	0.8	13.6
Metatarsal	33	28	2.8	28.0	13	7	0.7	12.7
Phalanx (back)	52	42	1.5	15.0	9	9	0.3	5.8
Total	690	566			271	243		

* Note: I1 = Inskeep 1 and I2 = Inskeep 2.

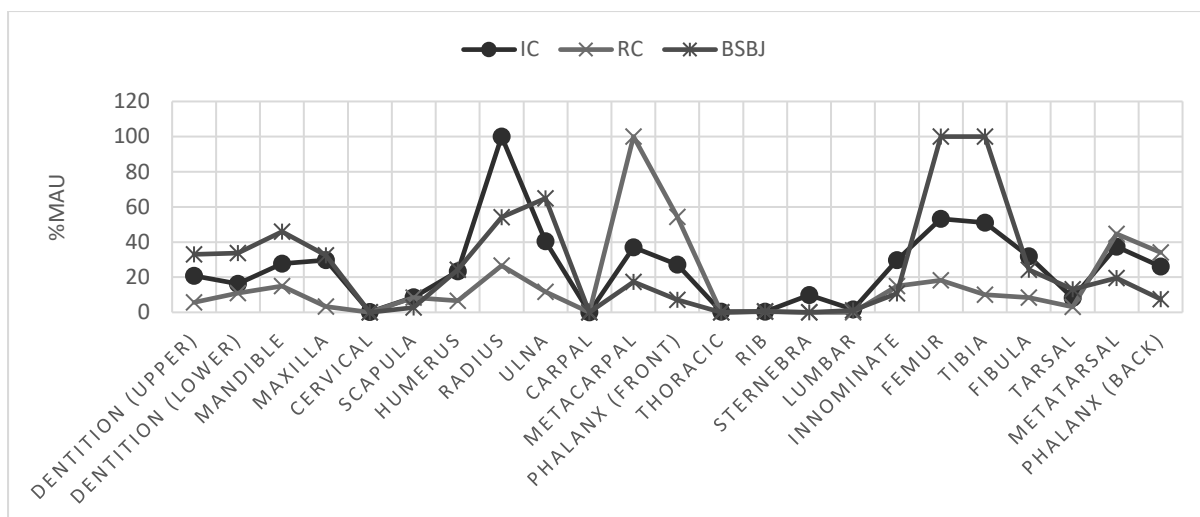


Figure 4.4: Skeletal element frequency (%MAU) of the Middle- to Late Holocene levels IC, RC and BSBJ at NBC.

Figure 4.4 shows the patterns of skeletal element frequencies (%MAU) for layers BSBJ, RC and IC at NBC are similar. In all three levels, the skull, front limb and back limb were present in medium (11-50%) to high abundance (51-100%) while elements of the axial skeleton in the form of the vertebrae, ribs and sternebrae were present in low abundance (0.1-10%). Carpals, sacral and caudal vertebrae were absent from all Early Holocene levels at NBC.

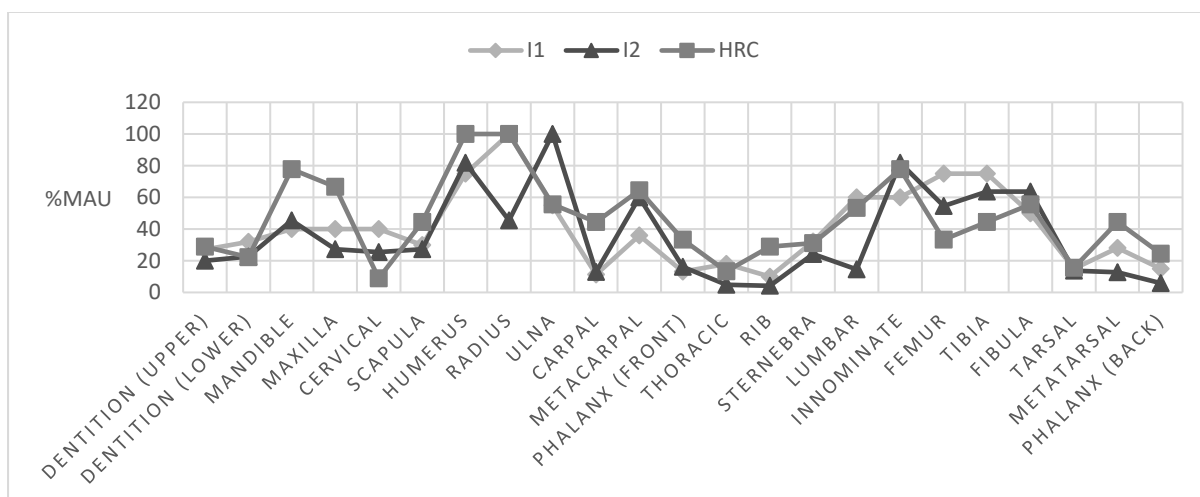


Figure 4.5: Skeletal element frequency (%MAU) of the Late Holocene levels I1, I2 at NBC and HRC at Hoffman's/Robberg Cave.

Figure 4.5 shows the patterns of skeletal element frequencies (%MAU) for the Late Holocene assemblages (HRC, I1 and I2) are the same, although the hyoid, axis, sacrum and caudal vertebrae were excluded from the figure. The skull and front limb were present in medium (11-50%) to high abundance (51-100%), while the back limb, ribs, vertebrae and sternebrae varied from low (0.1-50%) to high abundance.

4.3.3 Skeletal element frequency and food utility index

The skeletal element frequency was compared to the Standardised Modified Bulk Utility Index (SMBUI) for Cape fur seals (Woodborne 1996) (Tables 4.8 - 4.9) to assess butchery and transport decisions at NBC and HRC (Figures 4.6 – 4.7).

Table 4.8: Skeletal element frequency (%MAU) and food utility index (%SMBUI) from IC, RC and BSBJ at NBC.

Skeletal Element	IC MAU	% MAU	RC MAU	% MAU	BSBJ MAU	% MAU	% SMBUI
Head (cranium, dental, maxilla, mandible and hyoid)	22.3	67.6	10.5	22.7	27.0	100.0	26.0
Cervical vertebrae	4.2	12.7	0.0	0.0	1.0	3.7	69.0
Ribs/Thoracic vertebrae	0.2	0.6	0.1	0.2	0.1	0.4	100.0
Lumbar vertebrae	0.4	1.2	0.0	0.0	0.2	0.7	59.0
Pelvis/Sacrum/Femora	19.5	59.1	10.0	21.6	20.5	76.0	15.0
Tibia/Fibula	19.5	59.1	5.5	11.9	23.0	85.3	10.0
Back flippers (tarsals/metatarsals/phalanges)	16.9	51.2	24.6	53.0	7.4	27.6	7.0
Scapula	2.0	6.1	2.5	5.4	0.5	1.9	30.0
Humerus	5.5	16.7	2.0	4.3	4.5	16.7	24.0
Radius/Ulna	33.0	100.0	11.5	24.8	22.0	81.6	15.0
Front flippers (carpals/metacarpals/phalanges)	15.1	45.7	46.3	100.0	4.5	16.8	8.0

* Note: IC = Ivan Complex, RC = RICE Complex and BSBJ = Brown Soil Below Jake.
Cape fur seal utility index (SMBUI) from Woodborne (1996).

Table 4.8 shows that there is an inverse relationship between the skeletal element frequency values (%MNE) from IC, RC, BSBJ and the %SMBUI values.

Table 4.9: Skeletal element frequency (%MAU) and food utility index (%SMBUI) for I1 and I2 at NBC and HRC at Hoffmans'/Robberg Cave.

Skeletal Element	I1 MAU	% MAU	I2 MAU	% MAU	HRC MAU	% MAU	% SMBUI
Head (cranium, dentition, maxilla, mandible and hyoid)	14.5	78.1	6.7	83.5	9.5	100.0	26.0
Cervical vertebrae	16.0	86.5	5.4	67.5	1.4	14.7	69.0
Ribs/Thoracic vertebrae	2.8	15.1	0.5	6.3	1.9	20.0	100.0
Lumbar vertebrae	6.0	32.4	0.8	10.0	2.4	25.3	59.0
Pelvis/Sacrum/Femora	18.5	100.0	7.5	93.8	5.0	52.6	15.0
Tibia/Fibula	12.5	67.6	7.0	87.5	4.5	47.4	10.0
Back flippers (tarsals/metatarsals/phalanges)	5.8	31.4	1.8	22.1	3.8	40.0	7.0
Scapula	3.0	16.2	1.5	18.8	2.0	21.1	30.0
Humerus	7.5	40.5	4.5	56.3	4.5	47.4	24.0
Radius/Ulna	15.5	83.8	8.0	100.0	7.0	73.7	15.0
Front flippers (carpals/metacarpals/phalanges)	6.1	32.8	4.9	61.3	6.4	67.4	8.0

* Note: I1 = Inskeep 1, I2 = Inskeep 2 and HRC = Hoffman's/Robberg Cave. Cape fur seal utility index (SMBUI) from Woodborne (1996).

Table 4.9 shows that there is an inverse relationship between the skeletal element frequency (%MAU) and the %SMBUI values for Cape fur seals at I1, I2 and HRC.

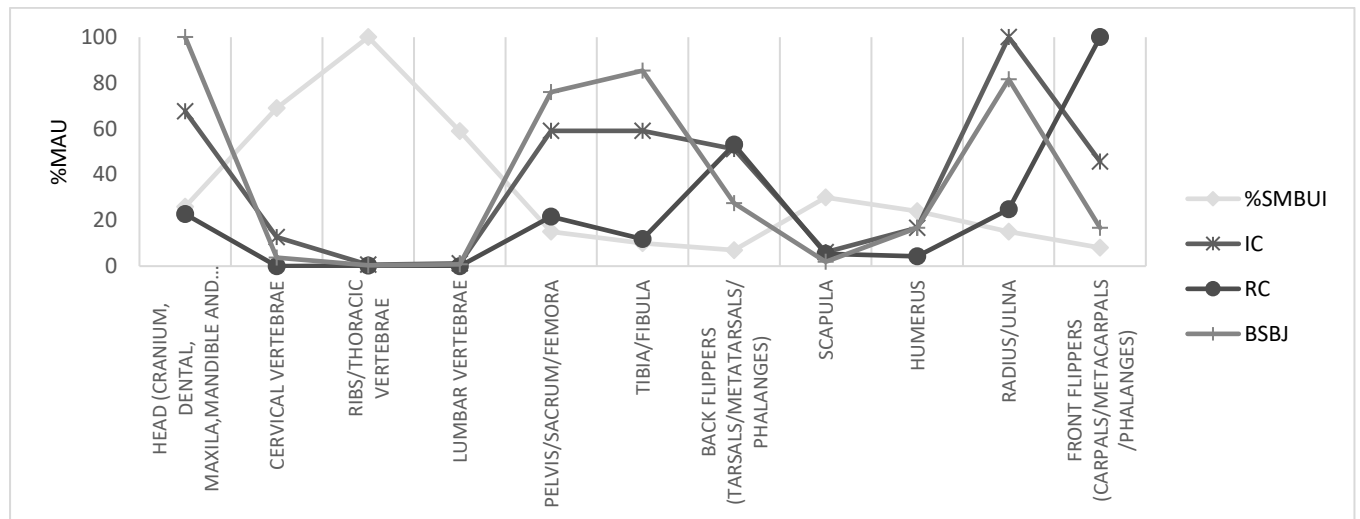


Figure 4.6: The %MAU from BSBJ (Brown Soil Below Jake), RC (RICE Complex) and IC (Ivan complex) compared with %SMBUI from Woodborne (1996).

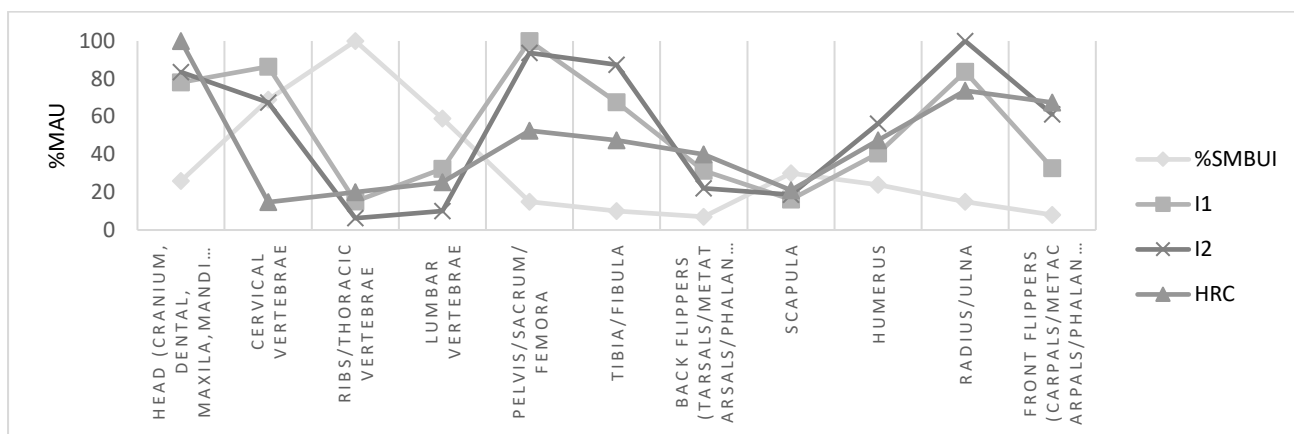


Figure 4.7: The %MAU from I1 (Inskeep 1), HRC (Hoffman's/Robberg Cave) and I2 (Inskeep2) compared with %SMBUI from Woodborne (1996).

Figures 4.6 and 4.7 show an inverse relationship between body part (%MAU) representation and their food utility values (%SMBUI) throughout the Holocene at NBC and HRC. This pattern will be discussed further in Chapter 5.

4.4 The age profiles of Cape fur seals at NBC and HRC

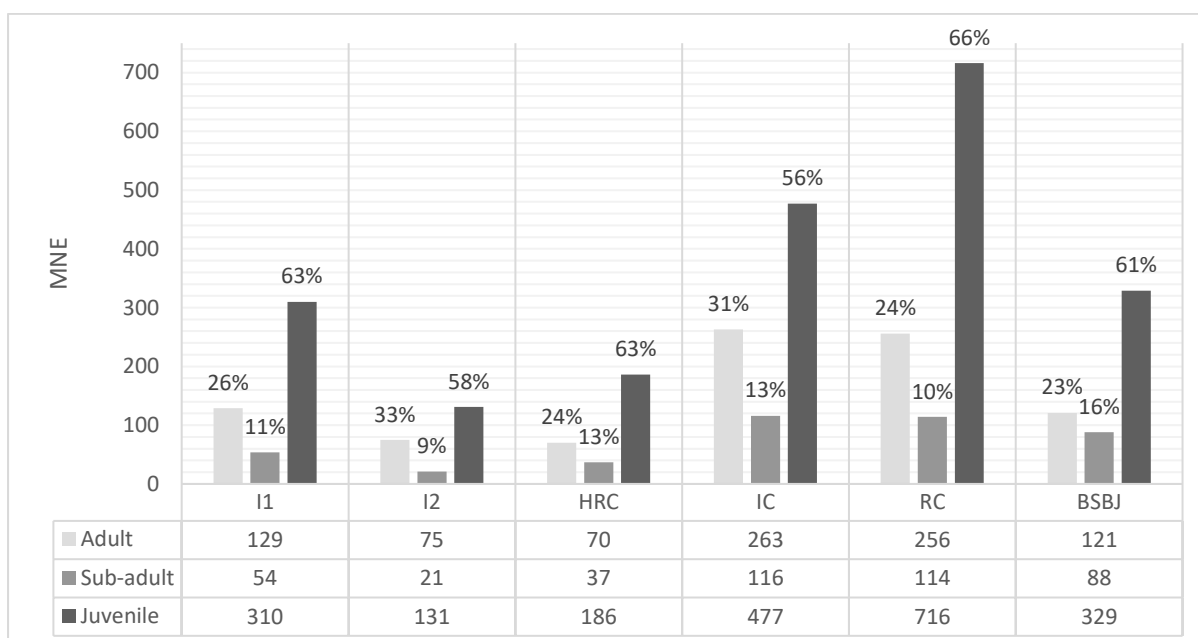


Figure 4.8: Minimum number of elements (MNE) of adult, sub-adult and juvenile seals from I1, I2, HRC, IC, RC and BSBJ. MNE values tabulated beneath the bar chart and the percentage values of each age group labelled at the top of each bar.

Table 4.10: Minimum number of elements (MNE) of adult, sub-adult and juvenile seal bones from Robberg.

Robberg	
Age	MNE
Adult	914
Sub-adult	430
Juvenile	2149
Total	3493

*Note: Robberg = NBC + HRC

Figure 4.8 shows that juvenile seal bones dominated the assemblages at NBC and HRC. 61.5% (2149/3493) of the Robberg collection consisted of juvenile bones, followed by 26.2% (914/3493) adult, and 12.3% (430/3493) sub-adult remains (Table 4.10).

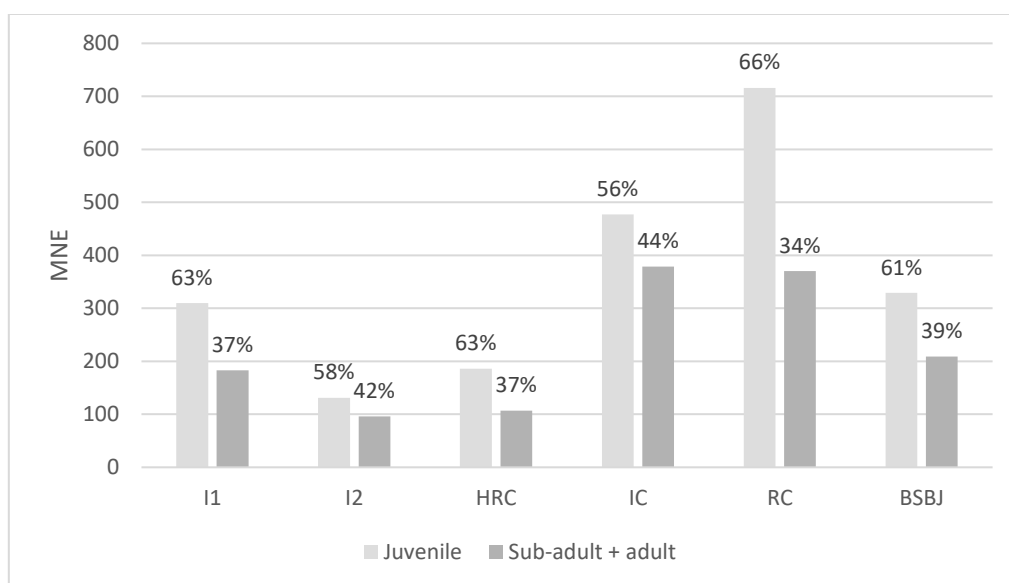


Figure 4.9: Minimum number of elements (MNE) for juvenile and sub-adult + adult bones from I1, I2, HRC, IC, RC and BSBJ. Percentage values for each age group labelled at the top of each bar.

Figure 4.9 shows that overall, juveniles make up approximately 60% and adults and sub-adults 40% of the totals.

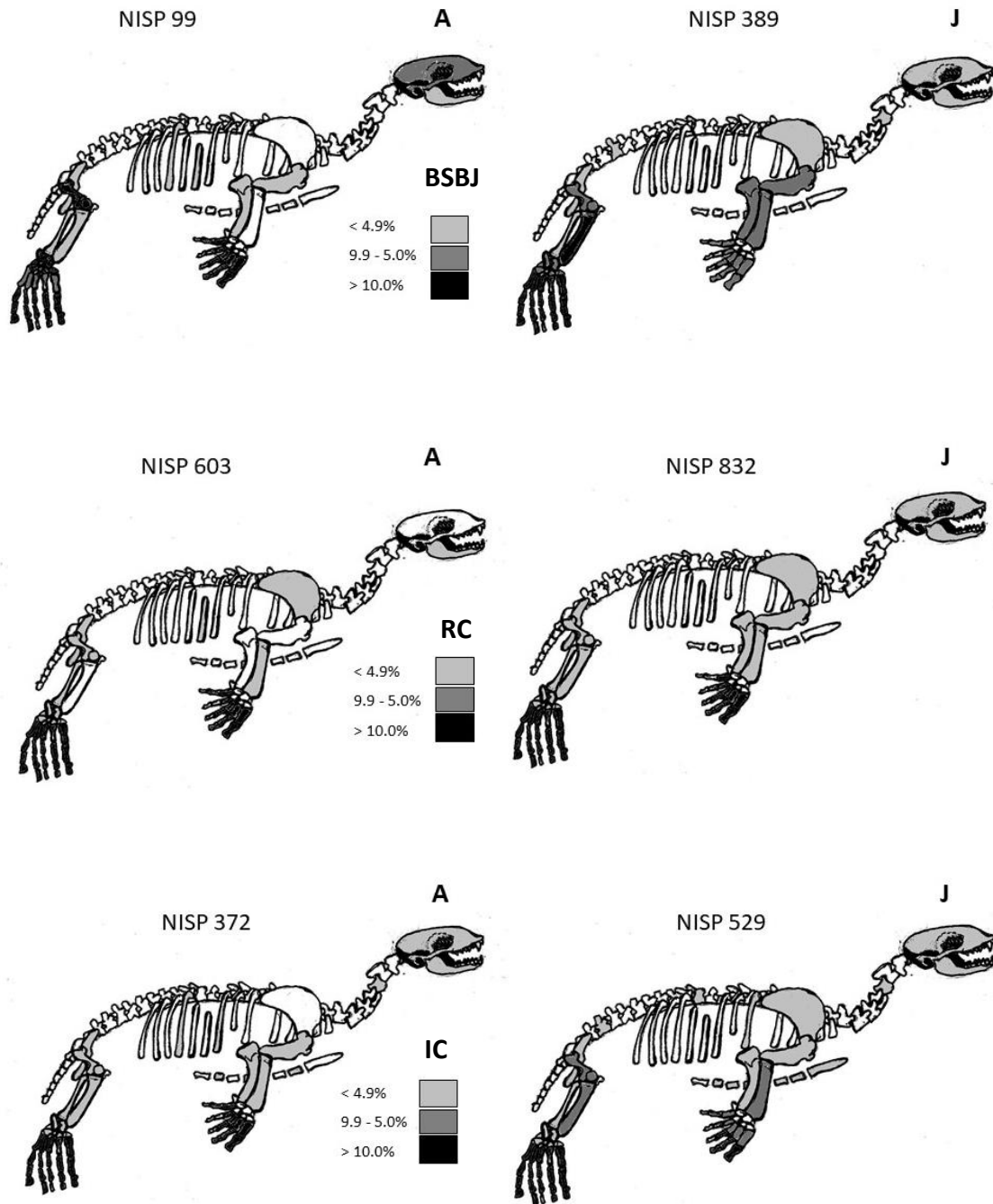


Figure 4.10: Skeletal representation and frequency (NISP) of sub-adult + adult (A) and juvenile (J) Cape fur seal bones from BSBJ (~10 000 BP), RC (~9 000 – 6 000 BP) and IC (~5 000 BP) at NBC. Seal template modified from Bebej (2009) and Post (2004). NISP values were used to calculate skeletal frequency. Note: dental and non-identified specimens excluded from this figure.

Figure 4.10 shows within both age groups (A & J) at BSBJ, RC and IC majority of the axial skeleton (except the skull) was absent. Percentages were calculated using the NISP value of a particular skeletal element from a certain age group divided by the frequency of that element occurring in one individual. This value was then divided by the calculated MNI value for a certain age group and multiplied by a hundred to derive skeletal frequency. The

skull and upper limbs respectively were in low (< 4.9%) to medium (9.9-5.0%) abundance. The lower limbs (flippers) were in medium to high (>10%) abundance. Also note the absence of the carpals for both age groups in layers BSBJ, RC and IC.

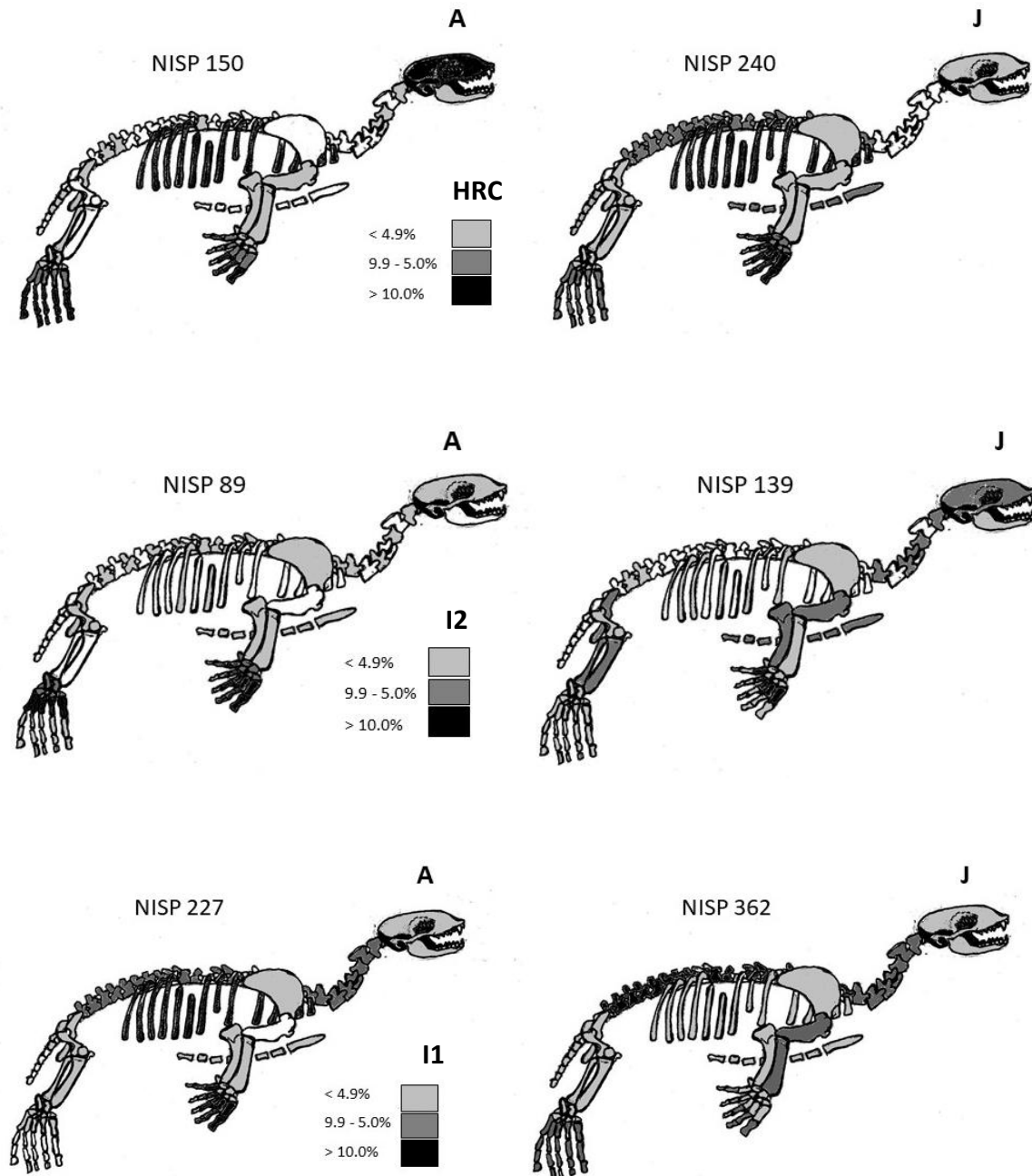


Figure 4.11: Skeletal representation and frequency of sub-adult + adult (A) and juvenile (J) Cape fur seal bones from (Top to bottom) HRC, (~4 000 – 3 000 BP), I2 (~3 000 – 2 000 BP) and I1 (~2 000 – 500 BP) at NBC. Seal template modified from Bebej (2009) and Post (2004). NISP values were used to calculate skeletal frequency. Note: dental and non-identified specimens were used in this figure.

Figure 4.11 shows within both age groups (A&J), the majority of each skeletal element type from the axial and appendicular skeleton were present in layers HRC, I2 and I1. The axial

skeleton respectively varied from low (<4.9%) to high (>10%) abundance, the upper limbs from low to medium (9.9-5.0%) abundance and the lower limbs varied from low to high abundance.

4.5 Taphonomy

4.5.1 Post-depositional damage

Table 4.11: Numbers of seal bones from NBC and HRC showing weathering, root etching, exfoliation, and trampling. The stages of weathering (0-5) recorded according to Behrensmeier's (1978) criteria. Four categories (0-3) for root etching, exfoliation and trampling are percentages of cortical surfaces showing damage.

Site	Weathering (NISP)					
	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
NBC	4387	136	21	4	0	0
HRC	451	4	5	0	0	0
Site	Root etching (NISP)					
	0	1	2	3		
	0%	<50%	>50%	100%		
NBC	4510	32	5	1		
HRC	0	0	0	0		
Site	Exfoliation (NISP)					
	0	1	2	3		
	0%	<50%	>50%	100%		
NBC	4511	22	10	5		
HRC	460	0	0	0		
Site	Trampling (NISP)					
	0	1	2	3		
	0%	<50%	>50%	100%		
NBC	4541	6	1	0		
HRC	460	0	0	0		

Table 4.11 shows the number of bones at NBC and HRC with surface damage due to weathering, root etching, exfoliation and trampling. Overall, 5.3% (243/4548) of the bones from NBC and 2% (9/460) of those from HRC were damaged by these processes. At NBC 3.5% (161/4548) of the seal bones showed weathering (stages 1-3), 0.8% (38/4548) showed

root etching, 0.8% (37/4548) exfoliation and 0.2% (7/4548) trampling. At HRC only 2% (9/460) of the bones showed stage 1 or 2 weathering. No root etching, exfoliation or trampling damage was observed at HRC.



Figure 4.12: Embedded stone (quartzite) and shell in an adult carpal (Specimen: LR256) from Layer Cedric, NBC. Photographed with a DinoLight microscope with 30x magnification.

Figure 4.12 shows trampling damage on the triquetral (carpal) from an adult Cape fur seal from layer Cedric (Inskeep 2) at NBC. Irregular striation marks associated with an embedded piece of shell and stone (quartzite) are visible on the medial surface of the seal carpal.



Figure 4.13: Embedded stone and shell on a juvenile phalanx (Specimen: LR381) from IC (Ivan Complex), NBC. Photographed with a DinoLight microscope with 15x magnification.

Figure 4.13 shows trampling damage on the proximal shaft of a juvenile Cape fur seal phalanx from IC at NBC, leading to shell and stone becoming embedded on the dorsal surface.



Figure 4.14: Trampling marks visible (top right) on the middle shaft of an adult rib (Specimen LR906) from IC (Ivan Complex), NBC. Photographed with a DinoLight microscope with 15x magnification.

Figure 4.14 shows trampling damage on the rib of an adult Cape fur seal from IC at NBC. Numerous parallel striations due to trampling are visible on the middle shaft.

4.5.2 Skeletal element completeness

Table 4.12: Seal skeletal elements from NBC and HRC and their average percentage of completeness.

Skeletal Element	NBC		HRC	
	NISP	Average % Complete	NISP	Average % Complete
Cranium †	27	4.9	13	3.1
Hyoid †	10	90.0	6	86.7
Maxilla †	48	33.0	7	44.3
Mandible †	60	26.3	9	61.9
Atlas •	13	37.9	1	100.0
Axis •	8	32.8	0	0.0
Other Vertebrae •	178	42.9	46	53.8
Sternebra †	58	88.4	13	89.2
Rib †	58	51.7	65	44.3
Pelvis •	69	29.1	9	29.4
Femur ‡	126	67.3	3	87.7
Tibia ‡	133	50.8	8	100.0
Fibula ‡	59	57.9	5	90.0
Scapula †	26	17.6	4	93.6
Humerus ‡	92	65.4	10	86.6
Radius ‡	144	63.0	12	89.8
Ulna ‡	78	51.1	7	84.8
Carpal/Tarsal ◇	148	89.2	39	98.5
Metapodial Ω	914	75.9	54	95.7
Phalanx Ω	1570	78.2	104	85.1
Baculum	4	70.0	2	85.0

*Note this table does not include non-ID fragments and dental specimens. The following symbols were used to group skeletal elements: † = Flat bones, • = Irregular bones, ‡ = Long bones, Ω = digitopodia, ◇ = Short bones

Table 4.12 shows the numbers of different skeletal elements from NBC and HRC and their average percentage completeness. Table 4.13 groups skeletal elements from Table 4.12.

Table 4.13: Average percentage completeness of various seal skeletal element types at NBC and HRC.

Skeletal Element Types	NBC Average % Complete	HRC Average % Complete
Flat bones	37	56.1
Irregular bones	35.6	45.8
Long bones	59.2	89.8
Digitopodia	77	90.4
Short bones	89.2	98.5
Entire skeleton	53.5	71.9

Table 4.13 shows the average percentage completeness for the Cape fur seal skeleton was 53.5% at NBC and 71.9% at HRC. The digitopodia and short bones were the most complete, with 77% and 89.2% completeness at NBC and 90% and 98.5% at HRC. The long bones were less complete with averages of 59.2% and 89.8% at NBC and HRC respectively. Flat bones and irregular bones were the least complete (37% and 35.6% at NBC; 45.8% and 56.1% at HRC).

4.5.3 Long bone modification

4.5.3.1 Long bone fracture outlines and angles

A total of 3129 long bones was present at NBC and 213 at HRC. 53% (1628/3129) and 82% (174/213) of the long bone ends were unbroken. Long bone ends are defined as the [fused] proximal and distal epiphyses of adult and sub-adult specimens and the articular surfaces of the proximal and distal diaphyses of juvenile specimens. The outlines and angles of shaft breaks were recorded according to the criteria of Villa and Mahieu (1991). The results are shown in Table 4.14.

Table 4.14: Long bone shaft fracture outlines and angles (NISP) at NBC and HRC, according to the criteria of Villa and Mahieu (1991).

	NBC	HRC
Fracture outline		
Curved/V-shaped	1278	65
Intermediate	32	0
Transverse	114	0
Transverse and Curved	34	1
Total	1458	66
Fracture angle		
Oblique	1323	65
Oblique/Right	3	0
Right	114	1
Total	1440	66

Table 4.14 shows that nutritive breaks (curved/V-shaped and oblique) were the most abundant at both NBC and HRC. 87% (1278/1458) and 99% (65/66) of the fracture outlines were curved/V-shaped, while 92% (1323/1440) and 99% (65/66) of the fracture angles were oblique. Non-nutritive breaks (transverse and right) were minimal, contributing 8% and <1% respectively to broken long bone assemblage at NBC and HRC.

4.5.3.2 Long bone shaft circumferences

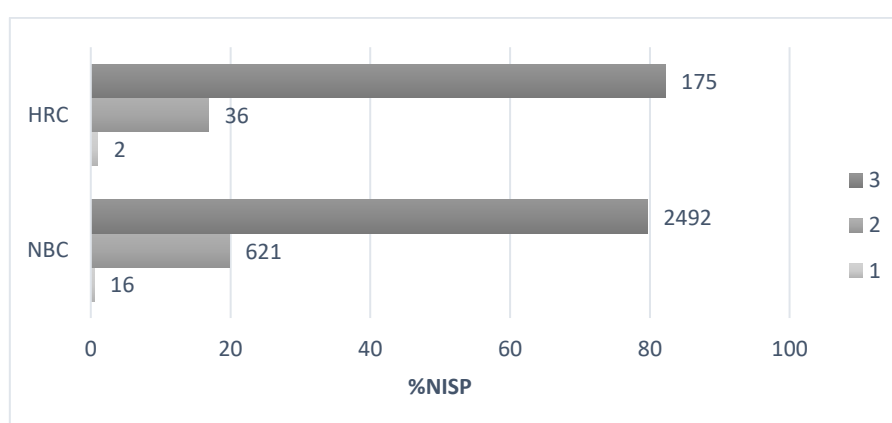


Figure 4.15: Long bone shaft completeness at NBC and HRC. 3=100% circumference preserved, 2=>50% and 1=<50% (Bunn 1983). The sample size depicted as bar labels. Digitopodia are included in this figure.

Figure 4.15 shows the percentage completeness of the circumferences of long bone shafts. At NBC, 79.6% (2492/3129) of the long bone shafts were complete, while at HRC, the figure was 82.2% (175/213). 19.9% (621/3129) and 16.9% (36/213) of the long bone shafts at the

two sites preserved more than 50% of the circumference. Only 0.5% (16/3129) at NBC and 0.9% (2/213) at HRC were less than 50% in circumference. A 3 x 2 chi-square distribution test was conducted to determine if the proportions of long bone shafts in the three categories from NBC and HRC were significantly different. There was no significant difference (chi-squared = 1.72, 2 d.f. $p=0.05$).

4.5.3.3 Long bone shafts versus epiphyses

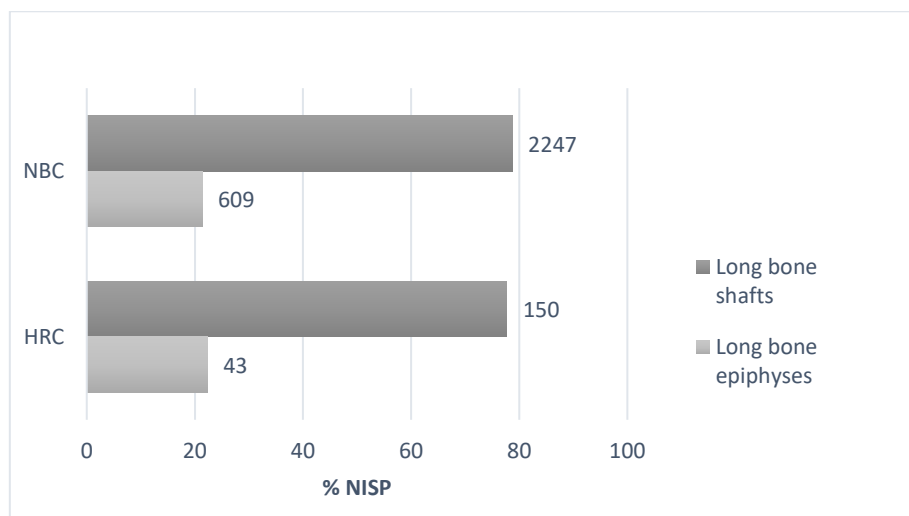


Figure 4.16: The percentages of long bone shafts compared with epiphyses at NBC and HRC. The sample size depicted as bar labels. Digitopodia are included in this figure.

Figure 4.16 shows the percentages of the assemblages of long bones at NBC and HRC made up by shafts and epiphyses. Long bone shafts contribute 78.7% (2247/2856) and 77.7% (150/193) while the epiphyses contribute 21.3% (609/2856) and 22.2% (43/193). The proportions of the two sites were virtually identical.

4.5.3.4 Comparing terrestrial mammal with seal bone fracture patterns

Studies of long bone fracture patterns in terrestrial mammals report that breakage patterns vary depending on the bone modifying agent. Data on the fracture patterns of the NBC and HRC seal bones were collected to determine if similar inferences could be made. Figure 1 - 4 in Appendix A compares seal long bone fracture patterns seen at NBC and HRC with actualistic studies of terrestrial mammal bone fractures caused by human and carnivore activity. The patterns seen in seals are completely different from those in terrestrial mammals. Marine mammals do not have a medullary marrow cavity. One should thus

expect, as the results show, that their bones will fracture differently. To better interpret fracture patterns on seal long bones, actualistic studies should be conducted in the future.

4.5.4 Bone surface modification

4.5.4.1 Percussion marks

Table 4.15: Numbers of percussion marks (PM) on each skeletal element from NBC and HRC.

Skeletal Element	NBC			HRC		
	NISP	NISP with PM	Number Of PM	NISP	NISP with PM	Number of PM
Cranial and hyoid	37	0	0	19	0	0
Maxilla	48	0	0	7	0	0
Mandible	62	0	0	9	2	15
Atlas	13	0	0	1	0	0
Axis	8	0	0	0	0	0
Cervical vertebrae	35	0	0	2	0	0
Thoracic vertebrae	56	0	0	20	0	0
Lumbar vertebrae	62	0	0	15	0	0
Sacrum	5	0	0	0	0	0
Caudal vertebrae	6	0	0	5	0	0
Rib	58	0	0	65	0	0
Sternebra	58	0	0	13	0	0
Scapula	26	0	0	4	0	0
Humerus	92	1	1	10	0	0
Radius	144	0	0	12	0	0
Ulna	78	2	3	7	0	0
Carpal	26	0	0	28	0	0
Metacarpal	524	1	1	32	0	0
phalanx (front)	818	2	2	46	0	0
Innominate	69	0	0	9	0	0
Femur	126	0	0	3	0	0
Tibia	133	0	0	8	0	0
Fibula	59	0	0	5	0	0
Tarsal	121	0	0	11	0	0
Metatarsal	378	1	1	21	0	0
Phalanx (back)	619	0	0	38	0	0
Total	3661	7	8	390	2	15

*Note this table does not include non-identifiable bone flakes and fragments not assigned to a specific skeletal element

Percussion marks were rare, with only 0.2% and 0.3% of the seal bones from NBC and HRC respectively having percussion marks. Table 4.15 shows the numbers of percussion marks per skeletal element. At NBC percussion marks were present on a humerus, two ulnae, metacarpal, metatarsal and two phalanges from the front flipper. Percussion marks at HRC were present on two mandibles.

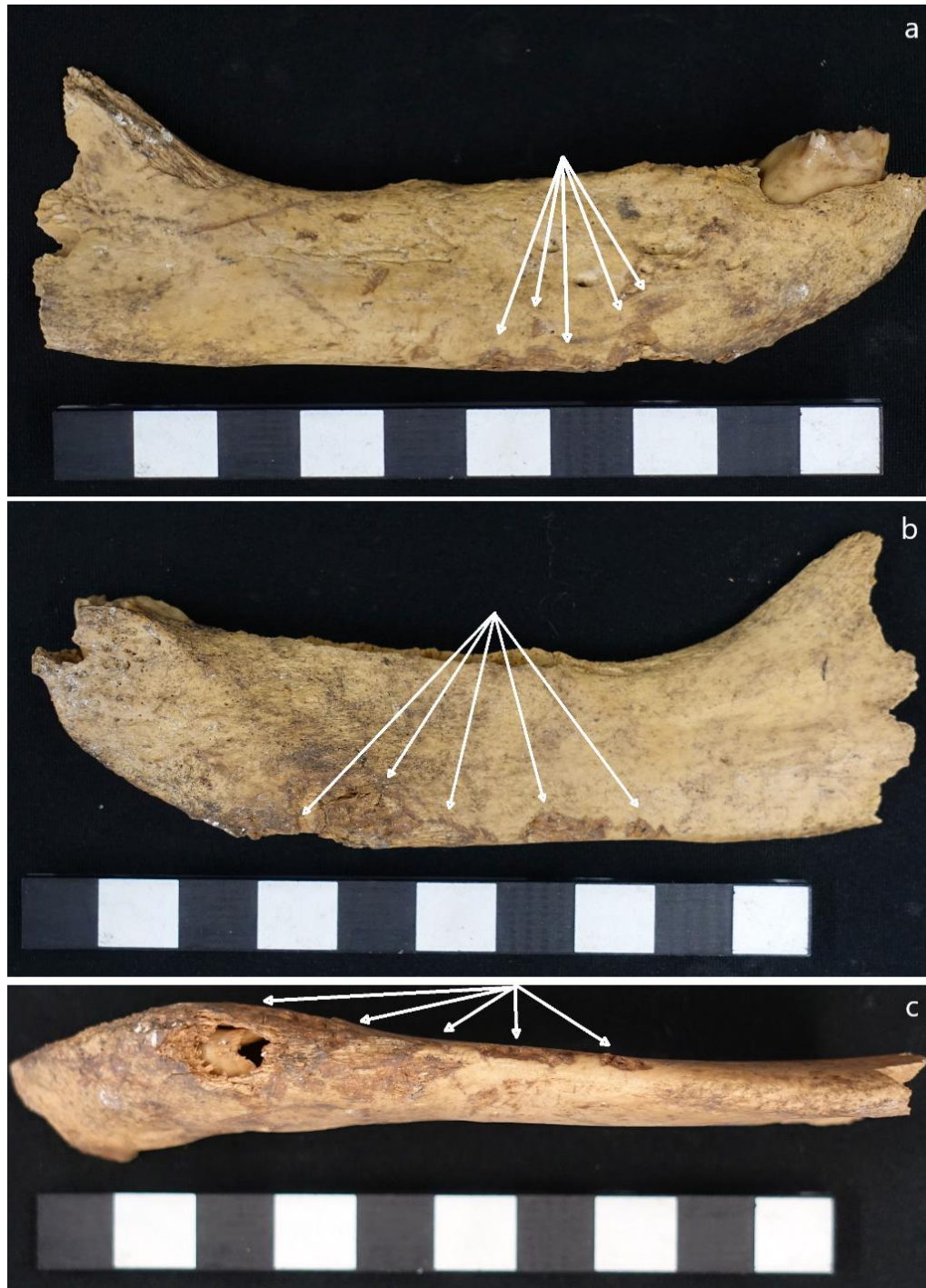


Figure 4.17: (a) lateral (b) medial and (c) ventral views of a seal mandible from HRC (Specimen LR 357). Percussion marks (arrowed) are visible on the body of the mandible.

Figure 4.17 shows the specimen with the largest number of percussion marks: a mandible from HRC. Seal mandibles do not have a marrow cavity, so it is unlikely that these attempts to break the mandibular body were for dietary purposes.

Personal experience in the removal of Cape fur seal teeth from the mandible and maxilla has shown that breaking open the body of the mandible in the locations arrowed in Fig. 4.17 helps to loosen the root of the canine, facilitating its removal. Canine removal may have been the motive of the HRC occupants; they probably abandoned their attempts after the canine broke.

4.5.4.2 Tooth marks

Table 4.16: Numbers of carnivore tooth marks (TM) on each skeletal element from NBC and HRC.

Skeletal Element	NBC			HRC		
	NISP	NISP with TM	Number of TM	NISP	NISP With TM	Number Of TM
Cranial and hyoid †	37	0	0	19	0	0
Maxilla †	48	1	3	7	0	0
Mandible †	62	3	6	9	0	0
Atlas •	13	0	0	1	0	0
Axis •	8	0	0	0	0	0
Cervical vertebrae •	35	0	0	2	0	0
Thoracic vertebrae •	56	0	0	20	0	0
Lumbar vertebrae •	62	0	0	15	0	0
Sacrum •	5	0	0	0	0	0
Caudal vertebrae •	6	0	0	5	0	0
Rib †	58	3	13	65	0	0
Sternebra †	58	5	19	13	0	0
Scapula †	26	0	0	4	0	0
Humerus ‡	92	1	4	10	0	0
Radius ‡	144	0	0	12	0	0
Ulna ‡	78	2	7	7	0	0
Carpal ◇	26	1	3	28	0	0
Metacarpal Ω	524	9	22	32	0	0
phalanx (front) Ω	818	6	8	46	0	0
Innominate •	69	1	7	9	0	0
Femur ‡	126	5	9	3	0	0
Tibia ‡	133	3	7	8	0	0
Fibula ‡	59	2	6	5	0	0
Tarsal ◇	121	3	15	11	0	0
Metatarsal Ω	378	4	6	21	0	0
Phalanx (back) Ω	619	1	3	38	0	0
Total	3661	50	138	390	0	0

*Note this table does not include non-identifiable bone flakes and fragments not assigned to a specific skeletal element. The following symbols were used to group skeletal elements: † = Flat bones, • = Irregular bones, ‡ = Long bones, Ω = digitopodia, ◇ = Short bones.

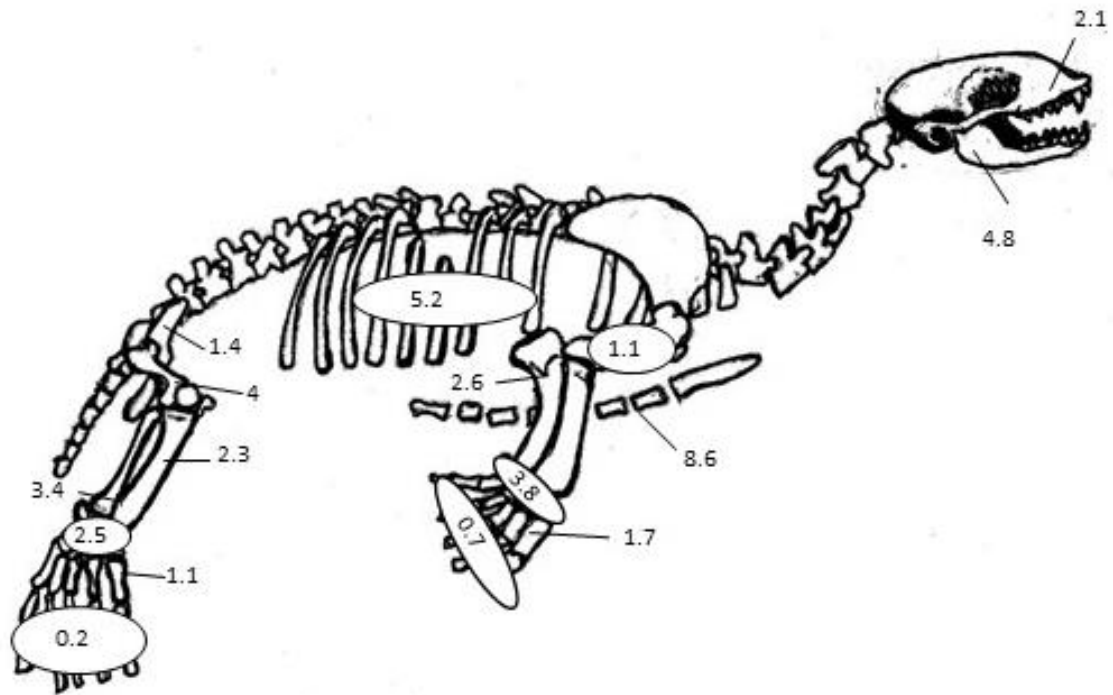


Figure 4.18: Percentage of each skeletal element from NBC showing one or more carnivore tooth marks. Diagram modified from Bebej (2009) and Post (2004).

Table 4.16 shows the numbers of carnivore tooth marks on each skeletal element at NBC and HRC. None of the bones from HRC showed carnivore tooth marks. Carnivore activity at NBC was rare, with only 1.4% (50/3661) of the bones having bite marks. The percentages of each skeletal element showing carnivore tooth marks varied, but was mostly below 4% (Figure 4.18). Skeletal elements with higher than average percentages of carnivore tooth marks were the sternbrae (5/58 = 8.6%), ribs (3/58 = 5.2%) and mandible (3/62 = 4.8%).

Table 4.17: Percentages of skeletal element types at NBC with one or more carnivore tooth marks.

Skeletal Types	NBC
	%
Long bones	2.1
Flat bones	4.2
Irregular bones	0.4
Digitopodia	0.9
Short bones	2.7
Entire skeleton	1.4

Table 4.17 shows the percentages of skeletal element types with one or more tooth marks at NBC. 4.2% of the flat bones (12/289) had tooth marks followed by 2.7% of the short bones (4/147) and 2.1% of the long bones (13/632). Only 0.4% of the irregular bones (1/254) and 0.9% of the digitopodia (20/2339) had one or more carnivore tooth marks. Irregular bones were, however, frequently fractured (Table 4.13), which might have destroyed tooth marks and other evidence of surface modification.



Figure 4.19: Juvenile seal metacarpal from NBC (specimen: LR3639) with carnivore bite marks on the (a) distal diaphysis and (b) proximal epiphysis. Photographed with a DinoLight microscope with 15x magnification.

Figure 4.19 shows carnivore bite marks on the proximal and distal ends of a juvenile metacarpal from NBC. All the bite marks at NBC were small in diameter, which may indicate that they were made by a size 1 carnivore such as a jackal.

4.5.4.3 Cut marks

Table 4.18: The numbers of cut marks (CM) on each skeletal element at NBC and HRC.

Skeletal Element	NBC			HRC		
	NISP	NISP with CM	Number of CM	NISP	NISP with CM	Number of CM
Cranial and hyoid †	37	2	8	19	0	0
Maxilla †	48	0	0	7	0	0
Mandible †	62	8	31	9	2	9
Atlas •	13	1	3	1	0	0
Axis •	8	0	0	0	0	0
Cervical vertebrae •	35	0	0	2	0	0
Thoracic vertebrae •	56	1	1	20	0	0
Lumbar vertebrae •	62	2	5	15	1	3
Sacrum •	5	1	3	0	0	0
Caudal vertebrae •	6	0	0	5	0	0
Rib †	58	3	20	65	7	23
Sternebra †	58	2	4	13	0	0
Scapula †	26	4	13	4	0	0
Humerus ‡	92	11	59	10	1	1
Radius ‡	144	5	19	12	0	0
Ulna ‡	78	7	52	7	0	0
Carpal ◇	26	0	0	28	0	0
Metacarpal Ω	524	26	80	32	2	7
phalanx (front) Ω	818	21	69	46	0	0
Innominate •	69	3	12	9	0	0
Femur ‡	126	10	23	3	0	0
Tibia ‡	133	7	33	8	0	0
Fibula ‡	59	1	8	5	0	0
Tarsal ◇	121	17	54	11	1	1
Metatarsal Ω	378	7	31	21	1	1
Phalanx (back) Ω	619	21	48	38	0	0
Total	3661	160	576	390	15	43

*Note this Table does not include non-identifiable flakes and fragments not assigned to a specific skeletal element. The following symbols were used to group skeletal elements: † = Flat bones, • = Irregular bones, ‡ = Long bones, Ω = digitopodia, ◇ = Short bones

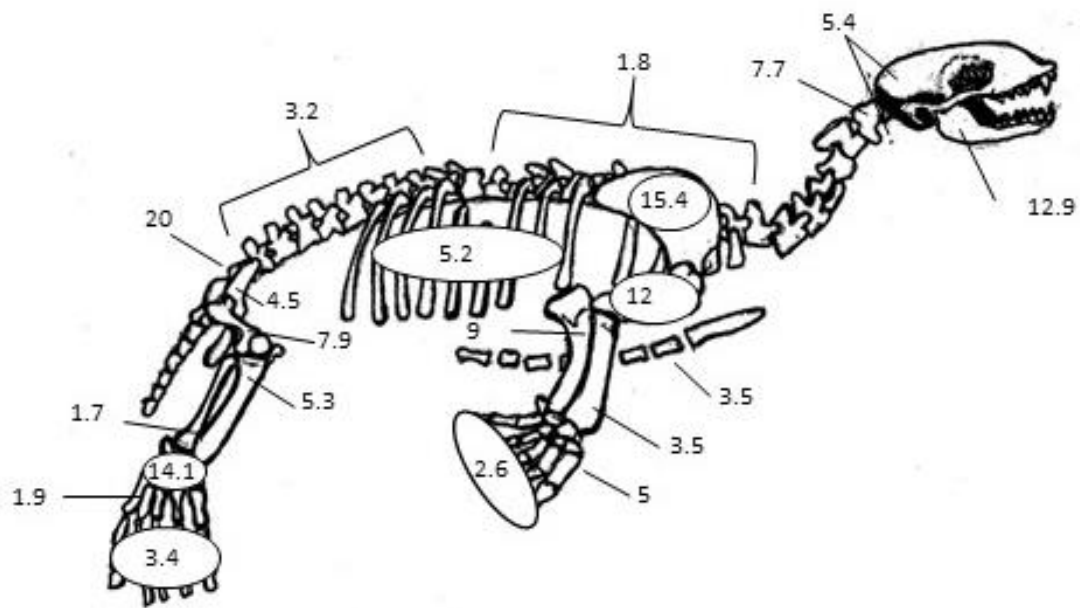


Figure 4.20: Percentages of each skeletal element at NBC showing one or more cut marks. Diagram modified from Bebej (2009) and Post (2004).

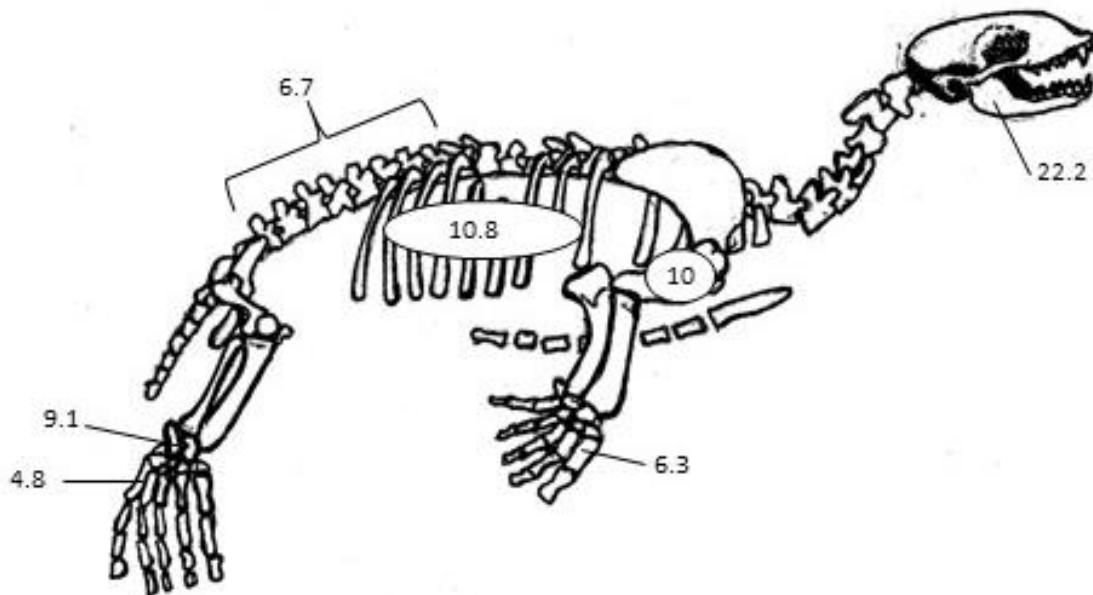


Figure 4.21: Percentages of each skeletal element at HRC showing one or more cut marks. Diagram modified from Bebej (2009) and Post (2004).

Table 4.18 shows the numbers of cut marks at NBC and HRC were low. Only 4.4% (160/3661) of the seal bones at NBC and 3.8% (15/390) of those at HRC had cut marks. Cut marks were present on all skeletal elements at NBC except for carpals and caudal and

cervical vertebrae (Figure 4.20). Cut marks at HRC were limited to certain skeletal elements such as the metapodials, tarsals, humerus, mandible, ribs and lumbar vertebrae (Figure 4.21).

Table 4.19: Percentages of each skeletal type with one or more cut marks at NBC and HRC.

	NBC	HRC
Skeletal Type	%	%
Long bones	6.5	2.2
Flat bones	6.6	7.7
Irregular bones	3.1	1.9
Digitopodia	3.4	2.2
Short bones	11.6	2.6
Entire skeleton	4.4	3.8

Table 4.19 shows that certain skeletal element types showed more evidence of cut marks than others. At NBC cut marks were more frequent on short bones ($17/147 = 11.6\%$) than on flat bones ($19/289 = 6.6\%$) or long bones ($41/632 = 6.5\%$). Cut marks were the least common on the digitopodia ($21/619 = 3.4\%$) and irregular bones ($8/254 = 3.1\%$). A 2x5 chi-square distribution tests were conducted to compare the cut marks on the five skeletal element types at NBC (Table 4.8). The distribution of the cut marks among the five skeletal element types at NBC was significantly different (chi-square = 20.35, 4 d.f. $p=0.05$). At NBC, the frequencies of cut marks on the long bones, flat bones and irregular bones were not significantly different (chi-square = 4.14, 2 d.f. $p=0.05$) but those on digitopodia and short bones were (chi-square = 16.83, 1 d.f. $p=0.05$).

At HRC cut marks were more common on the flat bones ($9/11 = 7.7\%$) than any of the other skeletal element types. Cut marks were less common on the short bones ($1/39 = 2.6\%$), digitopodia ($3/137 = 2.2\%$), long bones ($1/45 = 2.2\%$) and irregular bones ($1/52 = 1.9\%$). The sample of skeletal elements with cut marks was too small to test for differences.

Table 4.20: Numbers of cut marks (CM) per skeletal element at NBC.

NBC	Anatomical region					
	Number of CM	Number of CM PE	Number of CM PS	Number of CM MS	Number of CM DS	Number of CM DE
Skeletal Element						
Cranial and hyoid †	8	0	2	6	0	0
Maxilla †	0	0	0	0	0	0
Mandible †	31	6	24	1	0	0
Atlas •	3	0	2	0	1	0
Axis •	0	0	0	0	0	0
Cervical vertebrae •	0	0	0	0	0	0
Thoracic vertebrae •	1	1	0	0	0	0
Lumbar vertebrae •	5	4	1	0	0	0
Sacrum •	3	0	0	0	3	0
Caudal vertebrae •	0	0	0	0	0	0
Rib †	20	9	3	8	0	0
Sternebra †	4	0	2	2	0	0
Scapula †	13	0	12	0	1	0
Humerus ‡	59	0	23	23	13	0
Radius ‡	19	8	4	0	6	1
Ulna ‡	52	0	1	14	34	3
Carpal ◇	0	0	0	0	0	0
Metacarpal Ω	80	4	21	22	30	3
phalanx (front) Ω	69	3	20	29	8	9
Innominate •	12	0	8	4	0	0
Femur ‡	23	5	9	3	6	0
Tibia ‡	33	0	7	11	15	0
Fibula ‡	8	0	0	4	4	0
Tarsal ◇	54	8	9	33	4	0
Metatarsal Ω	31	1	8	3	18	1
Phalanx (back) Ω	48	0	23	10	15	0
Total	576	49	179	173	158	17

* Note: PE = Proximal Epiphysis, PS = Proximal Shaft, MS = Middle Shaft, DS = Distal Shaft and DE = Distal Epiphysis. The following symbols were used to group skeletal elements:

† = Flat bones, • = Irregular bones, ‡ = Long bones, Ω = digitopodia, ◇ = Short bones

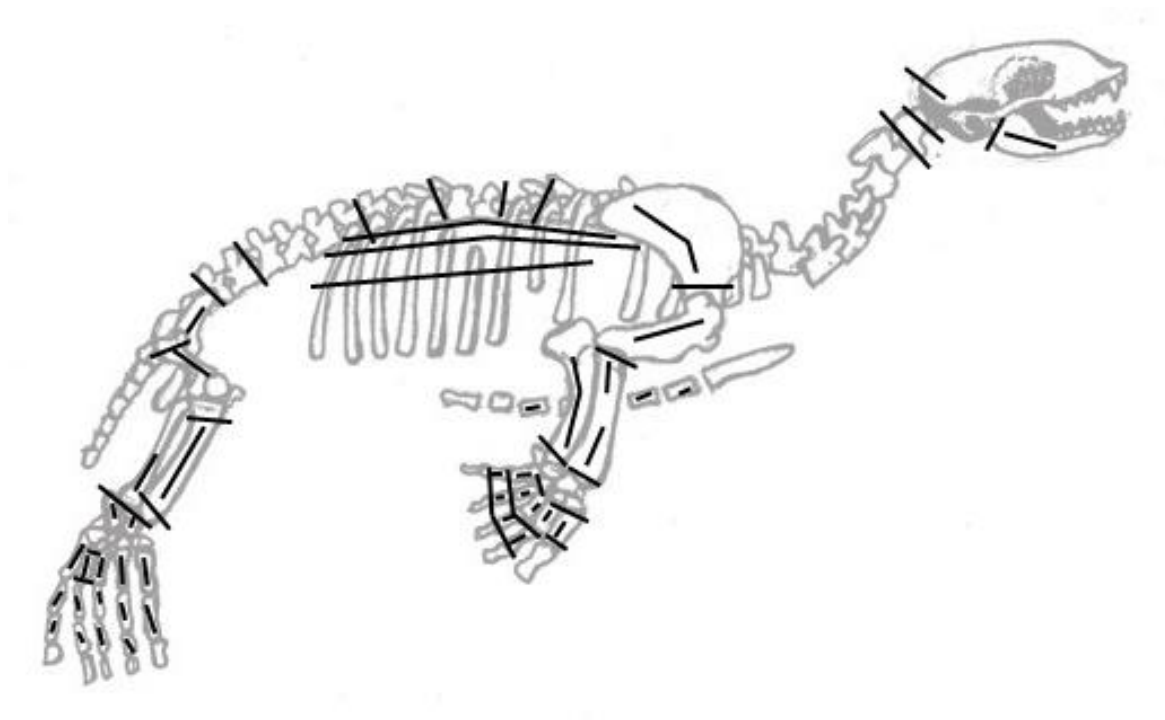


Figure 4.22: Locations of cut marks on the skeletal elements at NBC. Diagram modified from Bebej (2009) and Post (2004).

Table 4.20 shows 88.5% (510/576) of the identified cut marks at NBC were located on the shaft/body of the skeletal element, with only 11.5 % (66/576) of the cut marks present on the epiphyses/ends. Cuts marks were clustered in some regions of the seal skeleton (Figure 4.22).

Cut marks occurred on the basicranium, atlas and some hyoid bones. Cut marks were also present between the articular and the coronoid process of the mandible. Cut marks was present on the sternbrae, thoracic-, lumbar- and sacral-vertebrae and the mid-shafts of the ribs. No cut marks were observed on the cervical vertebrae. Large numbers of cut marks were located on both the shafts and epiphyses of the long bones from both front and hind limbs. Cut marks were also concentrated on and around the innominate/femur and the scapula/humerus attachment areas. Cut marks on the short bones were limited to the tarsals. It should, however, be noted that fewer carpals (NISP 26) than tarsals (NISP 121) were present in the archaeological record. The frequencies of cut marks on the digitopodia of the front and back limb differed. Cut marks were present on the shafts and epiphyseal ends of the digitopodia of the front limb, but for the back limb, were mostly limited to the shafts.

Table 4.21: Numbers and percentages of cut marks (CM) for each skeletal element type at NBC.

Skeletal Type	NBC					CM Total
	Number Of CM PE	Number Of CM PS	Number Of CM MS	Number Of CM DS	Number Of CM DE	
Long bones	13	44	55	78	4	194
Flat bones	15	43	17	1	0	76
Irregular bones	5	11	4	4	0	24
Digitopodia	8	72	64	71	13	228
Short bones	8	9	33	4	0	54
						576
Skeletal Type	% CM PE	% CM PS	% CM MS	% CM DS	% CM DE	
Long bones	6.7	22.7	28.4	40.2	2.1	
Flat bones	19.7	56.6	22.4	1.3	0.0	
Irregular bones	20.8	45.8	16.7	16.7	0.0	
Digitopodia	3.5	31.6	28.1	31.1	5.7	
Short bones	14.8	16.7	61.1	7.4	0.0	

* Note: PE = Proximal Epiphysis, PS = Proximal Shaft, MS = Middle Shaft, DS = Distal Shaft and DE = Distal Epiphysis.

Table 4.21 shows that cut marks were concentrated in certain anatomical regions. 91.3% and 90.8% of the cut marks on the long bones and the digitopodia respectively were located on the shafts, with 8.7% and 9.2% respectively on the epiphyses. On the flat, irregular and short bones, cut marks were distributed from the proximal end to the distal body with no cut marks present on the distal ends.

Table 4.22: Numbers of cut marks per skeletal element from HRC.

HRC	Anatomical region					
Skeletal Element	Number of CM	Number of CM PE	Number of CM PS	Number of CM MS	Number of CM DS	Number of CM DE
Cranial and hyoid †	0	0	0	0	0	0
Maxilla †	0	0	0	0	0	0
Mandible †	9	0	2	7	0	0
Atlas •	0	0	0	0	0	0
Axis •	0	0	0	0	0	0
Cervical vertebrae •	0	0	0	0	0	0
Thoracic vertebrae •	0	0	0	0	0	0
Lumbar vertebrae •	3	0	0	3	0	0
Sacrum •	0	0	0	0	0	0
Caudal vertebrae •	0	0	0	0	0	0
Rib †	23	0	15	0	8	0
Sternebra †	0	0	0	0	0	0
Scapula †	0	0	0	0	0	0
Humerus ‡	1	1	0	0	0	0
Radius ‡	0	0	0	0	0	0
Ulna ‡	0	0	0	0	0	0
Carpal ◇	0	0	0	0	0	0
Metacarpal Ω	7	0	5	1	1	0
phalanx (front) Ω	0	0	0	0	0	0
Innominate •	0	0	0	0	0	0
Femur ‡	0	0	0	0	0	0
Tibia ‡	0	0	0	0	0	0
Fibula ‡	0	0	0	0	0	0
Tarsal ◇	1	1	0	0	0	0
Metatarsal Ω	1	1	0	0	0	0
Phalanx (back) Ω	0	0	0	0	0	0
Total	45	3	22	11	9	0

* Note: PE = Proximal Epiphysis, PS = Proximal Shaft, MS = Middle Shaft, DS = Distal Shaft and DE = Distal Epiphysis. The following symbols were used to group skeletal elements:

† = Flat bones, • = Irregular bones, ‡ = Long bones, Ω = digitopodia, ◇ = Short bones

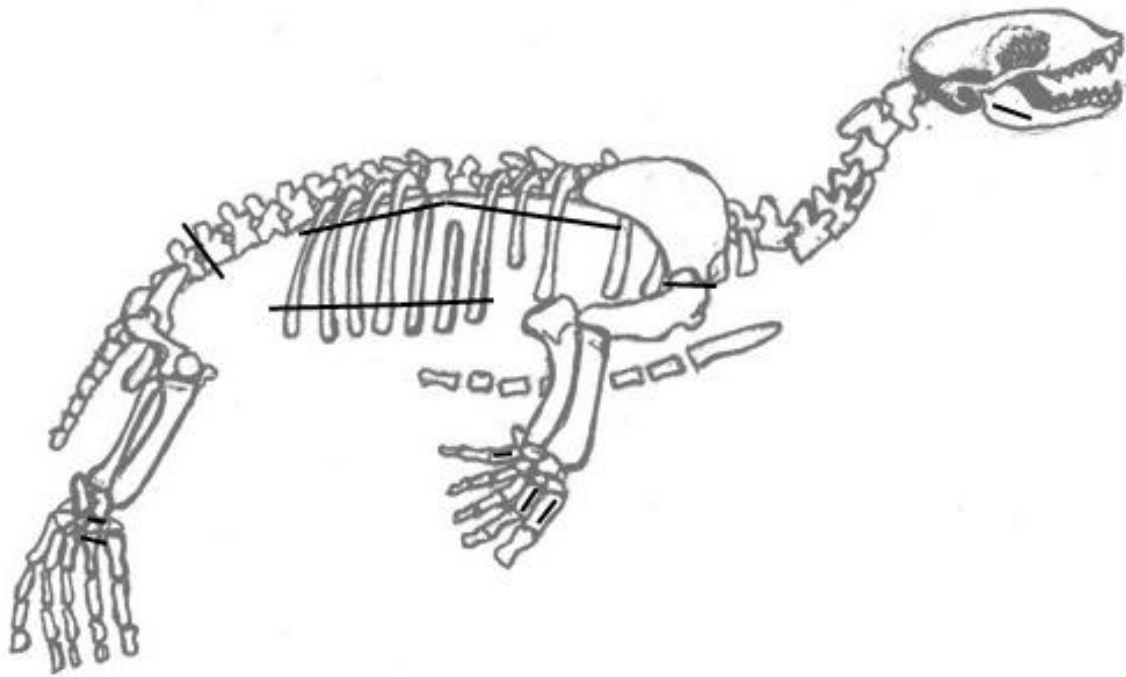


Figure 4.23: Locations of cut marks on skeletal elements at HRC. Diagram modified from Bebej (2009) and Post (2004).

Table 4.22 and Figure 4.23 show that cut marks at HRC were infrequent (45 cut marks) and found mostly on the ribs (23/45 = 51.1%), mandible (9/45 = 20%) and metacarpals (7/45 = 15.6%). A few marks were found on the lumbar vertebrae (3/45 = 6.6%) and one each on the proximal end/epiphysis of a tarsal, metatarsal and humerus.

Table 4.23: Numbers and percentages of cut marks (CM) for each skeletal element type at HRC.

Skeletal Type	HRC					CM Total
	Number Of CM PE	Number Of CM PS	Number Of CM MS	Number Of CM DS	Number Of CM DE	
Long bones	1	0	0	0	0	1
Flat bones	0	17	7	8	0	32
Irregular bones	0	0	3	0	0	3
Digitopodia	1	5	1	1	0	8
Short bones	1	0	0	0	0	1
						45
Skeletal Type	% CM PE	% CM PS	% CM MS	% CM DS	% CM DE	
Long bones	100.0	0.0	0.0	0.0	0.0	
Flat bones	0.0	53.1	21.9	25.0	0.0	
Irregular bones	0.0	0.0	100.0	0.0	0.0	
Digitopodia	12.5	62.5	12.5	12.5	0.0	
Short bones	100.0	0.0	0.0	0.0	0.0	

* Note: PE = Proximal Epiphysis, PS = Proximal Shaft, MS = Middle Shaft, DS = Distal Shaft and DE = Distal Epiphysis.

Table 4.23 shows the numbers of cut marks on the different skeletal element types at HRC. Cut marks were present on all five skeletal element types but most abundant on the flat bones (32/45) and digitopodia (8/45). 87.5 % of the cut marks on the digitopodia were located on the shaft with only 12.5 % located on the proximal end/epiphysis. 100% of the cut marks on the flat- and irregular bones were located on the shaft. The numbers of cut marks on the long and short bones were too small for any interpretation.



Figure 4.24: (a) dorsal and (b) medial view of a Cape fur seal mandible (Specimen: LR 5) from Garth (Inskeep 2), NBC. Cut marks (arrowed) are visible on the body of the mandible. Image photographed with a DinoLight microscope with 20x and 15x magnification.

Figure 4.24 shows three deep parallel cuts between the articular and the coronoid process of a seal mandible from NBC, extending from dorsal to the lateral side of the mandible.

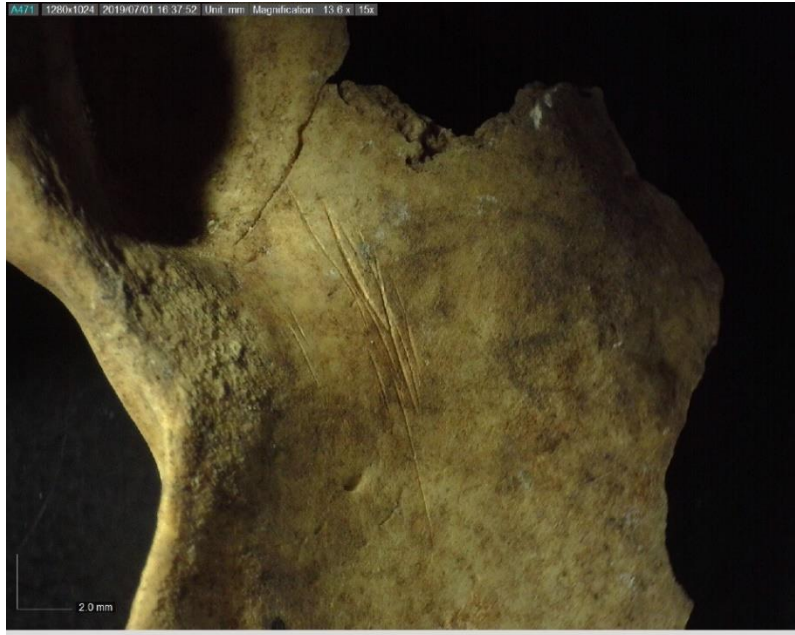


Figure 4.25: Cut marks present on the occiput of a Cape fur seal cranium (Specimen: LR 1388) from IC (Ivan Complex), NBC. Image photographed with a DinoLight microscope with 15x magnification.

Figure 4.25 shows shallow, overlapping cut marks on the occipital surface of a Cape fur seal cranium.



Figure 4.26: Cut marks on the phalanx (Specimen: LR 377) of a Cape fur seal from IC (Ivan Complex), NBC. Image photographed with a DinoLight microscope with 40x magnification.



Figure 4.27: Cut marks on the phalanx (Specimen: LR 562) of a Cape fur seal from IC (Ivan Complex), NBC. Image photographed with a DinoLight microscope with 35x magnification.



Figure 4.28: Cut marks on the phalanx (Specimen: LR 664) of a Cape fur seal from IC (Ivan Complex), NBC. Image photographed with a DinoLight microscope with 25x magnification.

Figure 4.26-28 shows cut marks on the mid-shafts of Cape fur seal phalanges from IC at NBC. The cuts varied from shallow (Fig 4.26) to deep (Fig. 4.27) and a combination of both (Fig.4.28).



Figure 4.29: Cut marks on the canine (Specimen: LR 896) of an adult Cape fur seal from IC (Ivan Complex), NBC. Image photographed with a DinoLight microscope with 15x magnification.

Figure 4.29 shows deep cut marks on the occlusal surface of an adult Cape fur seal canine with medium to heavy wear.

4.5.4.4 Burning

Seal bones from NBC and HRC were examined for evidence of burning, using the criteria of Stiner et al. (1995).

Table 4.24: Numbers and percentages of burnt skeletal elements at NBC and HRC.

Skeletal Element	NBC			HRC		
	NISP	Number Of Burnt Bones	% Burnt Bones	NISP	Number Of Burnt Bones	% Burnt Bones
Cranial (including maxilla) †	75	1	1.3	20	3	11.5
Mandible †	62	5	8.1	9	0	0
Atlas •	13	1	7.7	1	0	0
Axis •	8	0	0	0	0	0
Cervical vertebrae •	35	0	0	2	1	50
Thoracic vertebrae •	56	0	0	20	0	0
Lumbar vertebrae •	62	1	1.6	15	0	0
Sacrum •	5	0	0	0	0	0
Caudal vertebrae •	6	0	0	5	1	20
Rib †	58	3	5.2	65	1	0
Sternebra †	58	3	5.2	13	1	7.7
Scapula †	26	0	0	4	1	25
Humerus ‡	92	3	3.3	10	1	10
Radius ‡	144	5	3.5	12	2	16.7
Ulna ‡	78	1	1.3	7	1	14.3
Carpal ◇	26	0	0	28	3	10.7
Metacarpal Ω	524	87	16.6	32	2	6.3
Phalanx (front) Ω	818	89	10.9	46	1	2.2
Innominate •	69	1	1.5	9	2	22.2
Femur ‡	126	11	8.7	3	1	33.3
Tibia ‡	133	3	2.3	8	0	0
Fibula ‡	59	1	1.7	5	0	0
Tarsal ◇	121	11	9.1	11	1	9.1
Metatarsal Ω	378	38	10.1	21	1	4.8
Phalanx (back) Ω	619	70	11.3	38	1	2.6
Total	3651	334		384	24	

*Note this table does not include non-identifiable flakes and fragments that were not assigned to a specific skeletal element. The following symbols were used to group skeletal elements: † = Flat bones, • = Irregular bones, ‡ = Long bones, Ω = digitopodia, ◇ = Short bones

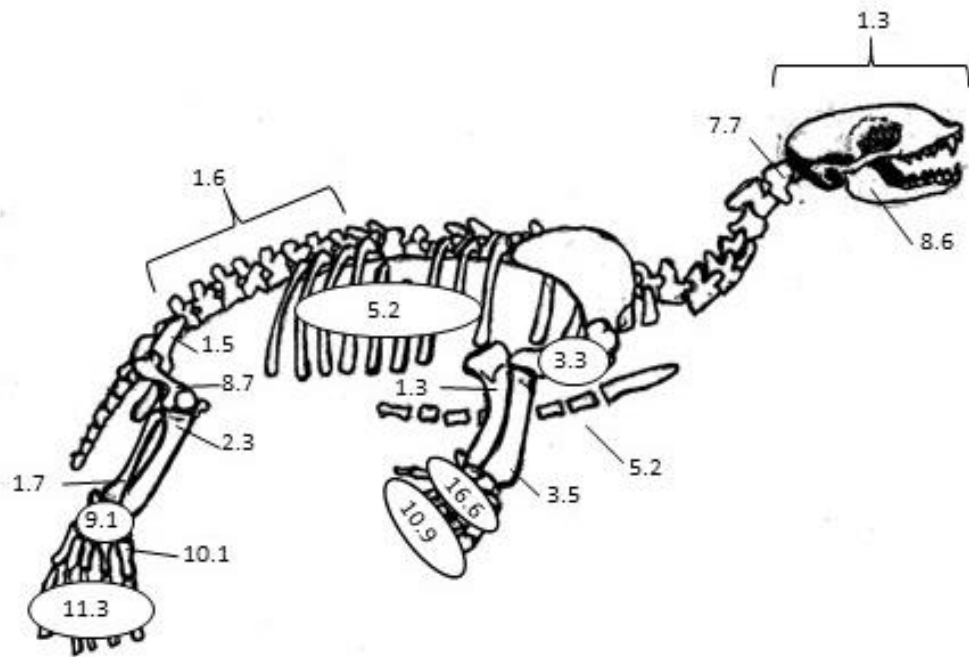


Figure 4.30: Percentages of burned bones for each skeletal element at NBC. Diagram modified from Bebej (2009) and Post (2004).

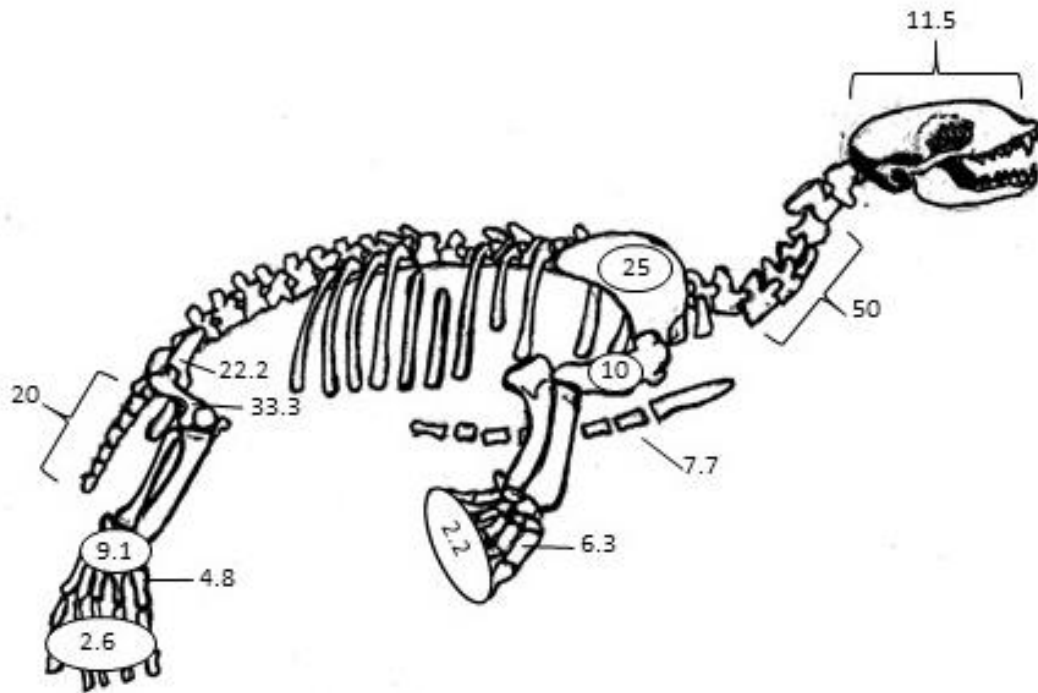


Figure 4.31: Percentages of burned bones for each skeletal element at HRC. Diagram modified from Bebej (2009) and Post (2004).

Table 4.24 shows that 9.1% (334/3651) of skeletal elements at NBC were burnt, as were 6.3% (24/384) of those at HRC. At NBC, burn marks were more common on the appendicular than the axial elements (Figure 4.30). It should, however, be noted that fewer of the axial skeletal remains were present in the archaeological record. On the axial skeleton, burn marks were clustered around the chest, lower back and the skull regions

The majority of skeletal elements of both the front and back limbs showed evidence of burning, especially digitopodia (>10%) and short bones (9.1%), followed by femora (8.7%), radii (3.5%) and humeri (3.3%). Only scapulae and carpals showed no evidence of burning.

At HRC (Table 4.24 & Figure 4.31), half the cervical vertebrae showed burning, but since only two specimens were present, this is not a very meaningful figure. Small numbers of caudal vertebrae (20%), cranium (maxilla included) (11.5%) and a single sternum (7.7%) were also burnt. No ribs or other vertebrae showed evidence of burning. On the appendicular skeleton, the femur, scapula, innominate and humerus showed evidence of burning, but since this was restricted to only one or two specimens in each case, these patterns should be regarded with caution. None of the other long bones (tibia, fibula, radius and ulna) showed evidence of burning. The distal limbs (digitopodia and short bones) did

show evidence of burning, but once again, the numbers are very small – too small to show the kind of patterning seen at NBC.

Table 4.25: Percentages of skeletal element types showing burning at NBC and HRC.

	NBC	HRC
Skeletal Types	% Burnt	% Burnt
Long bones	3.8	11.1
Flat bones	4.3	5.4
Irregular bones	1.2	7.7
Digitopodia	12.1	3.6
Short bones	7.5	10.3
Entire skeleton	9.1	6.3

Table 4.25 shows that certain skeletal element types were more frequently burned than others, especially digitopodia ($284/2339 = 12.1\%$) and short bones ($11/147 = 7.5\%$). Flat- ($12/279 = 4.3\%$), long- ($24/632 = 3.8\%$) and irregular-bones ($3/254 = 1.2\%$) were less often burnt. At HRC the numbers are too small to see any patterning.

A 2x5 chi-square distribution test was conducted to determine if there was a significant difference in the number of burnt bones among the five skeletal elements types at NBC and HRC. At NBC, there was a significant difference in the numbers of burnt bone among the five skeletal element types (chi-square = 77.22, 4 d.f. $p=0.05$). The numbers of burnt long bones, flat bones and irregular bones were not significantly different (chi-square = 4.74, 2 d.f. $p=0.05$). The numbers of burnt digitopodia and short bones were also not significantly different (chi-square = 2.87, 1 d.f. $p=0.05$). At HRC, there was no significant difference in the numbers of burnt bone among the five different skeletal element types (chi-square = 2.88, 4 d.f. $p=0.05$).

Table 4.26: Numbers of bones from NBC and HRC classified according to Stiner et al.'s (1995) stages of burning.

Site	Number		0	1	2	3	4	5	6	% Burnt
	NISP	Burnt	Unburnt	<50% Carbonised	>50% Carbonised	Fully Carbonised	<50% Calcined	>50% Calcined	Fully Calcined	
NBC	4548	362	4186	90	83	34	43	41	71	8.7
HRC	460	26	434	12	1	6	1	0	6	5.7

*Note: This table includes non-identifiable flakes and fragments. The NISPs and numbers of burnt bones therefore differ from those in Tables 4.24 and 4.25

Table 4.26 shows that 57% (207/362) and 73% (19/26) of the burnt bones at NBC and HRC were carbonised (Stage 1-3). Only 43% (155/362) and 27% (7/26), respectively, were calcined (Stage 4-6).

Table 4.27: Numbers of skeletal element types from NBC and HRC that were carbonised (Stage 1-3) and calcined (Stage 4-6).

Skeletal Types	<u>NBC</u> Number Carbonised Bones Stage 1-3	<u>NBC</u> Number Calcined Bones Stage 4-6	<u>HRC</u> Number Carbonised Bones Stage 1-3	<u>HRC</u> Number Calcined Bones Stage 4-6
Long bones	22	2	4	1
Flat bones	22	5	6	1
Irregular bones	3	0	4	0
Short bones	10	1	0	3
Digitopodia	149	147	3	2
Other	1	0	2	0
Total	207/362	155/362	19/26	7/26

*Note: Stiner et al. (1995) used to identify burning stages. This table includes non-identifiable flakes and fragments.

Table 4.27 shows that 57.2% (207/362) and 73.1% (19/26) of the bones at NBC and HRC were carbonised with 42.8% (155/362) and 26.9% (7/26) respectively, calcined. It is important to note that 81.2% (296/362) of the burnt bone at NBC were digitopodia, of which 50.3% were carbonised (149/296) and 49.7% calcined (147/296). At HRC the sample of burnt bones (26) was too small for interpretation.

4.6 Summary of results

This chapter has reported on the analysis of the seal bone assemblages from selected stratigraphic units at NBC and from the 2007-8 excavations at HRC, reporting on abundance, representation of different skeletal elements, age profiles and taphonomy. There are substantial differences in the representation of different body parts between the Early- to Middle Holocene and the Late Holocene layers. The body part representation between juveniles and older individuals were similar. The seal assemblage at NBC and HRC were dominated by juveniles with some adults and sub-adults also present within the record. The age profiles at NBC and HRC remained constant throughout the Holocene. At both sites, the average percentage of skeletal element completeness was above 50%. Post-depositional damage, such as trampling and weathering were rare (<6%). Seal bone shaft circumference ratios and shaft to epiphyses ratios were virtually identical at NBC and HRC. Carnivore activity was noted at NBC but bite marks were rare (1.4%). Surface modifications such as percussion marks (<0.3%), cut marks (<5%) and burn marks (<10%) on seal bones from NBC and HRC were low. The cut mark patterns and abundance of burnt flipper bones, at NBC, were noteworthy.

Chapter 5: Discussion

5.1 Introduction

Results reported in the last chapter enable us, for the first time, to explore issues of seal procurement, butchery, transport, processing and taphonomy in the important coastal site of NBC. This has long been recognized as a gap in research (Marean 2006). It will also enable us, for the first time, to compare patterns of seal utilization at NBC with those reported amongst coastal hunter-gatherers in other parts of the world.

5.2 Major findings of the NBC and HRC seal assemblage

5.2.1 Specimen counts and identification

A total of 4518 seal specimens (NISP) were identified in the selected Holocene layers from NBC and 460 from HRC. Most were of the Cape fur seal, the only pinniped species that breeds and lives along the coast of South Africa and Namibia (David 1989). Dental remains of the elephant seal (NISP = 23) and Antarctic fur seal (NISP = 4) were also found in the assemblages studied. The presence of these two species at Robberg is not unusual.

According to quarterly reports, several of these non-endemic seals haul out on the Robberg Peninsula and the southern Cape coast on an annual basis to rest, moult or die (Conry et al. 2018; Conry et al. 2019b). The presence of Antarctic fur seal and elephant seal teeth in the archaeological record at NBC shows that human populations utilised a range of marine mammals when encountered.

A minimum number of 94 Cape fur seals were identified. 59 came from the Early Holocene layers BSBJ and RC at NBC and 35 from the Middle- to Late Holocene layers IC, I2 and I1 at NBC and from HRC. Site formation processes such as the rate of sediment accumulation, level of sediment compaction and the amount of shell within the deposit make it difficult to compare the volumes of deposit between different layers at a site. Due to these site formation processes and the relatively small seal bone sample, it was not possible to make inferences about the increase or decrease of sealing through the Holocene.

5.2.2 The age profiles of Cape fur seals at NBC and HRC

Cape fur seals are highly seasonal in their behaviour. They haul out on land in the summer months to breed and moult and they return to sea in the winter months to build up their fat reserves (Marean 1986). They do not undertake regular migration (Rand 1956) and tend to

return to their natal breeding colony (Oosthuizen 1991). This makes Cape fur seals ideal for seasonality studies.

To determine seasonality from Cape fur seal remains an extensive morphometric database similar to Ericson and Storå (1999) is required. Others have used dental growth rate annuli (Fletemeyer 1974,1977) and measurements of Cape fur seal mandibles (Woodborne et al. 1995; Woodborne 1996,2006), femora and humeri (Inskeep 1987a; Klein & Cruz-Urbe 1996,2016) to try to determine the age/season of death of seals from archaeological assemblages (Section 2.8.3). Setting up a morphometric database such as that of Ericson and Storå will require an extensive comparative collection of seals from various age groups, mainly due to the fact that sexual dimorphism is exceptionally high in Cape fur seals (Bonner 1994). Given the lack of suitable comparative collections and lack of a morphometric database for known-age Cape fur seals, it was not possible to establish seasonality at Robberg.

However, it was possible to assign the Robberg seal assemblage to broad age groups by looking at the overall size and state of fusion of the bone (Crockford & Frederick 2011). The majority of the seals from NBC and HRC were juveniles (61.5%, MNE = 2149) followed by adults (26.2%, MNE = 914) and sub-adults (12.3%, MNE = 430). The demography of haul-out and breeding colonies for Cape fur seals are well studied (Oosthuizen & David 1988; Woodborne 1996). The dominance of juveniles with the presence of older seals at NBC is consistent with the demographic profile of seals being hunted (Marean & Binford 1986) or scavenged (Inskeep 1987a) from a land-based breeding colony.

Based on earlier studies on Cape fur seal mandibles, femora and humeri from NBC, Inskeep (1987a) argued that approximately equal numbers of juveniles and adults were exploited in the Middle Holocene. During the Late Holocene, there was an increase in juvenile seal exploitation. This study has shown that there was high exploitation of juvenile seals (60/40) not only during the Late Holocene but also during the Early Holocene. It is only during the Middle Holocene that there was an almost equal (55/45 percentage ratio) exploitation of juveniles and sub-adult/adult seals at Robberg.

5.2.3. Skeletal representation, frequency and completeness

The skeletal element representation and frequencies were calculated to assess which agents and taphonomic factors contributed to the accumulation of the Robberg seal assemblage. During the analysis of the Early- to Middle Holocene layers, BSBJ, RC and IC, it was noted

that the majority of the axial skeletal elements and the carpals were absent from the assemblage. A possibility exists that these skeletal elements are missing due to a curational issue. It should, however, be noted that all of the boxes of seal bones listed in IZIKO Museums' catalogue for these levels of NBC were studied. The discussion below will therefore be based on the premise that the assemblage is complete, and that the patterns are not due to curation.

There is a difference in the Cape fur seal skeletal representation in the Early- to Middle Holocene compared with the Late Holocene layers. In the Early- to Middle Holocene layers BSBJ, RC and IC the appendicular skeleton and the skull is well represented, while the axial skeleton is mostly absent. In the Late Holocene layers HRC, I2 and I1, both the appendicular and axial skeleton are well represented.

The skeletal representation and frequency analyses showed that skeletal elements such as the skull and flippers, which have a low utility and hardness index, were present throughout the Holocene archaeological record. Skeletal elements such as the ribs and vertebrae, which have high utility and hardness index values, were absent from the Early- to Middle Holocene layers but present during the Late Holocene layers. The preservation of bones with a low hardness index such as the second and third phalanges suggests that the variations in skeletal representation and frequency at Robberg were related to human choices and not post-depositional damage.

Ethnographic studies among Inuit people from Greenland and Alaska have shown that the seal's head is a valuable resource. Fragmentation of the cranium, maxilla, mandible and hyoid are associated with the disarticulation of the head and the removal of the brain and tongue (Henshaw 2000; Lantis 1946). Fragmentation of other flat bones such as the scapula, ribs and sternbrae and the irregular bones (vertebrae) is likely to be associated with the carcass disarticulation and sectioning technique used by the butcher (Nelson 1969).

According to ethnographic accounts, when seals are hunted/scavenged on land, larger seals undergo primary disarticulation at the kill site, with only selected portions returned to the home base, while smaller seals are returned whole (Binford 1978). At NBC, however, the body part profiles of adults and juveniles are similar. This would suggest that seal weight and size did not factor in to transport decisions at Robberg. Many of the juvenile seals (12-24 months) would have weighed at most about 44 kg for males and 29 kg for females (Rand

1956). This is below the maximum carrying capacity of 45 kg for a Hadza hunter-gatherer (O'Connell et al. 1988).

The poor representation of the ribs and vertebrae in the Early- to Middle Holocene layers suggest that these elements did not return with the skull and appendicular elements. It has already been suggested this skeletal pattern is based on human transport decisions. According to O'Connell et al. (1990) the number of animal parts that return to the site is influenced by the size of the animal, distance from the kill site and the size of the hunting party.

The “schlepp effect” (Perkins & Daly 1968; White 1952,1953a,1954) might be a likely explanation for skeletal representation at Robberg. According to the “schlepp effect” the axial skeleton of larger animals will be stripped of meat and left at the kill site, while the appendicular skeleton with large volumes of muscle attached is taken back to home base. However, unlike the “schlepp effect” which applies mostly to larger animals, both the juvenile and adult seal remains from NBC were field butchered in a similar manner.

If the transport decision was based on distance, one might expect the seal colony to be located further than the typical foraging radius of 10 km (Binford 1982). The seal colonies on the Robberg Peninsula and at Beacon Island were both located less than 5 km away. If the Early- to Middle Holocene hunting party was small and hunter-gatherers had to track over a steep and rocky Robberg landscape, the “schlepp effect” would be relevant for both adult and juvenile seals.

Arguably if the hunting party was small, both large and small seals would have been field butchered near the kill or scavenging site. The absence of the ribs and vertebrae suggest the meat would have been removed from these skeletal elements, which were then discarded at the butchering site. The meat would likely have been taken back to site with the head, flippers and the hide. Alternatively, meat from the ribs could also have been stored on the beach for later consumption. Studies have shown that seal meat and blubber can preserve for 10 days when buried underneath the sand within the intertidal zone (Smith 2006b; Smith et al. 1992; Woodborne 1996).

The return of low utility elements such as the skull and flippers cannot entirely be explained by the “schlepp effect”. Considering seal anatomy, the head and the back limb are attached to the axial skeleton while the front limb is not. The absence of the axial skeleton and the presence of the head and back limb suggest that these were purposefully removed and taken

back to NBC. Inuit ethnographic studies have established that the brain, tongue (Henshaw 2000) and the flippers (Spray 2002) were delicacies. If the brain was eaten, it would be easier to transport if kept in the skull till later consumption. The removal of the tongue, the deboning of the flippers and the removal of the canines (Section 4.5.4.1) are time-consuming, and therefore better done at the living site. Arguably, the presence of low utility elements at NBC reflects a social preference for skeletal elements classified as delicacies throughout the Holocene.

During the Late Holocene (3 500 BP) the first “mega middens” appear on the South African coast, probably reflecting an increase in the coastal population (Erlandson 2001; Jerardino 2010,2012; Sealy 2016). It is after 3 500 BP that entire seal skeletons of both adults and juveniles are returned to NBC and HRC. If the coastal population had increased, the sizes of hunting parties would probably also have increased, making it easier to transport kills back to the living site. There would have been no need for extensive field butchery. To maximize nutritional benefit, seal carcasses should be processed at the home base. Unlike the smaller hunting parties from the Early- and Middle Holocene, the larger hunting parties of the Late Holocene could afford to do so.

5.2.4 Bone modification

In general, the preservation of the seal assemblages at both NBC and HRC was good, with little post-depositional damage. Natural bone surface modification was minimal. Only 5.3 % (NISP = 243/4548) of the bones from NBC and 2% (NISP = 9/460) of those from HRC were damaged by weathering, root etching exfoliation or trampling. Seal bones were, on average, 53.5% complete at NBC and 71.9% at HRC bones. At both sites, short bones were most complete (89.2% and 98.5%) followed by digitopodia (77% and 90.4%), long bones (59.2% and 89.8%), flat bones (37% and 56.1%) and irregular bones (35.6% and 45.8%).

Given the sparse literature on this topic, it is difficult to make comparisons with assemblages of seal bones elsewhere. Er Yoh, a Late Neolithic site in southern Brittany, is one of the few sites at which skeletal completeness is mentioned. Analyses showed that 59% of the skeletal elements were complete. Boyle (2005) argues that the tendency of the Er Yoh seal bones to be complete is consistent with Inuit ethnographic and ethnohistoric accounts which indicate seal bones were not used for marrow extraction. The percentage of complete skeletal elements from NBC (53.5%) and HRC (71.9%) indicate that Cape fur seal bones were not broken into small pieces for bone grease rendering at Robberg.

Only 0.2% (NISP = 7/3661) of the seal bones at NBC and 0.3% (NISP = 2/390) of those at HRC had percussion marks. These were located on the long bones of the upper front limb and the digitopodia of the front and back limbs, and on two mandibles. In one case, the intention was probably to remove the canine. Ethnographic accounts have stated that the Khoekhoen traded seal teeth with the Europeans at the Cape Colony in the 17th century (Raven-Hart 1967). There are too few percussion marks to detect any patterning.

Skeletal elements with tooth marks were rare (1.4 % NISP = 50/3661) at NBC and absent at HRC. Skeletal elements with a higher percentage of toothmarks were flat bones (4.2%, NISP = 12/289) followed by short bones (2.1%, NISP = 4/147) and long bones (2.1%, NISP = 13/632). The toothmarks from NBC were narrow in diameter, probably caused by black-backed jackals, which still roam some parts of the coast of South Africa and Namibia (David 1989).

At NBC skeletal elements that most frequently showed toothmarks were the sternbrae (8.6%), ribs (5.2%) and mandible (4.8%). Woodborne's (1996) observations of jackals scavenging washed-up seals on the west coast of Namibia indicate that they first try to penetrate the neck by biting through the skin at the neck. Their primary goal is to remove all flesh from the bones as well as the stomach and chest contents. The only bones that are destroyed during the scavenging process are the sternum, the distal cartilage of the ribs and the proximal margin of the scapula when they try to open the chest cavity. Arguably the toothmark damage to sternbrae, ribs and mandible seem to have resulted from the attempts of jackals to open the chest cavity. Bite marks on sternum and ribs suggest that the carcass were likely first ravaged by jackals before it was found and returned by hunter-gatherers to NBC.

Of the appendicular skeleton, the carpals (3.8%), tarsals (2.5%) and femur (4%) had the highest percentage toothmarks. Analyses of jackal middens from the North Cliff Midden and the East Rock Midden on the West Coast show that jackals mostly prefer to feed on the easily removable forelimbs. They feed on the axial skeleton and the hind limbs only when they are nutritionally stressed, gnawing on smaller bones such as the femur, long bone epiphyses, sternum, ribs, carpals and phalanges (Woodborne 1996). It is possible that jackals visited NBC when people were not there, scavenging for discarded seal bones, and chewing on small elements such as the short bones and femur because they were nutritionally

stressed. Arguably the presence of bite marks on the less desirable skeletal elements from front and back limbs suggest that jackals were the secondary modifying agents.

The average percentage of toothmarks (1.4%, NISP = 50/3661) and the number of jackals (MNI = 7) (Inskeep 1987b; Klein 1972a) found in the archaeological record at NBC seems to indicate a symbiotic relationship between the jackals and humans at Robberg.

Skeletal elements with cut marks were scarce. Only 4.4% (NISP = 160/3661), and 3.8% (NISP = 15/390) of the elements at NBC and HRC respectively had cut marks. At NBC skeletal element types with the highest percentages of cut marks were short bones (11.6%) followed by flat bones (6.6%), long bones (6.5%) and digitopodia (3.4%). At HRC, cut marks were seen most often on the flat bones (7.7%) followed by short bones (2.6%), digitopodia (2.2%) and long bones (2.2%). At both NBC and HRC, the skeletal element type with the lowest average percentages of cut marks was irregular bones (3.1% and 1.9%). It should be noted that the irregular bones were also the most incomplete, which may explain the low incidence of cut marks.

Cut marks may be more abundant in assemblages dominated by adults than those dominated by juveniles. At Imiwaia I, Tierra del Fuego, an assemblage dominated by adult male South American fur seals, 11.9% of the bones were cut (Martinoli 2015). At Zagan-Zaba II, Lake Baikal, Russia, a yearling and juvenile (sub-adult) dominated assemblage, the cut mark frequency varied from 0.2% to 5.2% (Nomokonova et al. 2015). The cut mark frequencies at NBC (4.4%) and HRC (3.8%) seem to correspond well with a juvenile dominated assemblage such as Zagan-Zaba II.

However, one adult-dominated and one juvenile-dominated assemblage isn't enough to say that cut mark frequency is related to seal size. Cut mark frequency may equally have to do with what kinds of tools were used to butcher the seals or in which state of preservation seals were consumed. Ethnographic accounts from South Africa indicate that the Khoekhoen would eat seals that European observers considered rotten (Raven-Hart 1967). Accounts from Alaska and Canada indicate that certain skeletal elements such as the flippers (Spray 2002) and head (Nansen 1893) were fermented before consumption. Unlike fresh or frozen meat, rotten and fermented meat can be removed from the bone without extensive cutting.

At NBC and HRC, cutmarks were clustered at several locations. The first cluster occurred on the head: on the occipital surface of the cranium, the atlas and hyoid bones. Cut marks were also present between the articular and the coronoid process of the mandible. Those on the

occiput may be associated with the removal of the seal scalp (blubber + hide) from the cranium, while those on the atlas and hyoid may result from disarticulation of the skull. Cut marks on the articular and coronoid process of the mandible indicate removal of the tongue.

The second cluster of cut marks was found on the sternbrae, vertebrae (other than cervical vertebrae), the proximal ends and the proximal to middle shafts of the ribs. Arguably, these cut marks are associated with the opening of the chest cavity and the removal and sectioning of the ribs and vertebrae. The cut marks on the proximal and middle rib shafts are associated with meat removal (Nelson 1969).

The third and fourth clusters of cut marks were found on the front and back limbs. Analyses of the upper limbs showed cut marks on the proximal and distal ends as well as the shafts of the long bones. Cut marks were also concentrated on and around the innominate/femur and the scapula/humerus attachments. Cut marks near the ends of the long bones are probably associated with carcass disarticulation (Binford 1981).

Cut marks on the short bones were limited to the tarsals. It should, however, be noted that fewer carpals (NISP= 26) than tarsals (NISP = 121) were present in the NBC assemblage studied. Cut marks were present on the shafts and epiphyseal ends of the digitopodia of the front flipper. Those on the shafts varied from deep marks to shallow ones, suggesting that they derive from filleting as well as skinning (Binford 1981). From the presence of marks on the epiphyseal ends, we may infer that the digits were being separated from one another and filleted and/or skinned. On the back limb, cut marks were present only on the shafts of the digitopodia, which implies that the digits were mostly kept together and skinned and/or filleted as a single element.

Extensive cut marks are noted on the front and back flippers of the South American fur seals at Imiwaia I, Tierra del Fuego. It is argued that this was done to access the layer of blubber located within the flipper (Martinoli 2015). What is important to note is that the cut-marks (and probably also the presence of percussion marks mentioned earlier) show that people took care (and must have spent time) processing the flippers. In Alaska, flippers are still considered a delicacy today (Spray 2002). The presence of filleting and sectioning marks on the flipper bones throughout the Holocene layers at NBC and HRC suggests that they were a highly sought after body part.

At NBC 9.1% (NISP = 334/3651) of the skeletal elements were burnt, and at HRC 6.3% (NISP = 24/384). Other studies have reported similarly low percentages of burnt seal bones:

on average, less than 15% of the assemblage (Martinoli 2015; Martinoli & Vázquez 2017; Moody & Hodgetts 2013; Nomokonova et al. 2015). Very few studies report which skeletal elements were most often burnt. Piana et al. (2008) mentioned that 25% of the burnt seal bones at Aje1 were flipper and sternum bones. At NBC, 81.2% (NISP = 296/362) of the burnt skeletal elements were digitopodia, of which 50.3% were carbonised (NISP = 149/296) and 49.7% calcined (NISP = 147/296). Experiments have shown that bones lying close to or underneath the fire typically show burn stages 0-3 (carbonised) while those directly exposed to fire show burn stages 3-6 (calcined) (Stiner et al. 1995). The carbonised/calcined (50.3/49.7) ratio for digitopodia suggests they were purposefully or accidentally discarded into or around a fire.

5.4 The Knysna seal scapula

In the light of the above, I would like to make some further comments on the painted seal scapula described in Chapter 2. In my personal opinion, the Knysna seal scapula depicts a Cape fur seal, superimposed African penguins and a humpback whale carcass lying on its back (Figure 2.3).

Artefacts like the painted stones and the painted seal scapula, in combination with our knowledge of San ethnography, strongly suggest that there was a ritual/spiritual component in Holocene hunter-gatherers' interactions with seals. In a study like this one, it is hard to distinguish aspects of peoples' behaviour that may have been linked to ritual/spiritual concerns from those that were primarily economic.

5.5 Changing our perspective of the Robberg seal colony

Not much was known of the importance of seals in the lifeways of hunter-gatherers and herders at Robberg during the Holocene. Earlier studies by Inskeep (1987a) and Klein and colleagues (Klein 1972a,b; Klein & Cruz-Urbe 1996) established that seals of all ages were being exploited at NBC throughout most of the Holocene. After 3 500 BP, juvenile seals become more prominent in the archaeological record. The most recent studies by Sealy (2006) have also shown that seals were an important food item in the diet of Later Holocene hunter-gatherers at Robberg.

The results have shown that a land-based breeding colony was already established on the Robberg Peninsula during the Early Holocene. Hunter-gatherers and herders from NBC and HRC exploited this colony throughout the Holocene. From the age profiles, it is clear that

the Robberg people preferred juveniles but also exploited sub-adult and adult seals. Their preference for juveniles may be associated with the fact that juveniles are more naïve and less dangerous than their older counterparts. The hunting of non-breeding individuals is also a more sustainable hunting practice. The rough Robberg terrain, as well as the population size, seemed to have influenced hunter-gatherer seal hunting/scavenging strategies throughout the Holocene. During the Early- to Middle Holocene, small population sizes and the rugged Robberg landscape meant that seals of all age groups had to be field butchered to increase the economic return rate. However, during the Late Holocene, the increase in coastal population meant larger hunting parties and more hands to carry the carcass back to site for processing and consumption. The skeletal representation and cut mark patterns suggest that hunter-gatherers and herders of Robberg preferred the seal head and flippers as these skeletal elements always returned to site. Arctic ethnographic accounts have highlighted the importance of these body parts as delicacies. The depiction of marine animals on burials stones and the Knysna seal scapula, as well as San ethnography, suggest that these animals had a spiritual significance to coastal Holocene hunter-gatherers. Overall the results have shown that seals formed an important part of the Robberg people's economic and spiritual livelihood throughout the Holocene.

5.6 Limitations and suggestions for future research

Due to time constraints, the GIS-based method of recording was not implemented in the analysis of these assemblages. This method takes into account otherwise difficult-to-identify mid-shaft fragments, enabling calculation of more accurate MNEs. Seal long-bones lack central marrow cavities, and therefore were not broken open to extract bone marrow. At NBC, 79.6 % (NISP = 2492/3129) of the seal long-bone shafts were complete, while at HRC the figure was 82.2 % (NISP = 175/213). In some cases, possibly in colder higher-latitude regions, seal bones may have been broken apart for marrow extraction. In such instances, it would be beneficial to implement the GIS method.

The breakage patterns of seal long bones were recorded to try to determine the bone modifying agent. Actualistic studies on the breakage patterns of long bones when processed for nutritional and non-nutritional purposes have been conducted for terrestrial mammals but not for seals. Seals have very different bone structure and therefore different breakage patterns. Actualistic studies on how seal bone fractures when broken by various bone modifying agents have yet to be conducted. Data from such a study will help future

archaeologists to interpret seal bone breakage patterns and identify the modifying agent within the assemblage.

It was not possible to sex and determine the season of death for the seal remains from NBC and HRC. South Africa lacks an extensive comparative Cape fur seal collection with known-age animals of both sexes and various age cohorts. Future studies should focus on the collection of such an assemblage and constructing a long bone measurement database similar to that developed by Ericson and Storå (1999) for harp seals. This will greatly help future archaeologists to positively identify sex and season of death of Cape fur seals in South African archaeological assemblages.

Chapter 6: Conclusion

This study provides the first comprehensive analysis of Cape fur seal remains from selected stratigraphic units at Nelson Bay Cave, and from the 2007-2008 excavations at the nearby Hoffman's/Robberg Cave.

The dominance of juveniles, together with the presence of adults and sub-adults throughout the Holocene suggests that hunter-gatherers and pastoralists at NBC and HRC lived within foraging distance of a breeding colony. This colony would have been a rich and predictable resource throughout the year, and it is clear that the people of Robberg fully utilised Cape fur seals for their meat, intestines, organs, blubber and hides. The absence of low utility skeletal elements in both juvenile and adult seals during the Early- and Middle Holocene suggest that animals of all ages were field butchered. The negative correlation between the body part frequency and the food utility values for Cape fur seals suggest elements such as the ribs and vertebrae were processed in the field and the bones discarded. The “schlepp effect” may have come into play during this time period not because of carcass weight and size but due to the rough terrain of Robberg and the smaller sizes of the hunting parties.

During the Late Holocene (3 500 BP onwards), megamiddens appear on the South African coast reflecting an increase in population size. During this period the entire skeletons of both juvenile and adult seals were returned to NBC and HRC. Arguably, an increase in coastal population would mean larger hunting parties.

The heads and flippers of seals of all ages were returned to NBC and HRC throughout the Holocene. Cut marks on the crania and mandibles as well as the low level of completeness of the cranial bones suggests that the head was a valued resource likely exploited for the brain, tongue and eyes. Similarly, the presence of cut-marks on the digitopodia suggest that considerable time and effort was spent on processing the flippers. Both the head and flippers require skill and time to process. To maximize nutritional benefit, these elements were taken back to NBC and HRC to process. Flipper bones were sometimes discarded into or close to fires. Evidence from Robberg is therefore consistent with ethnographic accounts of Inuit people, amongst whom seal heads and flippers were considered delicacies.

The Knysna seal scapula, and painted stones from the south coast show that seals and other marine mammals were of spiritual/symbolic significance to coastal hunter-gatherers in the Holocene. The seal's ability to transition from one world to another (water to land) echoes the shaman's ability to transition from the material world to the spirit world. Assessing the

role of spiritual, compared with economic considerations in the accumulation of archaeological seal bone assemblages is an ongoing challenge.

References

- Abe, Y., Marean, C.W., Nilssen, P.J., Assefa, Z. & Stone, E.C. 2002. The analysis of cutmarks on archaeofauna: a review and critique of quantification procedures, and a new image-analysis GIS approach. *American Antiquity*. 67(4):643-663.
- Avery, G., Cruz-Urbe, K., Goldberg, P., Grine, F.E., Klein, R.G., Lenardi, M.J., Marean, C.W., Rink, W.J. et al. 1997. The 1992–1993 excavations at the Die Kelders Middle and Later Stone Age cave site, South Africa. *Journal of Field Archaeology*. 24(3):263-291.
- Bailey, B.E. 1952. *Marine oils, with particular reference to those of Canada*. Fisheries Research Board of Canada, Bulletin 89: Ottawa.
- Bain, T.C.J. 1880. Bone caves at Knysna. *The Cape Monthly Magazine*. 2(3):255-256.
- Bar-Matthews, M., Marean, C.W., Jacobs, Z., Karkanas, P., Fisher, E.C., Herries, A.I., Brown, K., Williams, H.M. et al. 2010. A high resolution and continuous isotopic speleothem record of paleoclimate and paleoenvironment from 90 to 53 ka from Pinnacle Point on the south coast of South Africa. *Quaternary Science Reviews*. 29(17-18):2131-2145.
- Barham, L. 2008. *The first Africans : African archaeology from the earliest tool makers to most recent foragers*. Cambridge: Cambridge University Press.
- Baxter, I.L. & Hamilton-Dyer, S. 2003. Foxy in furs? A note on evidence for the probable commercial exploitation of the red fox (*Vulpes vulpes* L.) and other fur-bearing mammals in Saxo-Norman (10th-12th century AD) Hertford, Hertfordshire, UK. *Archaeofauna*. 12(8).
- Bebej, R.M. 2009. Swimming mode inferred from skeletal proportions in the fossil pinnipeds *Enaliarctos* and *Allodesmus* (Mammalia, Carnivora). *Journal of Mammalian Evolution*. 16(2):77-97.
- Behrensmeyer, A.K. 1975. The taphonomy and paleoecology of Plio-Pleistocene vertebrate assemblages east of Lake Rudolf, Kenya. *Bulletin of the Museum of Comparative Zoology*. 146:473-578.

- Behrensmeyer, A.K. 1978. Taphonomic and ecologic information from bone weathering. *Paleobiology*. 4(2):150-162.
- Behrensmeyer, A.K., Gordon, K.D. & Yanagi, G.T. 1986. Trampling as a cause of bone surface damage and pseudo-cutmarks. *Nature*. 319(6056):768.
- Best, P.B. & Shaughnessy, P.D. 1979. An independent account of Captain Benjamin Morrell's sealing voyage to the south-west coast of Africa in the Antarctic, 1828/29. *Fisheries Bulletin of South Africa*. 12:1-19.
- Binford, L.R. 1978. *Nunamiut Ethnoarchaeology*. New York: Academic Press.
- Binford, L.R. 1980. Willow smoke and dogs' tails: hunter-gatherer settlement systems and archaeological site formation. *American Antiquity*. 45(1):4-20.
- Binford, L.R. 1981. Ancient men and modern myths. *Academic Press, New York*.
- Binford, L.R. 1982. The archaeology of place. *Journal of Anthropological Archaeology*. 1(1):5-31.
- Binford, L.R. 1984. *Faunal Remains from Klasies River Mouth*. New York: Academic Press.
- Binford, L.R. & Bertram, J.B. 1977. Bone frequencies and attritional processes. In *For Theory Building in Archaeology*. L.R. Binford, Ed. New York: Academic Press. 77-153.
- Birket-Smith, K. 1936. *The Eskimos*. Translated by W.E. Calvert and C.D. Forde. London: Methuen & Co. Ltd.
- Blumenschine, R.J. 1988. An experimental model of the timing of hominid and carnivore influence on archaeological bone assemblages. *Journal of Archaeological Science*. 15(5):483-502.
- Blumenschine, R.J. & Selvaggio, M.M. 1988. Percussion marks on bone surfaces as a new diagnostic of hominid behaviour. *Nature*. 333(6175):763.
- Blumenschine, R.J. & Madrigal, T.C. 1993. Variability in long bone marrow yields of East African ungulates and its zooarchaeological implications. *Journal of Archaeological Science*. 20(5):555-587.

- Blumenschine, R.J., Marean, C.W. & Capaldo, S.D. 1996. Blind tests of inter-analyst correspondence and accuracy in the identification of cut marks, percussion marks, and carnivore tooth marks on bone surfaces. *Journal of Archaeological Science*. 23(4):493-507.
- Boaz, N.T. & Behrensmeyer, A.K. 1976. Hominid taphonomy: transport of human skeletal parts in an artificial fluvial environment. *American Journal of Physical Anthropology*. 45(1):53-60.
- Bogan, A.E. & Robison, N.D. 1987. *The zooarchaeology of eastern North America: history, method and theory, and bibliography*. Tennessee Anthropological Association.
- Bonner, W.N. 1994. *Seals and sea lions of the world*. New York: Facts on File.
- Bowen, W., Sergeant, D.E. & Øritsland, T. 1983. Validation of age estimation in the harp seal, *Phoca groenlandica*, using dentinal annuli. *Canadian Journal of Fisheries and Aquatic Sciences*. 40(9):1430-1441.
- Boyle, K. 2005. Late Neolithic seal hunting in southern Brittany: a zooarchaeological study of the site of Er Yoh (Morbihan). In *The exploitation and cultural importance of sea mammals*. G.G. Monks, Ed. Chippenham, Great Britain: Oxbow Books. 77-94.
- Brink, J.S. & Deacon, H.J. 1982. A study of a last interglacial shell midden and bone accumulation at Herolds Bay, Cape Province, South Africa. *Palaeoecology of Africa*. 15:31-39.
- Brink, J.W. 1997. Fat content in leg bones of bison, and applications to archaeology. *Journal of Archaeological Science*. 24(3):259-274.
- Broadhurst, C.L., Wang, Y., Crawford, M.A., Cunnane, S.C., Parkington, J.E. & Schmidt, W.F. 2002. Brain-specific lipids from marine, lacustrine, or terrestrial food resources: potential impact on early African Homo sapiens. *Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology*. 131(4):653-673.
- Brunborg, L.A., Julshamn, K., Nortvedt, R. & Frøylund, L. 2006. Nutritional composition of blubber and meat of hooded seal (*Cystophora cristata*) and harp seal (*Phagophilus groenlandicus*) from Greenland. *Food Chemistry*. 96(4):524-531.

Bunn, H.T. 1983. Comparative analysis of modern bone assemblages from a San hunter-gatherer camp in the Kalahari Desert, Botswana, and from a spotted hyena den near Nairobi, Kenya. *Animal and Archaeology*, 1. *Hunters and Their Prey*; BAR International Series. 163:141-148.

Bunn, H.T. 1986. Patterns of skeletal representation and hominid subsistence activities at Olduvai Gorge, Tanzania, and Koobi Fora, Kenya. *Journal of Human Evolution*. 15(8):673-690.

Bunn, H.T. & Kroll, E.M. 1986. Systematic butchery by Plio/Pleistocene hominids at Olduvai Gorge, Tanzania. *Current Anthropology*. 27(5):431-452.

Butzer, K.W. 1973. Geology of Nelson Bay Cave, Robberg, South Africa. *The South African Archaeological Bulletin*. 28(111/112):97-110.

Cannon, M.D. 2003. A model of central place forager prey choice and an application to faunal remains from the Mimbres Valley, New Mexico. *Journal of Anthropological Archaeology*. 22(1):1-25.

Carr, A.S., Bateman, M.D., Cawthra, H.C. & Sealy, J. 2019. First evidence for onshore marine isotope stage 3 aeolianite formation on the southern Cape coastline of South Africa. *Marine Geology*. 407:1-15.

Chambers, A.L. 1992. Seal bone mineral density: its effect on specimen survival in archaeological sites. University of Missouri.

Chase, P.G. 1986. *The hunters of Combe Grenal: approaches to Middle Paleolithic subsistence in Europe*. London: BAR International Series 286.

Compton, J.S. 2001. Holocene sea-level fluctuations inferred from the evolution of depositional environments of the southern Langebaan Lagoon salt marsh, South Africa. *The Holocene*. 11(4):395-405.

Conry, D. & Van der Vyver, F. 2017. *Robberg fur seal colony*. Available: http://oceanadventures.co.za/robberg_fur_seal_colony/ [Accessed: 3 April 2019].

Conry, D., Van der Vyver, F., Bakker, L. & Reeder, C. 2018. Seal research. Stranding response and necropsy. *ORCA Times*. ORCA Foundation's quarterly newsletter. September,

p. 11-13 Available: <http://orcafoundation.com/wp-content/uploads/2018/10/ORCA-Times-September-2018.pdf>.

Conry, D., Van der Vyver, F., Bakker, L. & Nel, M. 2019a. Bumper breeding season for Robberg seals? *ORCA Times. ORCA Foundation's quarterly newsletter*. March, p. 3 Available: <http://orcafoundation.com/wp-content/uploads/2019/04/ORCA-Times-March-2019.pdf>.

Conry, D., Van der Vyver, F., Bakker, L. & Nel, M. 2019b. A special visitor on Robberg beach! *ORCA Times. ORCA Foundation's quarterly newsletter*. June p. 10 Available: <http://orcafoundation.com/wp-content/uploads/2019/08/ORCA-Times-June-2019.pdf>.

Costamagno, S., Théry-Parisot, I., Brugal, J.-P. & Guibert, R. 2005. Taphonomic consequences of the use of bones as fuel. Experimental data and archaeological applications. In *Biosphere to Lithosphere, Proceedings of the 9th Conference of the International Council of Archaeozoology* Chippenham, Great Britain: Oxbow Books. 51-62.

Crockford, S.J. & Frederick, S.G. 2011. Neoglacial sea ice and life history flexibility in ringed and fur seals. *Human Impacts on Seals, Sea Lions, and Sea Otters: Integrating Archaeology and Ecology in the Northeast Pacific*. 65-91.

Cruz-Uribe, K. & Klein, R.G. 1986. Pascal programs for computing taxonomic abundance in samples of fossil mammals. *Journal of Archaeological Science*. 13(2):171-187.

Cruz-Uribe, K. & Klein, R.G. 1994. Chew marks and cut marks on animal bones from the Kasteelberg B and Dune Field Midden later Stone Age sites, western Cape Province, South Africa. *Journal of Archaeological Science*. 21(1):35-49.

Cunnane, S.C. 2010. Human brain evolution: a question of solving key nutritional and metabolic constraints on mammalian brain development. *Human Brain Evolution. The Influence of Freshwater and Marine Food Resources*. 33-76.

David, J. & Van Sittert, L. 2008. A reconstruction of the Cape (South African) fur seal harvest 1653-1899 and a comparison with the 20th-century harvest. *South African Journal of Science*. 104(3-4):107-110.

- David, J.H.M. 1989. Seals. In *Oceans of life off southern Africa*. A.I. Payne, R.J. Crawford and A. Van Dalsen, Eds. Cape Town: Vlaeberg Publishers. 288-302.
- De Villiers, D. & Roux, J. 1992. Mortality of newborn pups of the South African fur seal *Arctocephalus pusillus pusillus* in Namibia. *South African Journal of Marine Science*. 12(1):881-889.
- De Vynck, J.C., Anderson, R., Atwater, C., Cowling, R.M., Fisher, E.C., Marean, C.W., Walker, R.S. & Hill, K. 2016. Return rates from intertidal foraging from Blombos Cave to Pinnacle Point: Understanding early human economies. *Journal of Human Evolution*. 92:101-115.
- Deacon, H. & Wurz, S. 2001. Middle Pleistocene populations and the emergence of modern behaviour. *Human Roots: Africa and Asia in the Middle Pleistocene*.55-63.
- Deacon, H.J. 2001. Modern human emergence: an African archaeological perspective. *Modern Human Emergence*.1000-1010.
- Deacon, H.J. & Deacon, J. 1998. Excursion guide to sites north and east of Cape Town. Guidebook for the post-conference excursion to sites north and east of Cape Town, South Africa, for participants of the Dual Congress '98, a joint congress of the International Association for the Study of Human Palaeontology and the International Association of Human Biologists, Sun City, South Africa, 28 June - 4 July 1998: 22-27.
- Deacon, H.J. & Deacon, J. 1999. *Human beginnings in South Africa : uncovering the secrets of the Stone Age*. Cape Town: David Philip.
- Deacon, J. 1978. Changing patterns in the Late Pleistocene/Early Holocene prehistory of southern Africa as seen from the Nelson Bay Cave stone artifact sequence. *Quaternary Research*. 10(1):84-111.
- Deacon, J. 1982. The Later Stone Age in the southern Cape, South Africa. Unpublished PhD thesis. Cape Town: University of Cape Town.
- Deacon, J. 1984. *The later Stone Age of southernmost Africa*. Oxford: Cambridge monographs in African archaeology 12.

- Deacon, J. & Brett, M. 1993. Peeling away the past: The display of excavations at Nelson Bay Cave. *The South African Archaeological Bulletin*.98-104.
- Döckel, W. 1998. Re-investigation of the Matjes River rock shelter. Unpublished masters thesis. Stellenbosch: Stellenbosch University.
- Dubey, P., Jayasooriya, A.P. & Cheema, S.K. 2011. Diets enriched in fish-oil or seal-oil have distinct effects on lipid levels and peroxidation in BioF1B hamsters. *Nutrition and metabolic insights*. 4:7-17.
- Dudley, T. 1999. Incremental structures and wear patterns of teeth for age assessment of red deer. University of Cambridge.
- Dusseldorp, G. & Langejans, G. 2013. Carry that weight: coastal foraging and transport of marine resources during the South African Middle Stone Age. *Southern African Humanities*. 25(1):105-135.
- Erasmus, U. 1986. Fats and oils. *Vancouver, Canada: Alive Books*.244.
- Ericson, P.G. & Storå, J. 1999. A manual to the skeletal measurements of the seal genera *Halichoerus* and *Phoca* (Mammalia: Pinnipedia). *Department of Zoology, Swedish Museum of Natural History, Stockholm. Stencil*.
- Erlandson, J.M. 2001. The archaeology of aquatic adaptations: paradigms for a new millennium. *Journal of Archaeological Research*. 9(4):287-350.
- Erwin, J. 1996. *An intrasite analysis of Phillip's Garden: a Middle Dorset Palaeo-Eskimo site at Port au Choix, Newfoundland*. Memorial University of Newfoundland.
- Fairhall, A., Young, A. & Erickson, J. 1976. University of Washington dates IV. *Radiocarbon*. 18(2):221-239.
- Fenton, A. 1978. *The northern isles: Orkney and Shetland*. Edinburgh: Tugwell Press.
- Fiorillo, A.R. 1989. An experimental study of trampling: implications for the fossil record. *Bone modification*. 2:61-71.
- Fisher, E., Hodgkins, J. & Marean, C.W. 2017. An updated GIS-based system for calculating MNE and quantifying bone surface modification frequencies and spatial location on skeletal

elements in faunal assemblages. *The 82nd Annual Meeting of the Society for American Archaeology*. Vancouver, British Columbia., March 29 - April 2 2017. Available: <https://core.tdar.org/document/430391/an-updated-gis-based-system-for-calculating-mne-and-quantifying-bone-surface-modification-frequencies-and-spatial-location-on-skeletal-elements-in-faunal-assemblages>.

Fletemeyer, J.R. 1974. Age determination in the teeth of the Cape Fur Seal and its bearing on the seasonal mobility hypothesis. *Unpublished Honours project: Department of Archaeology, University of Cape Town*.

Fletemeyer, J.R. 1977. Age determination in the teeth of the Cape fur seal and its bearing on the seasonal mobility hypothesis proposed for the western Cape, South Africa. *The South African Archaeological Bulletin*.146-149.

Goodwin, A.J.H. 1935. A commentary on the history and present position of South African prehistory with full bibliography August, 1935: (report of a sub-committee appointed by the inter-university committee for African studies in July, 1933). *Bantu Studies*. 9(4):291-417.

Gowlett, J.A., Hedges, R.E., Law, I. & Perry, C. 1987. Radiocarbon dates from the Oxford AMS system: Archaeometry datelist 5. *Archaeometry*. 29(1):125-155.

Grayson, D. 1984. Quantitative zooarchaeology: topics in the quantification of archaeofaunas. *Orlando: Academic*.

Grayson, D.K. 1973. On the methodology of faunal analysis. *American Antiquity*. 38(4):432-439.

Harding, J. 2015. *Facts on Cape Fur Seal (Arctocephalus pusillus)*. Available: <http://oceanadventures.co.za/facts-cape-fur-seal-arctocephalus-pusillus-pusillus/> [2017, 15 December].

Henshaw, A.S. 1999. Location and appropriation in the Arctic: An integrative zooarchaeological approach to historic Inuit household economies. *Journal of Anthropological Archaeology*. 18(1):79-118.

- Henshaw, A.S. 2000. *Central Inuit Household Economies: Zooarchaeological, environmental, and historical evidence from outer Frobisher Bay, Baffin Island, Canada*. Oxford, BAR International Series: 870-872.
- Henshilwood, C. & Sealy, J. 1997. Bone artefacts from the middle stone age at Blombos Cave, Southern Cape, South Africa. *Current Anthropology*. 38(5):890-895.
- Henshilwood, C.S., D'errico, F., Marean, C.W., Milo, R.G. & Yates, R. 2001a. An early bone tool industry from the Middle Stone Age at Blombos Cave, South Africa: implications for the origins of modern human behaviour, symbolism and language. *Journal of Human Evolution*. 41(6):631-678.
- Henshilwood, C.S., d'Errico, F., Van Niekerk, K.L., Coquinot, Y., Jacobs, Z., Lauritzen, S.-E., Menu, M. & García-Moreno, R. 2011. A 100,000-year-old ochre-processing workshop at Blombos Cave, South Africa. *Science*. 334(6053):219-222.
- Henshilwood, C.S., Sealy, J.C., Yates, R., Cruz-Uribe, K., Goldberg, P., Grine, F.E., Klein, R.G., Poggenpoel, C. et al. 2001b. Blombos Cave, southern Cape, South Africa: preliminary report on the 1992–1999 excavations of the Middle Stone Age levels. *Journal of Archaeological Science*. 28(4):421-448.
- Hiseler, G. 1997. Harp seal (*Phoca groenlandica*) canine dentine incremental annuli as indicators of age and-or season of death. Memorial University of Newfoundland.
- Hodgetts, L.M. 2005. Dorset Palaeoeskimo harp seal exploitation at Phillip's Garden, northwestern Newfoundland. In *The exploitation and cultural importance of sea mammals*. G.G. Monks, Ed. Chippenham, Great Britain: Oxbow Books. 62-76.
- Hodgetts, L.M., Renouf, M.P., Murray, M.S., McCuaig-Balkwill, D. & Howse, L. 2003. Changing subsistence practices at the Dorset Paleoeskimo site of Phillip's Garden, Newfoundland. *Arctic Anthropology*. 40(1):106-120.
- Horsburgh, K.A. 2008. Wild or domesticated? An ancient DNA approach to canid species identification in South Africa's Western Cape Province. *Journal of Archaeological Science*. 35(6):1474-1480.

- Huisamen, J. 2012. Recolonisation of the Robberg Peninsula by the Cape Fur Seal *Arctocephalus pusillus pusillus* and its prey preferences. Masters thesis. Nelson Mandela Metropolitan University.
- Huisamen, J., Kirkman, S.P., Watson, L.H., Cockcroft, V.G. & Pistorius, P.A. 2011. Recolonisation of the Robberg Peninsula (Plettenberg Bay, South Africa) by Cape fur seals. *African Journal of Marine Science*. 33(3):453-461. DOI:10.2989/1814232X.2011.637349.
- Huisamen, J., Kirkman, S.P., van Der Lingen, C.D., Watson, L.H., Cockcroft, V.G., Jewell, R. & Pistorius, P.A. 2012. Diet of the Cape fur seal *Arctocephalus pusillus pusillus* at the Robberg Peninsula, Plettenberg Bay, and implications for local fisheries. *African Journal of Marine Science*. 34(3):431-441. DOI:10.2989/1814232X.2012.725524.
- Huisamen, J., Kirkman, S., van der Lingen, C., Watson, L., Cockcroft, V., Jewell, R. & Pistorius, P. 2012. Diet of the Cape fur seal *Arctocephalus pusillus pusillus* at the Robberg Peninsula, Plettenberg Bay, and implications for local fisheries. *African Journal of Marine Science*. 34(3):431-441.
- Hutten, L. 2005. K2 revisited: an archaeozoological study of an Iron Age site in the Northern Province, South Africa. Unpublished Masters thesis. University of Pretoria.
- Inskeep, R. & Vogel, J. 1985. Radiocarbon dates from the Holocene levels at Nelson Bay Cave, and an interim report on their associations. *The South African Archaeological Bulletin*. 103-105.
- Inskeep, R.R. 1987a. *Nelson Bay Cave, Cape Province, South Africa : the Holocene levels (Part i)*. Oxford, England: B.A.R.
- Inskeep, R.R. 1987b. *Nelson Bay Cave, Cape Province, South Africa : the Holocene levels (Part ii)*. Oxford, England: B.A.R.
- Jerardino, A. 2010. Large shell middens in Lamberts Bay, South Africa: a case of hunter-gatherer resource intensification. *Journal of Archaeological Science*. 37(9):2291-2302.
- Jerardino, A. 2012. Large shell middens and hunter-gatherer resource intensification along the West Coast of South Africa: the Elands Bay case study. *The Journal of Island and Coastal Archaeology*. 7(1):76-101.

- Jerardino, A. 2016. On the origins and significance of Pleistocene coastal resource use in southern Africa with particular reference to shellfish gathering. *Journal of Anthropological Archaeology*. 41:213-230.
- Jerardino, A. & Marean, C.W. 2010. Shellfish gathering, marine paleoecology and modern human behavior: perspectives from cave PP13B, Pinnacle Point, South Africa. *Journal of Human Evolution*. 59(3-4):412-424.
- Johnson, L.L. 2005. Aleut sea-mammal hunting: ethnohistorical and archaeological evidence. In *The exploitation and cultural importance of sea mammals*. G.G. Monks, Ed. Chippenham, Great Britain: Oxbow Books. 39-61.
- Jourdan, H. & Le Mouel, J.-F. 1987. Découpe du phoque. Partage entre l'homme et l'animal? *Anthropozoologica*. (1):31-38.
- King, J.E. 1983. *Seals of the world*. London: Oxford University Press.
- Kirkman, S., Oosthuizen, W., Meÿer, M., Seakamela, S. & Underhill, L. 2011. Prioritising range-wide scientific monitoring of the Cape fur seal in southern Africa. *African Journal of Marine Science*. 33(3):495-509.
- Kirkman, S.P. 2010. The Cape fur seal: monitoring and management in the Benguela Current ecosystem. Unpublished PhD thesis. University of Cape Town.
- Klein, R.G. 1972a. The late Quaternary mammalian fauna of Nelson Bay Cave (Cape Province, South Africa): its implications for megafaunal extinctions and environmental and cultural change. *Quaternary Research*. 2(2):135-142.
- Klein, R.G. 1972b. Preliminary report on the July through September 1970 excavations at Nelson Bay Cave, Plettenberg Bay (Cape Province, South Africa).
- Klein, R.G. 1975. Middle Stone Age man-animal relationships in southern Africa: Evidence from Die Kelders and Klasies River Mouth. *Science*. 265-267.
- Klein, R.G. 1976a. The mammalian fauna of the Klasies River mouth sites, southern Cape Province, South Africa. *South African Archaeological Bulletin*. 31(123):75-98.

Klein, R.G. 1976b. The mammalian fauna of the Klasies River mouth sites, southern Cape Province, South Africa. *The South African Archaeological Bulletin*. 31(123/124):75-98.

Klein, R.G. 1989. Why does skeletal part representation differ between smaller and larger bovids at Klasies River Mouth and other archeological sites? *Journal of Archaeological Science*. 16(4):363-381.

Klein, R.G. & Cruz-Urbe, K. 1984. *The analysis of animal bones from archeological sites*. University of Chicago press.

Klein, R.G. & Scott, K. 1986. Re-analysis of faunal assemblages from the Haua Fteah and other Late Quaternary archaeological sites in Cyrenaican Libya. *Journal of Archaeological Science*. 13(6):515-542.

Klein, R.G. & Cruz-Urbe, K. 1987. Large mammal and tortoise bones from Eland's Bay Cave and nearby sites, Western Cape Province, South Africa. *Papers in the prehistory of the western Cape, South Africa*. 1:132-163.

Klein, R.G. & Cruz-Urbe, K. 1989. Faunal evidence for prehistoric herder-forager activities at Kasteelberg, Western Cape Province, South Africa. *The South African Archaeological Bulletin*. 82-97.

Klein, R.G. & Cruz-Urbe, K. 1996. Exploitation of large bovids and seals at Middle and Later Stone Age sites in South Africa. *Journal of Human Evolution*. 31(4):315-334.

Klein, R.G. & Cruz-Urbe, K. 2000. Middle and later stone age large mammal and tortoise remains from Die Kelders Cave 1, Western Cape Province, South Africa. *Journal of Human Evolution*. 38(1):169-195.

Klein, R.G. & Cruz-Urbe, K. 2016. Large mammal and tortoise bones from Elands Bay Cave (South Africa): implications for Later Stone Age environment and ecology. *Southern African Humanities*. 29(1):259-282.

Klein, R.G., Cruz-Urbe, K., Halkett, D., Hart, T. & Parkinson, J.E. 1999. Paleoenvironmental and human behavioral implications of the Boegoeberg 1 late Pleistocene hyena den, Northern Cape Province, South Africa. *Quaternary Research*. 52(3):393-403.

- Koep, K., Hoffman, L., Dicks, L. & Slinde, E. 2007. Chemical composition of meat and blubber of the Cape fur seal (*Arctocephalus pusillus pusillus*). *Food Chemistry*. 100(4):1560-1565.
- Kyriacou, K. 2009. The reinvestigation of Hoffman's/Robberg cave-the artefactual and shellfish assemblages, 2007. University of Cape Town.
- Kyriacou, K. & Sealy, J. 2009. *The Archaeological Assemblage from the 1958 Excavation of Hoffman's/Robberg Cave and a Comparison with Nelson Bay Cave*. Navorsing van die Nasionale Museum, Bloemfontein 25(2): 49-71.
- Kyriacou, K., Parkington, J.E., Will, M., Kandel, A.W. & Conard, N.J. 2015. Middle and Later Stone Age shellfish exploitation strategies and coastal foraging at Hoedjiespunt and Lynch Point, Saldanha Bay, South Africa. *Journal of Archaeological Science*. 57:197-206.
- Lam, Y.M., Pearson, O.M., Marean, C.W. & Chen, X. 2003. Bone density studies in zooarchaeology. *Journal of Archaeological Science*. 30(12):1701-1708.
- Landon, D.B. 2005. Zooarchaeology and historical archaeology: progress and prospects. *Journal of Archaeological method and theory*. 12(1):1-36.
- Langejans, G.H., van Niekerk, K.L., Dusseldorp, G.L. & Thackeray, J.F. 2012. Middle Stone Age shellfish exploitation: Potential indications for mass collecting and resource intensification at Blombos Cave and Klasies River, South Africa. *Quaternary International*. 270:80-94.
- Lantis, M. 1946. The social culture of the Nunivak Eskimo. *Transactions of the American Philosophical Society*. 35(3):153-323.
- Leggatt, H. 2010. Bone art: the Knysna scapula. *The Digging Stick*. 27(1):1-20.
- Lewis-Williams, J.D. 1984. Ideological continuities in prehistoric southern Africa: the evidence of rock art. In *Interfaces: the relationship of past and present in hunter-gatherer studies*. C. Schrire, Ed. New York: Academic Press. 225-252.
- Lewis-Williams, J.D. & Dowson, T.A. 1990. Through the veil: San rock paintings and the rock face. *The South African Archaeological Bulletin*. 5-16.

- Lewis-Williams, J.D. & Dowson, T.A. 1999. *Images of power: understanding Bushman rock art*. 2nd edition. Southern Book Publishers.
- Loftus, E., Sealy, J. & Lee-Thorp, J. 2016. New radiocarbon dates and Bayesian models for Nelson Bay Cave and Byneskranskop 1: Implications for the South African later stone age sequence. *Radiocarbon*. 58(2):365-381.
- Lyman, R.L. 1992. Prehistoric seal and sea-lion butchering on the southern Northwest Coast. *American Antiquity*. 57(2):246-261.
- Lyman, R.L. 1994a. Relative abundances of skeletal specimens and taphonomic analysis of vertebrate remains. *Palaios*. 9(3):288-298.
- Lyman, R.L. 1994b. *Vertebrate taphonomy*. Cambridge University Press.
- Lyman, R.L. 1994c. Quantitative units and terminology in zooarchaeology. *American Antiquity*. 59(1):36-71.
- Lyman, R.L. 2016. *Prehistory of the Oregon coast: the effects of excavation strategies and assemblage size on archaeological inquiry*. Routledge.
- Lyman, R.L. 2019. A critical review of four efforts to resurrect MNI in zooarchaeology. *Journal of Archaeological method and theory*. 26(1):52-87.
- Lyman, R.L., Savelle, J.M. & Whitridge, P. 1992. Derivation and application of a meat utility index for phocid seals. *Journal of Archaeological Science*. 19(5):531-555.
- Marean, C.W. 1985. The faunal remains from Smitswinkelbaai Cave, Cape peninsula. *The South African Archaeological Bulletin*. 100-102.
- Marean, C.W. 1986. Seasonality and seal exploitation in the southwestern Cape, South Africa. *The African Archaeological Review*. 4:135-149.
- Marean, C.W. 2006. Response to "Diet, mobility, and settlement pattern among Holocene hunter-gatherers in southernmost Africa". *Current Anthropology*. 47(4):587-588.
- Marean, C.W. 2010. Pinnacle Point Cave 13B (Western Cape Province, South Africa) in context: the Cape floral kingdom, shellfish, and modern human origins. *Journal of Human Evolution*. 59(3-4):425-443.

- Marean, C.W. 2011. Coastal South Africa and the coevolution of the modern human lineage and the coastal adaptation. In *Trekking the shore*. Springer. 421-440.
- Marean, C.W. 2015. An evolutionary anthropological perspective on modern human origins. *Annual Review of Anthropology*. 44:533-556.
- Marean, C.W. & Binford, L.R. 1986. On the seal remains from Klasies River Mouth: an evaluation of Binford's interpretations. *Current Anthropology*. 27(4):365-368.
- Marean, C.W. & Spencer, L.M. 1991. Impact of carnivore ravaging on zooarchaeological measures of element abundance. *American Antiquity*. 56(4):645-658.
- Marean, C.W., Dominguez-Rodrigo, M. & Pickering, T.R. 2004. Journal of Taphonomy. *Journal of Taphonomy*. 2(2):69-98.
- Marean, C.W., Abe, Y., Frey, C.J. & Randall, R.C. 2000a. Zooarchaeological and taphonomic analysis of the Die Kelders Cave 1 Layers 10 and 11 Middle Stone Age larger mammal fauna. *Journal of Human Evolution*. 38(1):197-233.
- Marean, C.W., Abe, Y., Nilssen, P.J. & Stone, E.C. 2001. Estimating the minimum number of skeletal elements (MNE) in zooarchaeology: a review and a new image-analysis GIS approach. *American Antiquity*. 66(2):333-348.
- Marean, C.W., Goldberg, P., Avery, G., Grine, F.E. & Klein, R.G. 2000b. Middle Stone Age stratigraphy and excavations at Die Kelders Cave 1 (Western Cape Province, South Africa): the 1992, 1993, and 1995 field seasons. *Journal of Human Evolution*. 38(1):7-42.
- Marean, C.W., Bar-Matthews, M., Bernatchez, J., Fisher, E., Goldberg, P., Herries, A.I., Jacobs, Z., Jerardino, A. et al. 2007. Early human use of marine resources and pigment in South Africa during the Middle Pleistocene. *Nature*. 449(7164):905-908.
- Marshall, F. & Pilgram, T. 1991. Meat versus within-bone nutrients: another look at the meaning of body part representation in archaeological sites. *Journal of Archaeological Science*. 18(2):149-163.
- Marshall, F. & Pilgram, T. 1993. NISP vs. MNI in quantification of body-part representation. *American Antiquity*. 58(2):261-269.

- Martinoli, M.P. 2015. Procesamiento y consumo de pinnípedos: el caso de las ocupaciones canoeras tempranas del sitio Imiwaia I (Tierra del Fuego, República Argentina). *Intersecciones en antropología*. 16(2):367-381.
- Martinoli, M.P. & Vázquez, M. 2017. Pinniped Capture and Processing: A Comparative Analysis from Beagle Channel (Tierra del Fuego, Argentina). In *Zooarchaeology in the Neotropics*. Springer. 7-23.
- Mattlin, R. 1978. Pup mortality of the New Zealand fur seal. *New Zealand journal of ecology*. 1:138-144.
- Mead, J.F., Alfin-Slater, R.B., Howton, D.R. & Popjak, G. 1986. *Lipids: chemistry, biochemistry, and nutrition*. Plenum Press.
- Mentzel, O.F. 1919. *Life at the Cape in Mid-eighteenth Century: Being the Biography of Rudolf Siegfried Allemann, Captain of the Military Forces and Commander of the Castle in the Service of the Dutch East India Company at the Cape of Good Hope*. Cape Town: Van Riebeeck Society
- Mentzel, O.F. 1944. *A geographical and topographical description of the Cape of Good Hope*. Van Riebeeck Society.
- Metcalf, D. & Jones, K.T. 1988. A reconsideration of animal body-part utility indices. *American Antiquity*. 53(3):486-504.
- Metelerkamp, S. 1955. *George Rex of Knysna: the authentic story*. Cape Town: Timmins.
- Mitchell, P. 2002. *The archaeology of southern Africa*. Cambridge: Cambridge University Press.
- Monks, G.G. 2005. Discussion: sea mammals in zooarchaeology AD 2002. In *The exploitation and cultural importance of sea mammals*. G.G. Monks, Ed. Chippenham, Great Britain: Oxbow Books. 167-173.
- Moody, J.F. & Hodgetts, L.M. 2013. Subsistence practices of Pioneering Thule-Inuit: A faunal analysis of Tiktalik. *Arctic Anthropology*. 50(2):4-24.

- Mucina, L. & Rutherford, M.C. 2006. *The vegetation of South Africa, Lesotho and Swaziland*. South African National Biodiversity Institute.
- Nagaoka, L. 2006. Prehistoric seal carcass exploitation at the Shag Mouth site, New Zealand. *Journal of Archaeological Science*. 33(10):1474-1481.
- Nansen, F. 1893. *Eskimo life*. Translated by W. Archer. London: Longmans, Green, and Co.
- Nelson, R.K. 1969. *Hunters of the Northern ice*. Chicago: University of Chicago Press.
- Nomokonova, T., Losey, R.J., Ol'ga, I.G., Novikov, A.G. & Weber, A.W. 2015. A 9,000 year history of seal hunting on Lake Baikal, Siberia: the zooarchaeology of Sagan-Zaba II. *PLoS One*. 10(5):e0128314. DOI:10.1371/journal.pone.0128314.
- Nomokonova, T., Losey, R.J., Iakunaeva, V.N., Emel'ianova, I.A., Baginova, E.A. & Pastukhov, M.V. 2013. People and seals at Siberia's Lake Baikal. *Journal of Ethnobiology*. 33(2):259-281.
- Nowak, K. 2016. *Cape fur seal trade remains shrouded in secrecy: Namibia's sealing industry persists in the face of a global trend toward ending the trade*. Available: <https://www.nationalgeographic.com/news/2016/09/wildlife-watch-cape-fur-seal-trade-Namibia/> [2019, 14 September].
- O'Connell, J.F., Hawkes, K. & Jones, N.B. 1988. Hadza hunting, butchering, and bone transport and their archaeological implications. *Journal of Anthropological research*. 44(2):113-161.
- O'Connell, J.F., Hawkes, K. & Jones, N.B. 1990. Reanalysis of large mammal body part transport among the Hadza. *Journal of Archaeological Science*. 17(3):301-316.
- O'Connor, T. 2004. *The archaeology of animal bones*. Stroud, Gloucestershire, United Kingdom: Sutton Publishing Limited.
- Oosthuizen, W. 1991. General movements of South African (Cape) fur seals *Arctocephalus pusillus pusillus* from analysis of recoveries of tagged animals. *South African Journal of Marine Science*. 11(1):21-29.

Oosthuizen, W.H. & David, J.H.M. 1988. Non-breeding colonies of the South African (Cape) fur seal, *Arctocephalus pusillus pusillus* in southern Africa. *Investigational Reports of the Division of Sea Fisheries*. 132:1-17.

Oppenheimer, S. 2009. The great arc of dispersal of modern humans: Africa to Australia. *Quaternary International*. 202(1-2):2-13.

Orquera, L.A. 2000. *Instrucciones para el procesamiento de restos óseos de pinnípedos*. . MS.

Outram, A.K. 1998. The identification and Palaeoeconomic context of prehistoric bone marrow and grease exploitation. Durham University.

Outram, A.K. 1999. A comparison of paleo-eskimo and medieval Norse bone fat exploitation in western Greenland. *Arctic Anthropology*. 103-117.

Outram, A.K. 2001. A new approach to identifying bone marrow and grease exploitation: why the “indeterminate” fragments should not be ignored. *Journal of Archaeological Science*. 28(4):401-410.

Outram, A.K. 2002. Bone fracture and within-bone nutrients: an experimentally based method for investigating levels of marrow extraction. McDonald Institute for Archaeological Research.

Outram, A.K. 2003. Comparing levels of subsistence stress amongst Norse settlers in Iceland and Greenland using levels of bone fat exploitation as an indicator. *Environmental Archaeology*. 8(2):119-128.

Outram, A.K. 2005. Distinguishing bone fat exploitation from other taphonomic processes: what caused the high level of bone fragmentation at the Middle Neolithic site of Ajvide, Gotland? In *The zooarchaeology of milk and fats*. J. Mulville and A.K. Outram, Eds. Chippenham, Great Britain: Oxbow Books. 32-43.

Parkington, J. 1972. Seasonal mobility in the late Stone Age. *African Studies*. 31(4):223-244.

Parkington, J. 1976. Coastal settlement between the mouths of the Berg and Olifants Rivers, Cape Province. *The South African Archaeological Bulletin*. 31(123/124):127-140.

- Parkington, J. 2001. Presidential address: Mobility, seasonality and southern African hunter-gatherers. *The South African Archaeological Bulletin*. 56(173/174):1-7.
- Parkington, J. 2006. *Shorelines, strandlopers and shell middens : archaeology of the Cape coast*. Cape Town: Southern Cross Ventures.
- Parkington, J. 2007. On diet and settlement in Holocene South Africa. *Current Anthropology*. 48(4):581-583.
- Parkington, J., Nilssen, P., Reeler, C. & Henshilwood, C.S. 1992. Making sense of space at Dunefield Midden campsite, Western Cape, South Africa. *Southern African Field Archaeology*. 1(2):63-70.
- Pearce, D.G. 2005. Iconography and interpretation of the Tierkloof painted stone. *Goodwin Series*.45-53.
- Pearce, D.G. 2008. Later Stone Age burial practice in the Eastern Cape Province, South Africa. PhD dissertation. University of Witwatersrand.
- Perkins, D. & Daly, P. 1968. A hunters' village in Neolithic Turkey. *Scientific American*. 219(5):96-109.
- Piana, E.L., Vázquez, M. & Álvarez, M. 2008. Nuevos resultados del estudio del sitio Aje I: un aporte a la variabilidad de estrategias de los canoeros fueguinos. *Runa*. 29:87-100.
- Plug, I. 1999. Animal remains from archaeological sites in southern Africa as a tool to redress history. *Archaeozoologia*. 10(1-2):107-116.
- Plug, I. & Voigt, E.A. 1985. Archaeozoological studies of Iron Age communities in southern Africa. *Advances in world archaeology*. 4:189-238.
- Post, L. 2004. *Pinniped projects: Articulating seal and sea lion skeletons*. L. Post.
- Ralls, K. & Mesnick, S. 2009. Sexual dimorphism. In *Encyclopedia of marine mammals*. Elsevier. 1005-1011.
- Rand, R.W. 1956. *The Cape fur seal, Arctocephalus pusillus (Schreber) : its general characteristics and moult*. Pretoria: Government Printer.

- Rand, R.W. 1959. *The Cape fur seal (Arctocephalus pusillus): Distribution, abundance and feeding habits off the south western coast of the Cape Province*. Division of Sea Fisheries.
- Raven-Hart, R. 1967. *Before Van Riebeeck: Callers at South Africa from 1488 to 1652*. C. Struik.
- Raven-Hart, R. 1971a. *Cape Good Hope, 1652-1702: the first fifty years of Dutch colonisation as seen by callers, volume 1*. Cape Town: Balkema.
- Raven-Hart, R. 1971b. *Cape Good Hope, 1652-1702: the first fifty years of Dutch colonisation as seen by callers, volume 2*. Cape Town: Balkema.
- Reddering, J. 1988. Evidence for a middle Holocene transgression, Keurbooms estuary, South Africa. *Palaeoecology of Africa*. 19:79-86.
- Reddering, J.S.V. 1993. Sedimentary facies, sequences and depositional environments of the Mesozoic Robberg Formation in its type area, South Africa. University of Port Elizabeth.
- Reitz, E.J. & Wing, E.S. 2008. *Zooarchaeology*. 2nd ed. Cambridge University Press.
- Reynard, J.P. 2014. Trampling in coastal sites: an experimental study on the effects of shell on bone in coastal sediment. *Quaternary International*. 330:156-170.
- Riedman, M. 1990. *The pinnipeds: seals, sea lions, and walruses*. University of California Press.
- Roberts, R.G., Jones, R. & Smith, M.A. 1990. Thermoluminescence dating of a 50,000-year-old human occupation site in northern Australia. *Nature*. 345(6271):153-156.
- Robertshaw, P. 1979. Excavations at Duiker Eiland, Vredenburg District, Cape Province. *Annals of the Cape Provincial Museums (Human Sciences)*. 1(1):1-26.
- Robertshaw, P.T. 1977. Excavations at Paternoster, south-western Cape. *The South African Archaeological Bulletin*. 63-73.
- Rowe-Rowe, D.T. 1983. Black-backed jackal diet in relation to food availability in the Natal Drakensberg. *South African Journal of Wildlife Research*. 13(1):17-23.

- Rudner, J. 1971. Painted burial stones from the Cape. *South African Journal of Science (Special Issue Supplement)*. 2:54-61.
- Rudner, J. & Rudner, I. 1973. A note on early excavations at Robberg. *The South African Archaeological Bulletin*. 28(111/112):94-96.
- Saint-Germain, C. 2005. Animal fat in the cultural world of the Native Peoples of Northeastern America. In *The zooarchaeology of fats, oils, milk and dairying*. J. Mulville and A.K. Outram, Eds. Chippenham, Great Britain: Oxbow Books. 107-113.
- Schapera, I. & Farrington, E. 1933. *The Early Cape Hottentots*. Cape town: Van Riebeeck Society. Available: https://www.dbnl.org/tekst/dapp001earl01_01/dapp001earl01_01.pdf.
- Schiavini, A. 1990. *Estudio de la relación entre el hombre y los pinnípedos en el proceso adaptativo humano del canal Beagle (Tierra del Fuego, Argentina)*. Tesis Doctoral inédita. Buenos Aires: Universidad de Buenos Aires.
- Schoeman, K. 2001. *Armosyn van die Kaap: die wêreld van 'n slavin, 1652-1733*. Kaapstad: Human & Rosseau.
- Schutte-Vlok, A., Huisamen, J., Nieuwoudt, H. & Cleaver-Christie, G. 2012. *Robberg Nature Reserve complex managment plan 2013-2018*. Available: www.capenature.co.za/wp.../Robberg-Nature-Reserve-Complex-PAMP_signed.pdf.
- Schweitzer, F.R. 1979. *Excavations at Die Kelders, Cape Province, South Africa: the Holocene deposits*. South African Museum.
- Sealy, J. 2006. Diet, Mobility, and Settlement Pattern among Holocene Hunter-Gatherers in Southernmost Africa. *Current Anthropology*. 47(4):569-595. DOI:10.1086/504163.
- Sealy, J. 2016. Cultural change, demography, and the archaeology of the last 100 kyr in southern Africa. In *Africa from MIS 6-2*. Springer. 65-75.
- Sealy, J., Ludwig, B. & Henderson, Z. 2006. New radiocarbon dates for Matjes River rock shelter. *The South African Archaeological Bulletin*. 98-101.
- Shahidi, F. 2012. Nutraceuticals, functional foods and dietary supplements in health and disease. *Journal of Food and Drug Analysis*. 20(1):226-230.

Shahidi, F., Synowiecki, J., Amarowicz, R. & Wanasundara, U. 1994. Omega-3 fatty acid composition and stability of seal lipids. ACS Publications.

Shaughnessy, P.D. 1984. Historical population levels of seals and seabirds on islands off southern Africa, with special reference to Seal Island, False Bay. *Investigational Reports of the Division of Sea Fisheries*. 127:1-61.

Shaughnessy, P.D. 1987. Population Size of the Cape Fur Seal, *Arctocephalus Pusillus*. *Investigational Reports of the Division of Sea Fisheries*. 130:1-56.

Sidwell, V.D. 1981. Chemical and nutritional composition of finfishes, whales, crustaceans, mollusks, and their products. *NOAA Technical Memorandum NMFS F/SEC-11, U.S. Department of Commerce, Washington, DC*.

Singer, R. & Wymer, J. 1982. *The middle stone age at Klasies river Mouth in South Africa*. University of Chicago Press.

Smith, A.B. 2006a. *Excavations at Kasteelberg, and the Origins of the Khoekhoen in the Western Cape, South Africa*. Oxford: British Archaeological Reports International Series 1537.

Smith, A.B. 2006b. Kasteelberg: a pastoralist sealing camp in Western Cape Province, South Africa. *Journal of Island & Coastal Archaeology*. 1(1):109-122.

Smith, A.B., Woodborne, S., Lamprecht, E. & Riley, F. 1992. Marine mammal storage: analysis of buried seal meat at the Cape, South Africa. *Journal of Archaeological Science*. 19(2):171-180.

Smith, I. 1985. Sea mammal hunting and prehistoric subsistence in New Zealand. University of Otago.

Smith, I. 2004. Nutritional perspectives on prehistoric marine fishing in New Zealand. *New Zealand Journal of Archaeology*. 24(2002):5-31.

Smith, I. 2005. Retreat and resilience: fur seals and human settlement in New Zealand. In *The exploitation and cultural importance of sea mammals*. G.G. Monks, Ed. Chippenham, Great Britain: Oxbow Books. 6-18.

- Spennemann, D.H. & Colley, S.M. 1989. Fire in a pit: the effects of burning on faunal remains. *Archaeozoologia*. 3(1-2):51-64.
- Speth, J.D. & Spielmann, K.A. 1983. Energy source, protein metabolism, and hunter-gatherer subsistence strategies. *Journal of Anthropological Archaeology*. 2(1):1-31.
- Spray, Z. 2002. Alaska's vanishing Arctic cuisine. *Gastronomica*. 2(1):30-40.
- Stewardson, C. 1999. The impact of the fur seal industry on the distribution and abundance of Cape fur seals *Arctocephalus pusillus pusillus* on the Eastern Cape coast of South Africa. *Transactions of the Royal Society of South Africa*. 54(2):217-245.
- Stiner, M.C. 1991. The faunal remains from Grotta Guattari: a taphonomic perspective. *Current Anthropology*. 32(2):103-117.
- Stiner, M.C. 2002. On in situ attrition and vertebrate body part profiles. *Journal of Archaeological Science*. 29(9):979-991.
- Stiner, M.C., Kuhn, S.L., Weiner, S. & Bar-Yosef, O. 1995. Differential burning, recrystallization, and fragmentation of archaeological bone. *Journal of Archaeological Science*. 22(2):223-237.
- Storå, J. 2001. Skeletal development in the Grey seal *Halichoerus grypus*, the Ringed seal *Phoca hispida botnica*, the Harbour seal *Phoca vitulina vitulina* and the Harp seal *Phoca groenlandica*. Epiphyseal Fusion and Life History. *Archaeozoologia*. 11(1/2):199-222.
- Storå, J. 2002. Neolithic seal exploitation on the Åland Islands in the Baltic Sea on the basis of epiphyseal fusion data and metric studies. *International Journal of Osteoarchaeology*. 12(1):49-64.
- Storarr, P. & Komnick, G. 1984. *A colossus of roads*. Cape Town: Murray & Roberts/Concor.
- Stynder, D.D. 1997. The use of faunal evidence to reconstruct site history and Hoedjiespunt 1 (HDP1), Western Cape. Unpublished masters thesis. University of Cape Town.

- Stynder, D.D. 2008. The impact of medium-sized canids on a seal bone assemblage from Dunefield Midden, West coast, South Africa. *The South African Archaeological Bulletin*. 63(188):159-163.
- Tankard, A.J. & Schweitzer, F.R. 1974. Geology of Die Kelders Cave and environs-paleoenvironmental study. *South African Journal of Science*. 70(12):365-369.
- Thackeray, J. 1988. Molluscan fauna from Klasies River, South Africa. *The South African Archaeological Bulletin*. 27-32.
- Thom, H.B. 1952. *Journal of Jan van Riebeeck, volume I 1651-1655*. Cape Town: for the Van Riebeeck Society.
- Thom, H.B. 1954. *Journal of Jan van Riebeeck, volume II 1656-1658*. Cape Town: for the Van Riebeeck Society.
- Thom, H.B. 1958. *Journal of Jan van Riebeeck, volume III 1659-1662*. Cape Town: for the Van Riebeeck Society.
- Thorne, A., Grün, R., Mortimer, G., Spooner, N.A., Simpson, J.J., McCulloch, M., Taylor, L. & Curnoe, D. 1999. Australia's oldest human remains: age of the Lake Mungo 3 skeleton. *Journal of Human Evolution*. 36(6):591-612.
- Todd, L.C. & Rapson, D.J. 1988. Long bone fragmentation and interpretation of faunal assemblages: approaches to comparative analysis. *Journal of Archaeological Science*. 15(3):307-325.
- Van Niekerk, K.L. 2011. Marine fish exploitation during the Middle and Later Stone Age of South Africa. University of Cape Town.
- Villa, P. & Mahieu, E. 1991. Breakage patterns of human long bones. *Journal of Human Evolution*. 21(1):27-48.
- Volman, T.P. 1978. Early archeological evidence for shellfish collecting. *Science*. 201(4359):911-913.
- Wang, C.-C., Farina, S.E. & Li, H. 2013. Neanderthal DNA and modern human origins. *Quaternary International*. 295:126-129.

- Watts, I. 2010. The pigments from pinnacle point cave 13B, Western Cape, South Africa. *Journal of Human Evolution*. 59(3-4):392-411.
- Weber, A., Goriunova, O.I. & Konopatskii, A.K. 1993. Prehistoric seal hunting on Lake Baikal: methodology and preliminary results of the analysis of canine sections. *Journal of Archaeological Science*. 20(6):629-644.
- Weber, A.W., Link, D.W., Goriunova, O.I. & Konopatskii, A.K. 1998. Patterns of prehistoric procurement of seal at Lake Baikal: a zooarchaeological contribution to the study of past foraging economies in Siberia. *Journal of Archaeological Science*. 25(3):215-227.
- Weyer, E.M. 1932. *The Eskimos. Their environment and folkways*. New Haven: Yale University Press.
- White, T.E. 1952. Observations on the butchering technique of some aboriginal peoples: I. *American Antiquity*. 17(4):337-338.
- White, T.E. 1953a. Observations on the butchering technique of some aboriginal peoples: 2. *American Antiquity*. 19:160-164.
- White, T.E. 1953b. A method of calculating the dietary percentage of various food animals utilized by aboriginal peoples. *American Antiquity*. 18(4):396-398.
- White, T.E. 1954. Observations on the butchering technique of some aboriginal peoples: 3-6. *American Antiquity*. 19:254-264.
- Wickens, P. & York, A.E. 1997. Comparative population dynamics of fur seals. *Marine Mammal Science*. 13(2):241-292.
- Wickens, P., David, J., Shelton, P. & Field, J. 1991. Trends in harvests and pup numbers of the South African fur seal: implications for management. *South African Journal of Marine Science*. 11(1):307-326.
- Will, M., Parkington, J.E., Kandel, A.W. & Conard, N.J. 2013. Coastal adaptations and the Middle Stone Age lithic assemblages from Hoedjiespunt 1 in the western Cape, South Africa. *Journal of Human Evolution*. 64(6):518-537.

Will, M., Kandel, A.W., Kyriacou, K. & Conard, N.J. 2016. An evolutionary perspective on coastal adaptations by modern humans during the Middle Stone Age of Africa. *Quaternary International*. 404:68-86.

Woodborne, S., Hart, K. & Parkington, J. 1995. Seal bones as indicators of the timing and duration of hunter-gatherer coastal visits. *Journal of Archaeological Science*. 22(6):727-740.

Woodborne, S.M. 1996. A taphonomic study of seal remains from archaeological sites on the Western Cape coast. Unpublished PhD thesis. University of Cape Town.

Woodborne, S.M. 2006. The seals of Kasteelberg: seasonal indicators for pastoral occupation. In *Excavations at Kasteelberg and the Origins of the Khoekhoen in the Western Cape, South Africa*. A.B. Smith, Ed.: BAR International Series. 72-76.

Wurz, S. 2000. The Middle Stone Age at Klasies River, South Africa. PhD thesis. University of Stellenbosch South Africa.

Wurz, S. 2012. The significance of MIS 5 shell middens on the Cape coast: A lithic perspective from Klasies River and Ysterfontein 1. *Quaternary International*. 270:61-69.

Wurz, S. 2016. Development of the archaeological record during the middle stone age. In *Quaternary Environmental Change in Southern Africa: Physical and Human Dimensions*. J. Knight and S.W. Grab, Eds. Cambridge: Cambridge University Press. 371-384.

Appendix A

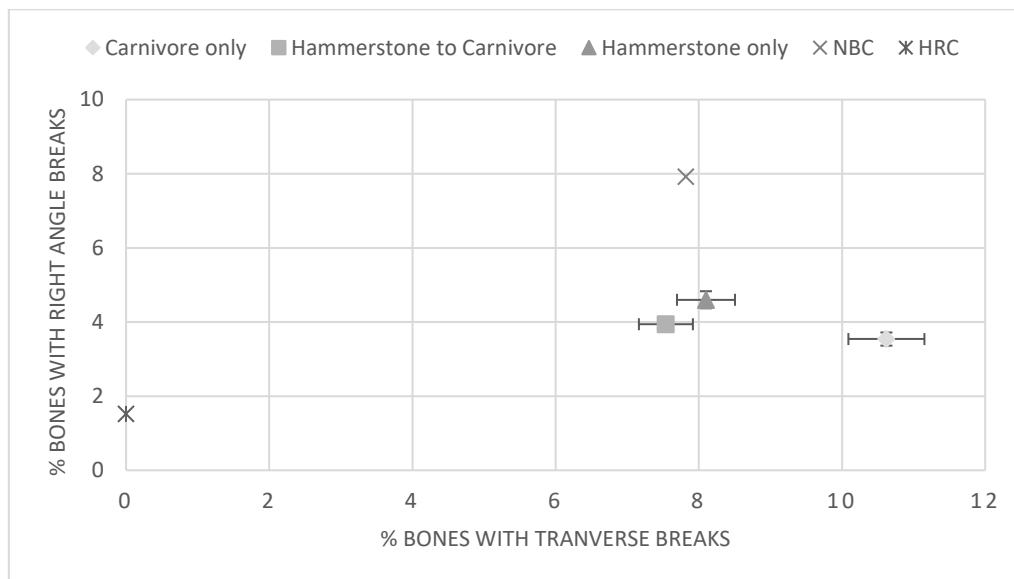


Figure 1: Average percentages of non-nutritive breaks in long bones of Cape seals from NBC and HRC. Data compared with results reported by Marean et al. (2000) for experiments in which bone marrow and other nutrients were extracted from terrestrial mammal long bones by carnivores only, hammerstones then carnivores and hammerstones only.

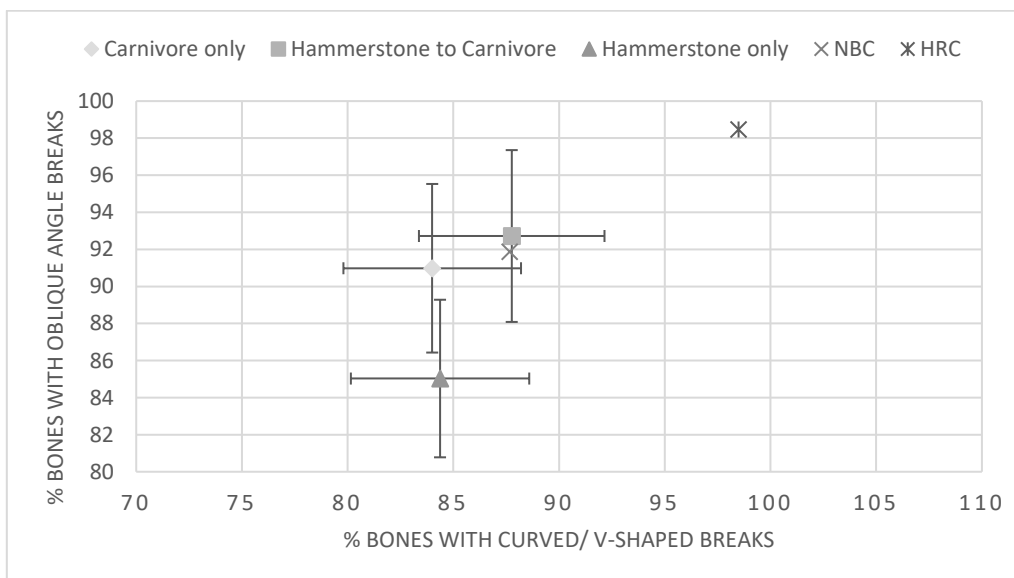


Figure 2: Average percentages of nutritive breaks in long bones of Cape fur seals from NBC and HRC. Data compared with results reported by Marean et al. (2000) for experiments in which bone marrow and other nutrients were extracted from terrestrial mammal long bones by carnivores only, hammerstones then carnivores and hammerstones only.

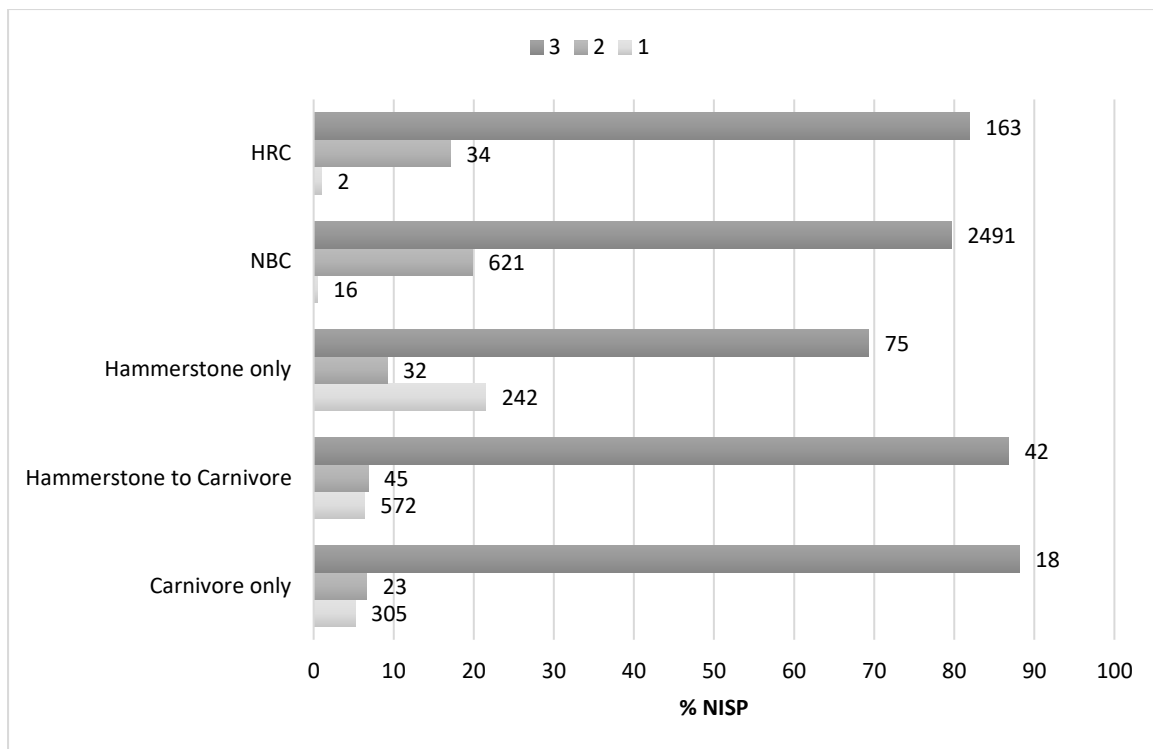


Figure 3: Average percentages of long bone shaft completeness at NBC and HRC. 3 = 100% circumference, 2 = >50% circumference and 1 = <50% circumference (Bunn 1983) compared with actualistic data on fragmentation of terrestrial mammal long bones caused by hammerstone only, hammerstone followed by carnivores and carnivores only (Marean et al. 2004). Sample sizes depicted as bar labels.

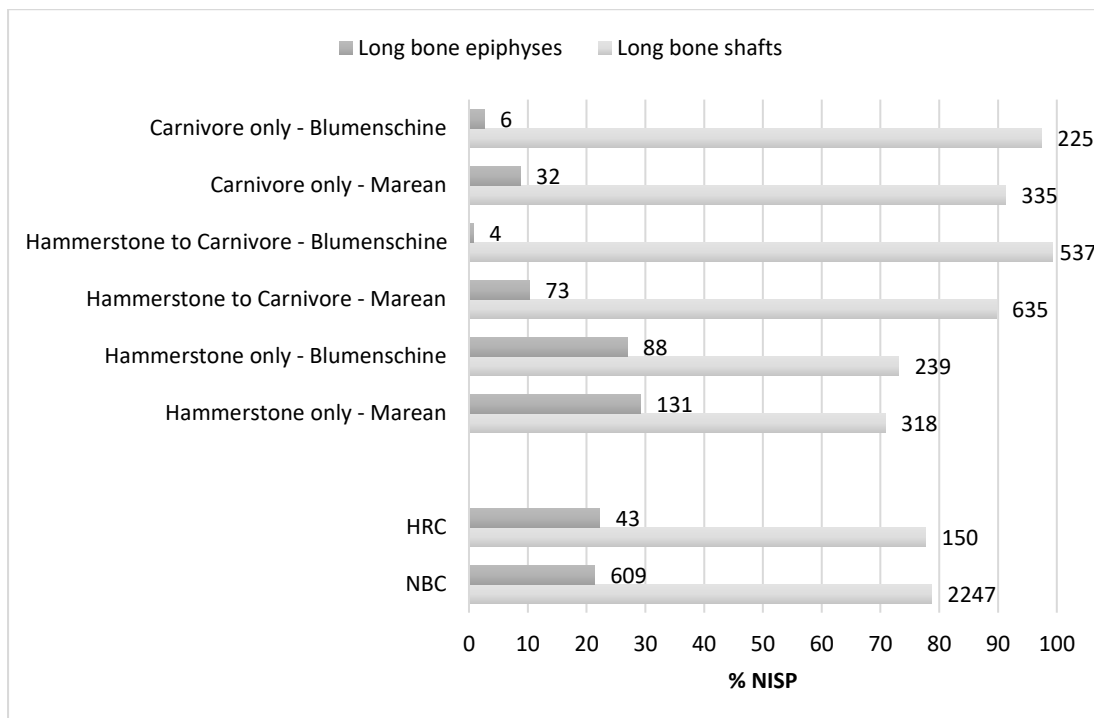


Figure 4: Percentages of long bone shafts compared with epiphyses at NBC and HRC. Data compared with actualistic studies on fragmented long bone shafts and epiphyses of terrestrial mammals after they were broken by hammerstones only, hammerstones followed by carnivores and carnivores only (Blumenschine 1988; Marean et al. 2004). Sample sizes depicted as bar labels.

Appendix B



Figure 32: Cape fur seal atlas (Photo Leesha Richardson).



Figure 33: Cape fur seal axis (Photo Leesha Richardson).



Figure 34: Cape fur seal cervical vertebrae (Photo Leesha Richardson).



Figure 35: Cape fur seal thoracic vertebrae (Photo Leesha Richardson).

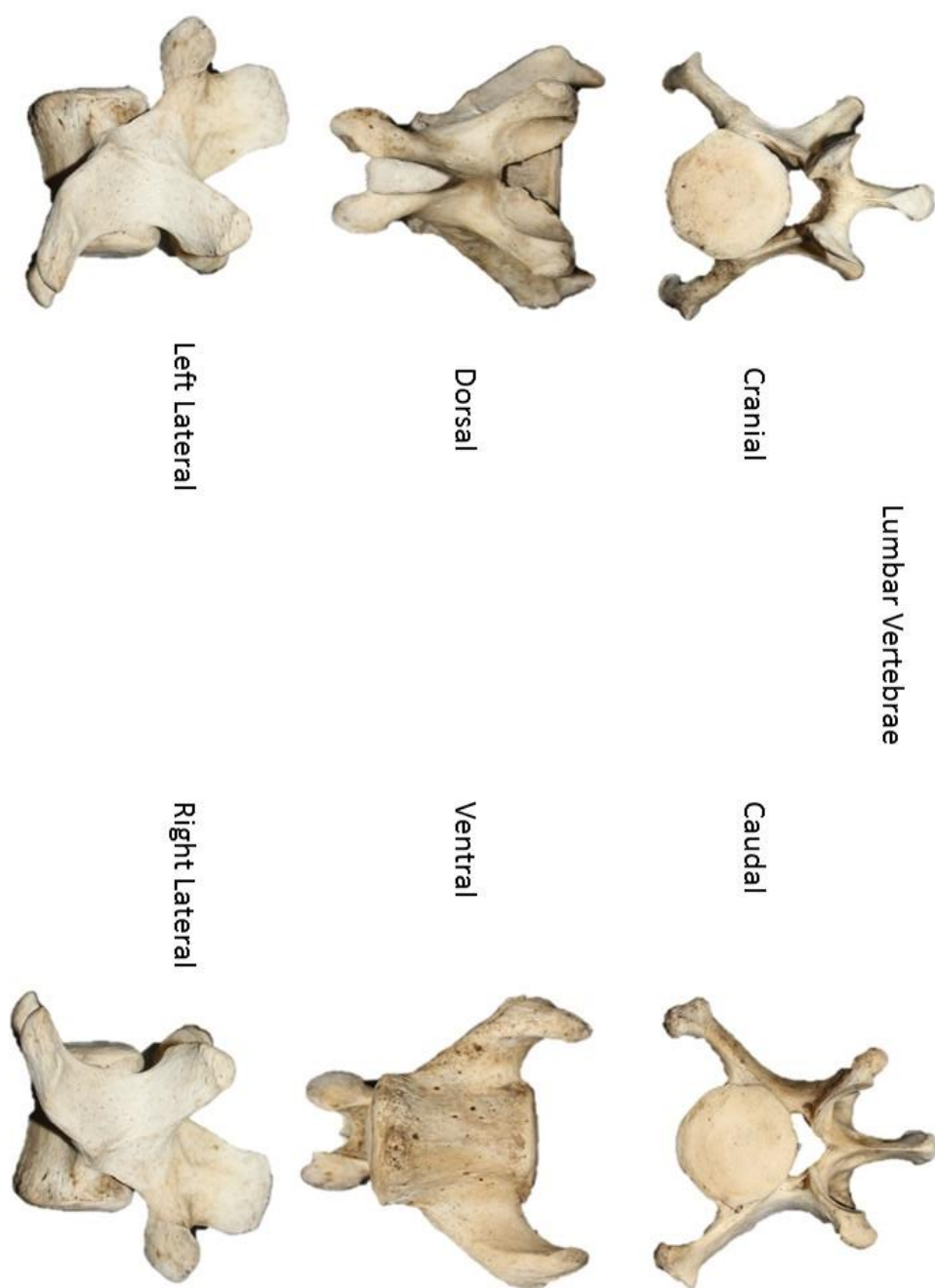


Figure 36: Cape fur seal lumbar vertebrae (Photo Leesha Richardson).

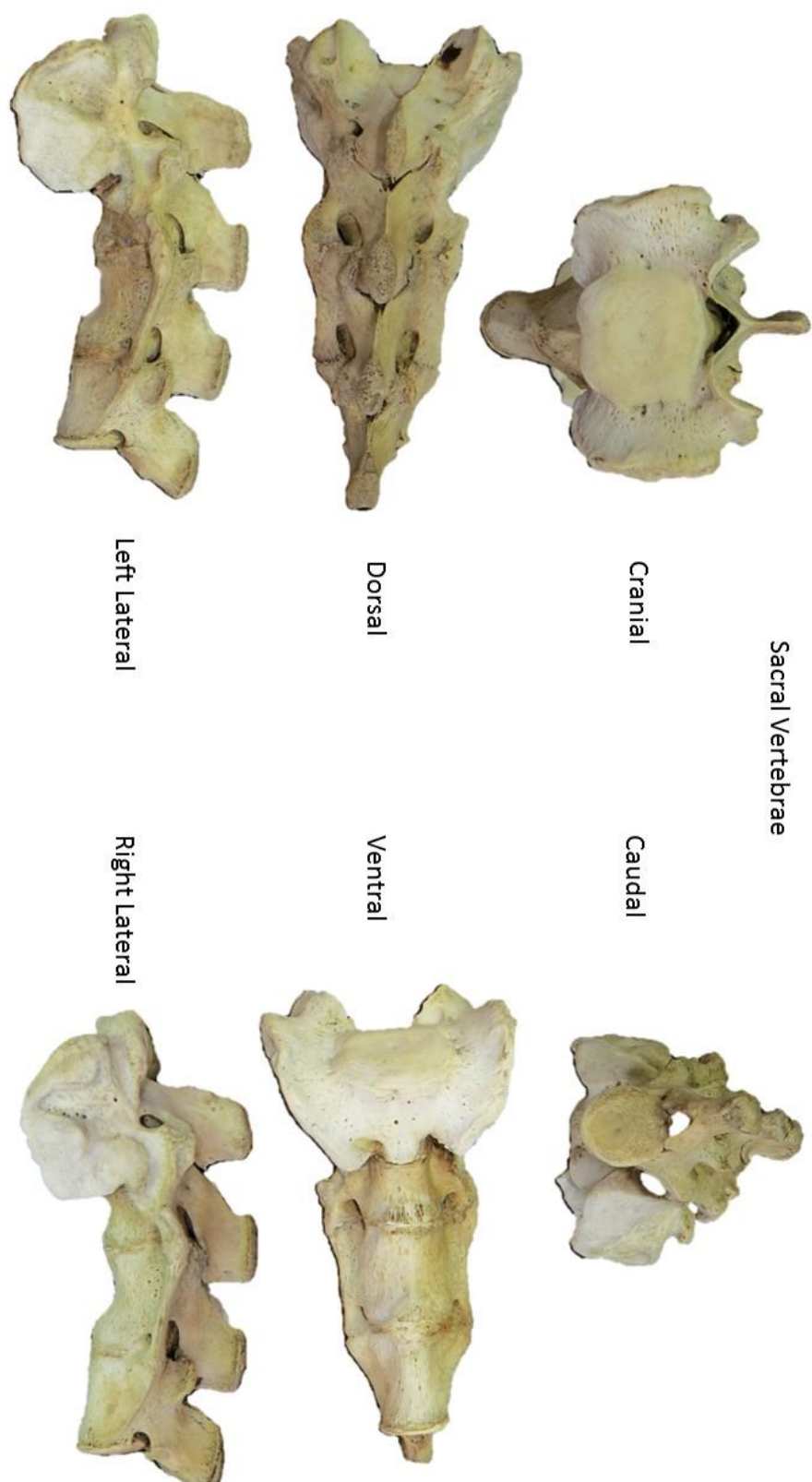


Figure 37: Cape fur seal sacral vertebrae (Photo Leesha Richardson).

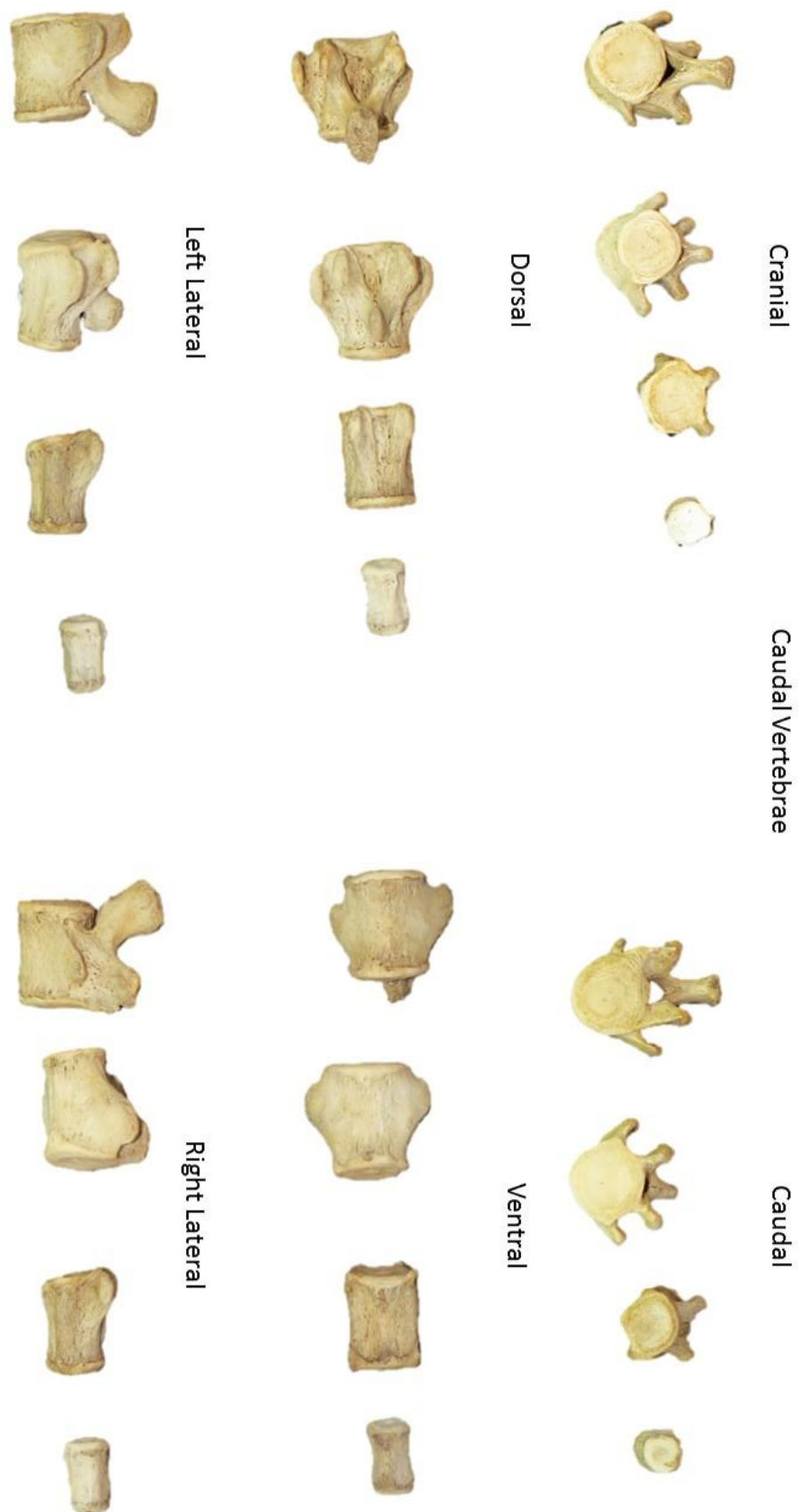


Figure 38: Cape fur seal caudal vertebrae (Photo Leesha Richardson).

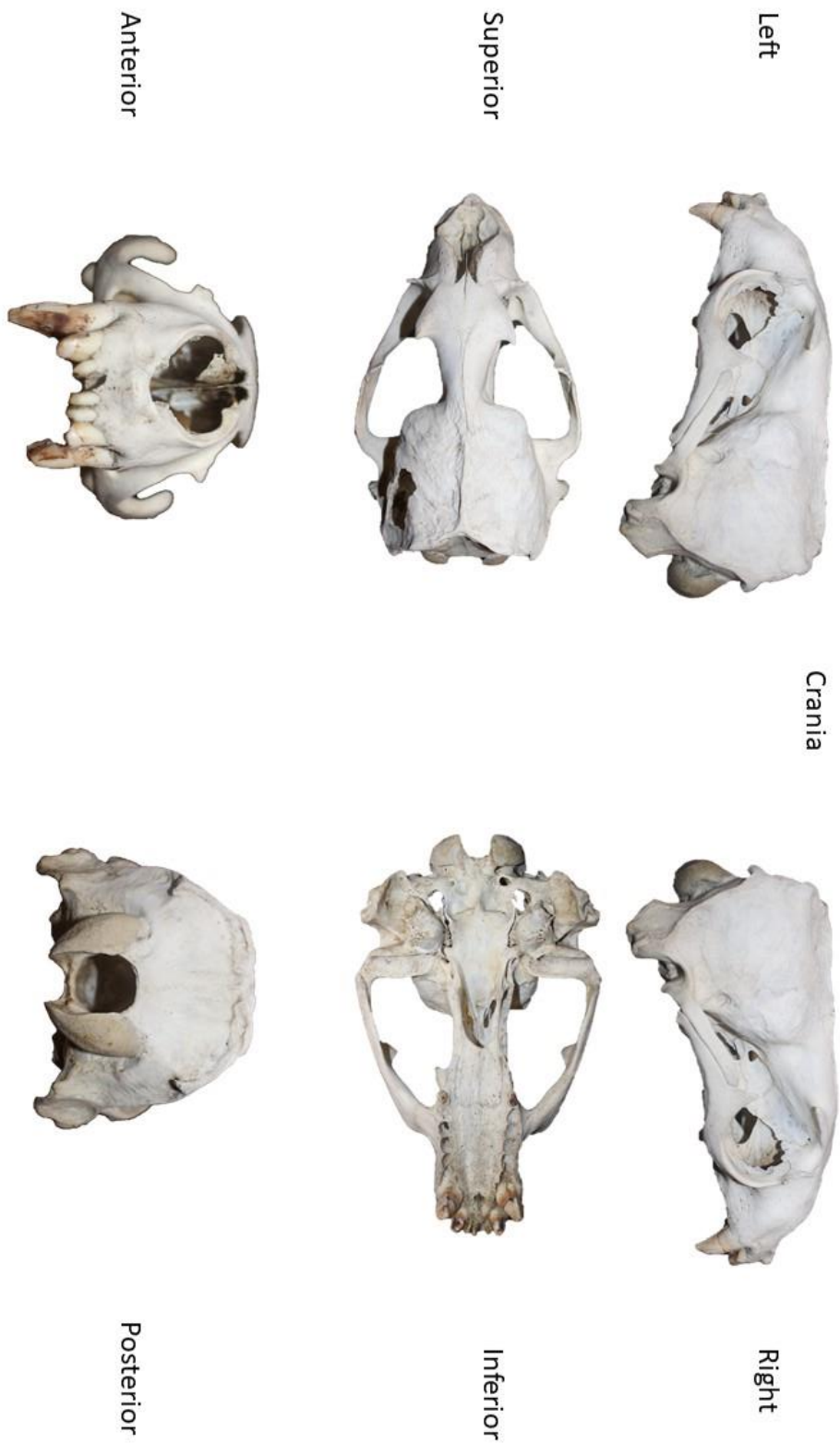


Figure 39: Cape fur seal cranium (Photo Leesha Richardson).

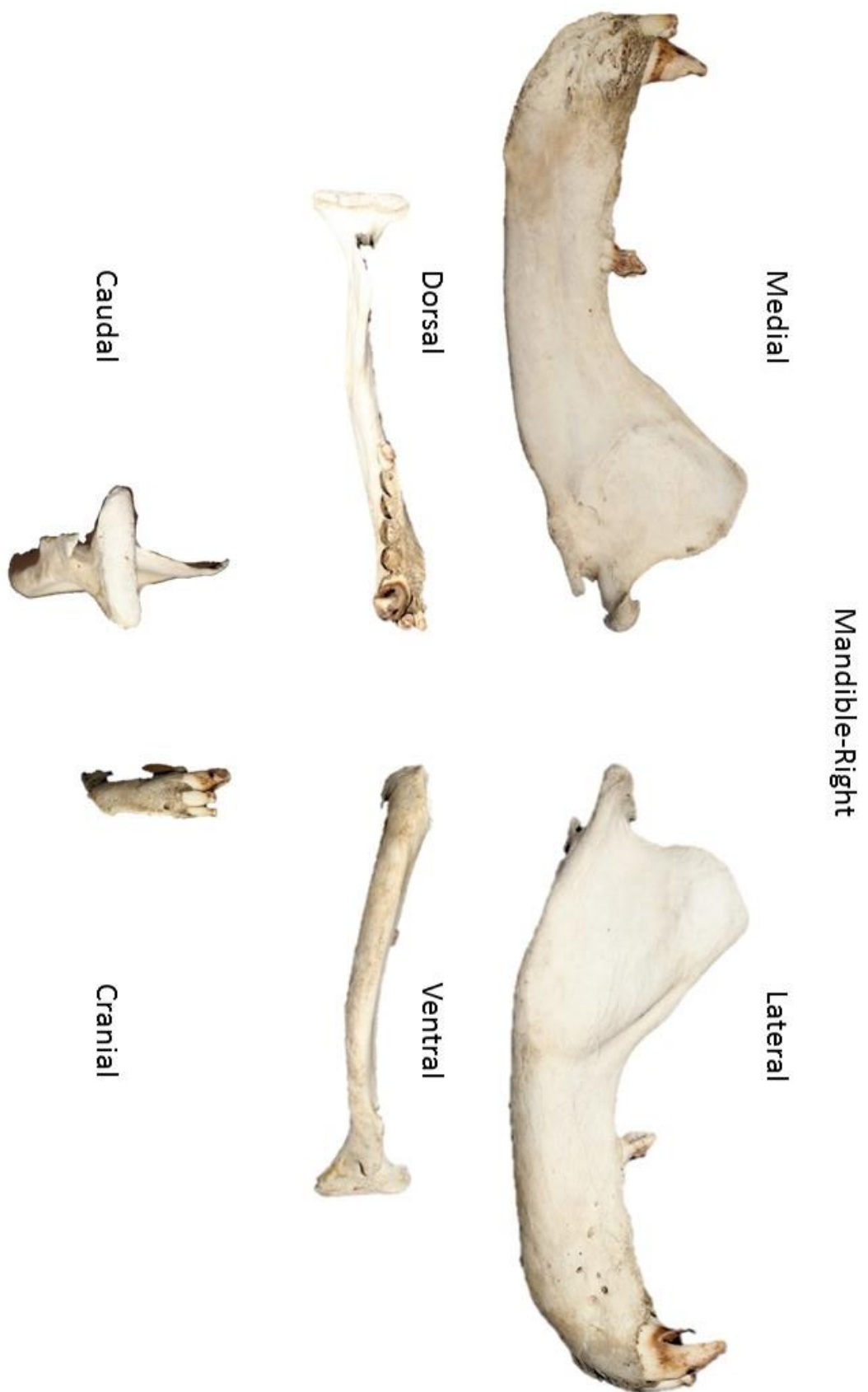


Figure 40: Cape fur seal mandible (R) (Photo Leesha Richardson).

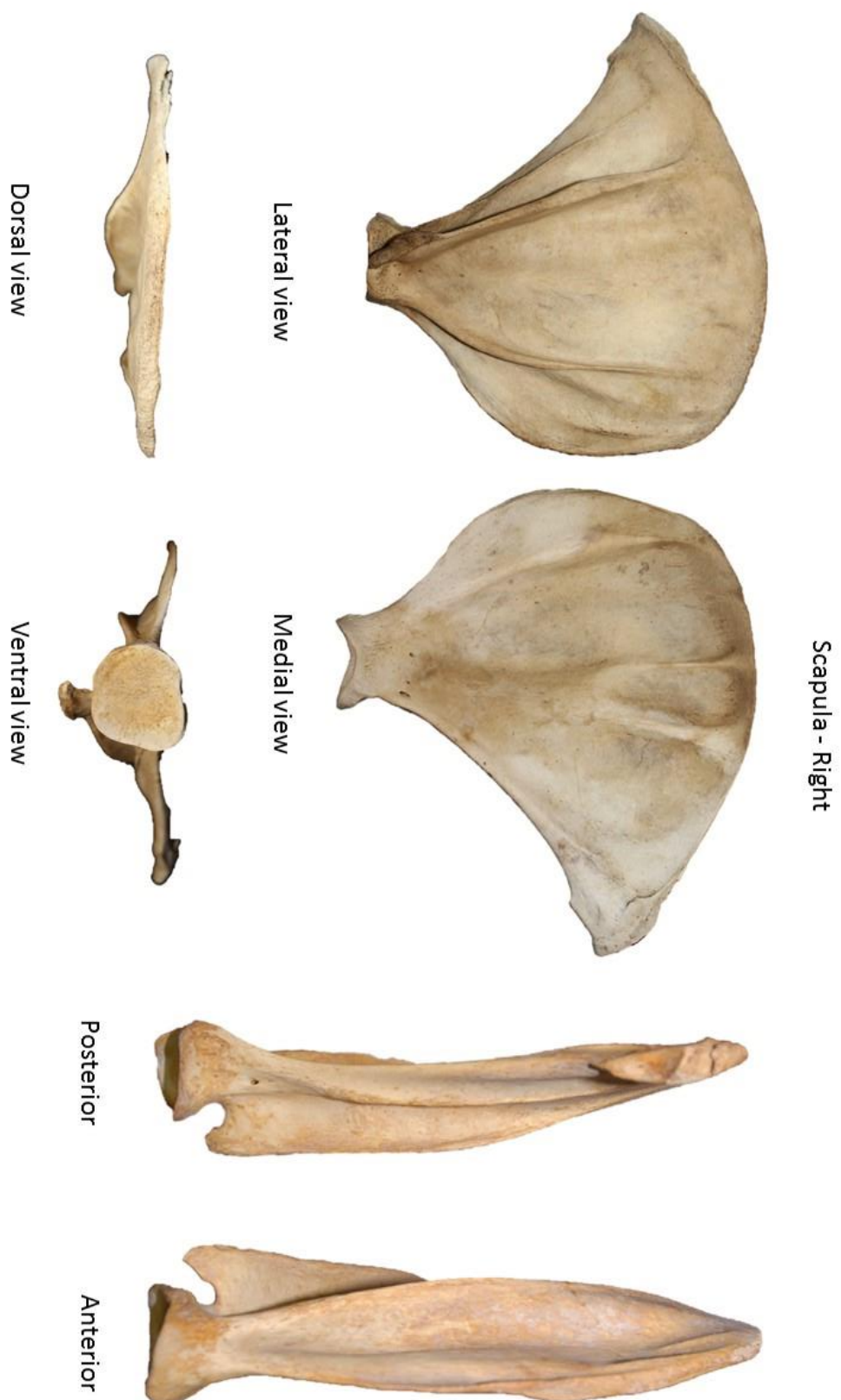


Figure 41: Cape fur seal scapula (R) (Photo Leesha Richardson).

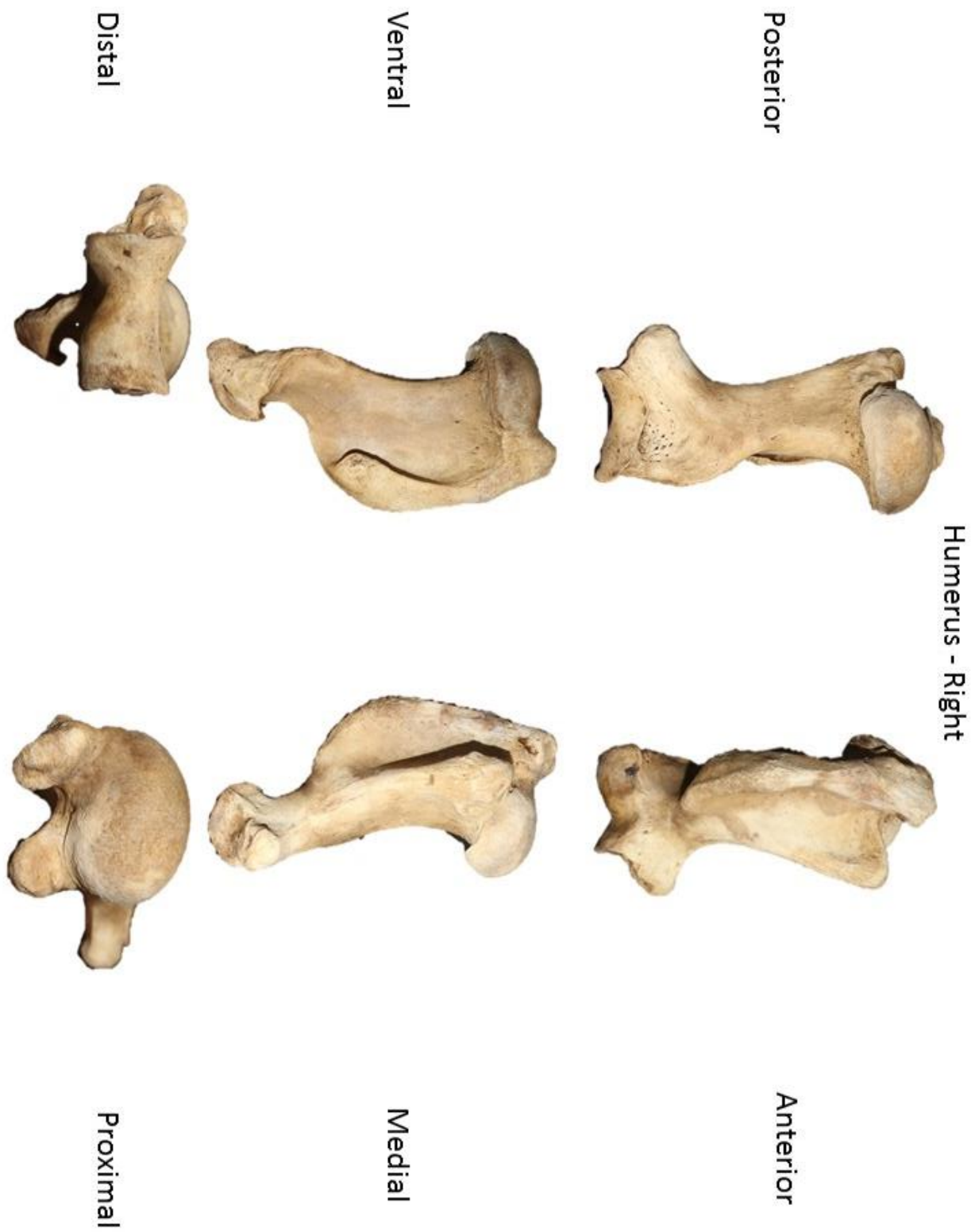


Figure 42: Cape fur seal humerus (R) (Photo Leesha Richardson).



Figure 43: Cape fur seal radius (R) (Photo Leesha Richardson).

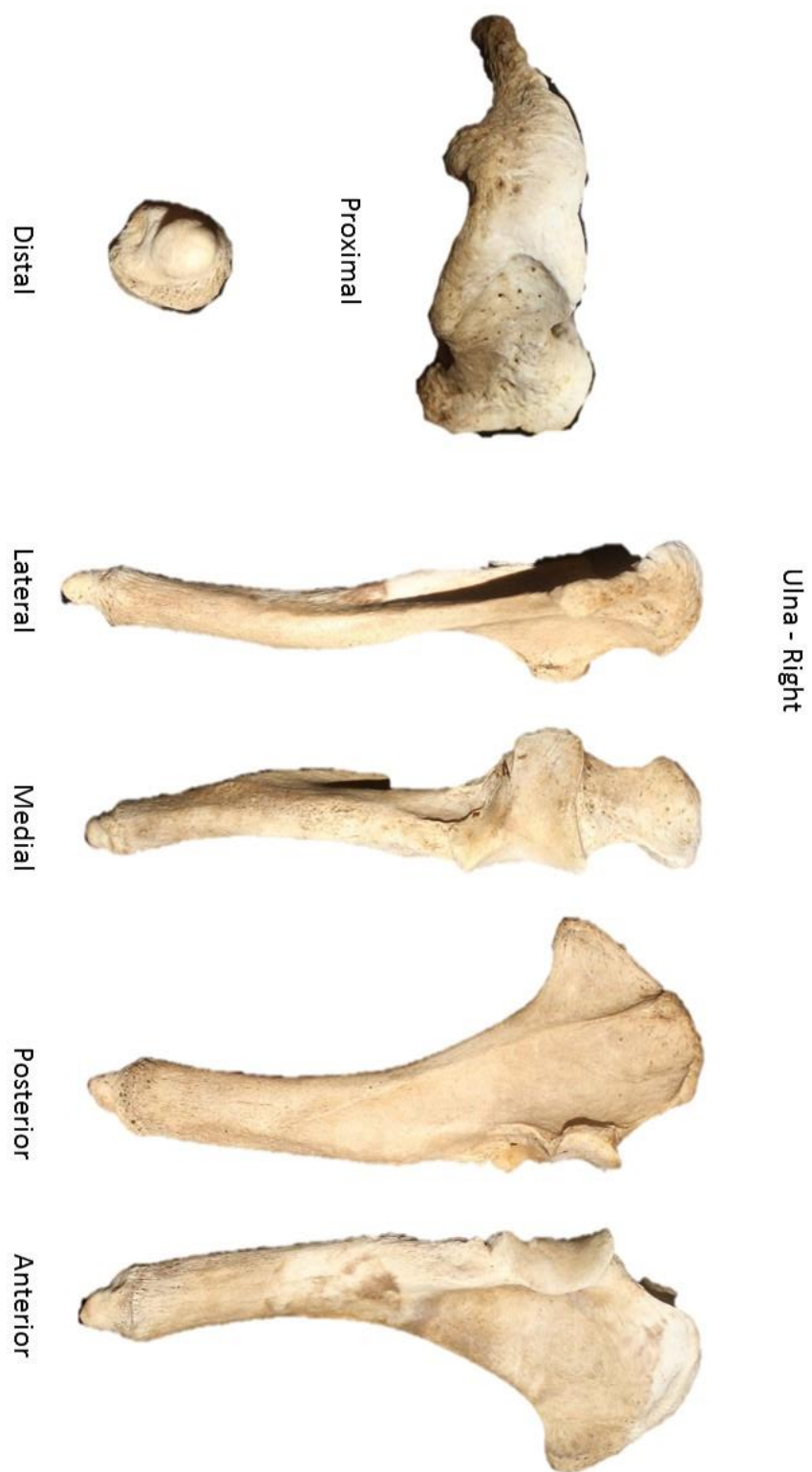


Figure 44: Cape fur seal ulna (R) (Photo Leesha Richardson).

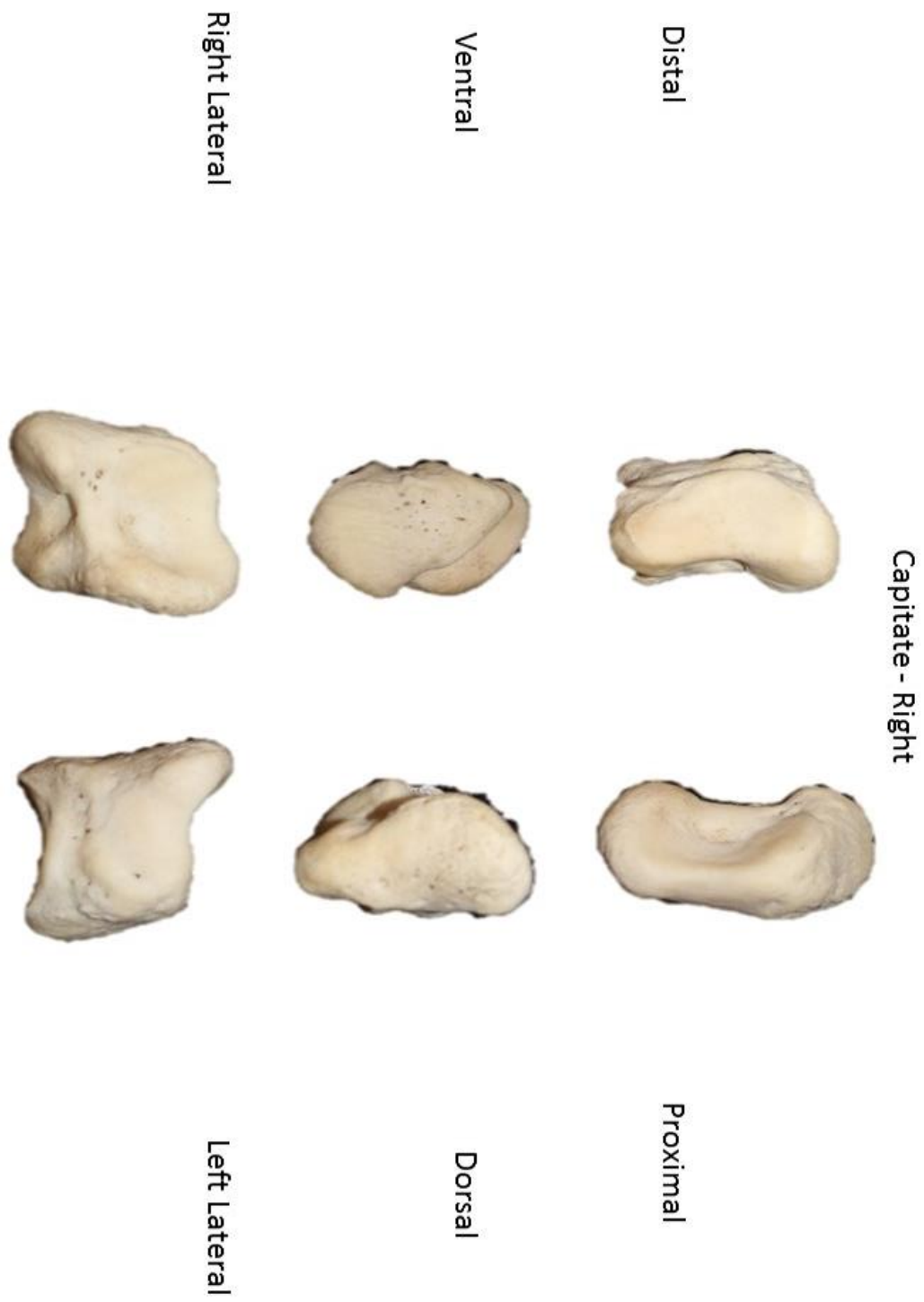


Figure 45: Cape fur seal capitate (R) (Photo Leesha Richardson).



Figure 46: Cape fur seal hamate (R) (Photo Leesha Richardson).



Figure 47: Cape fur seal pisiform (R) (Photo Leesha Richardson).



Figure 48: Cape fur seal scapolunar (R) (Photo Leesha Richardson).



Figure 49: Cape fur seal trapezium (R) (Photo Leesha Richardson).

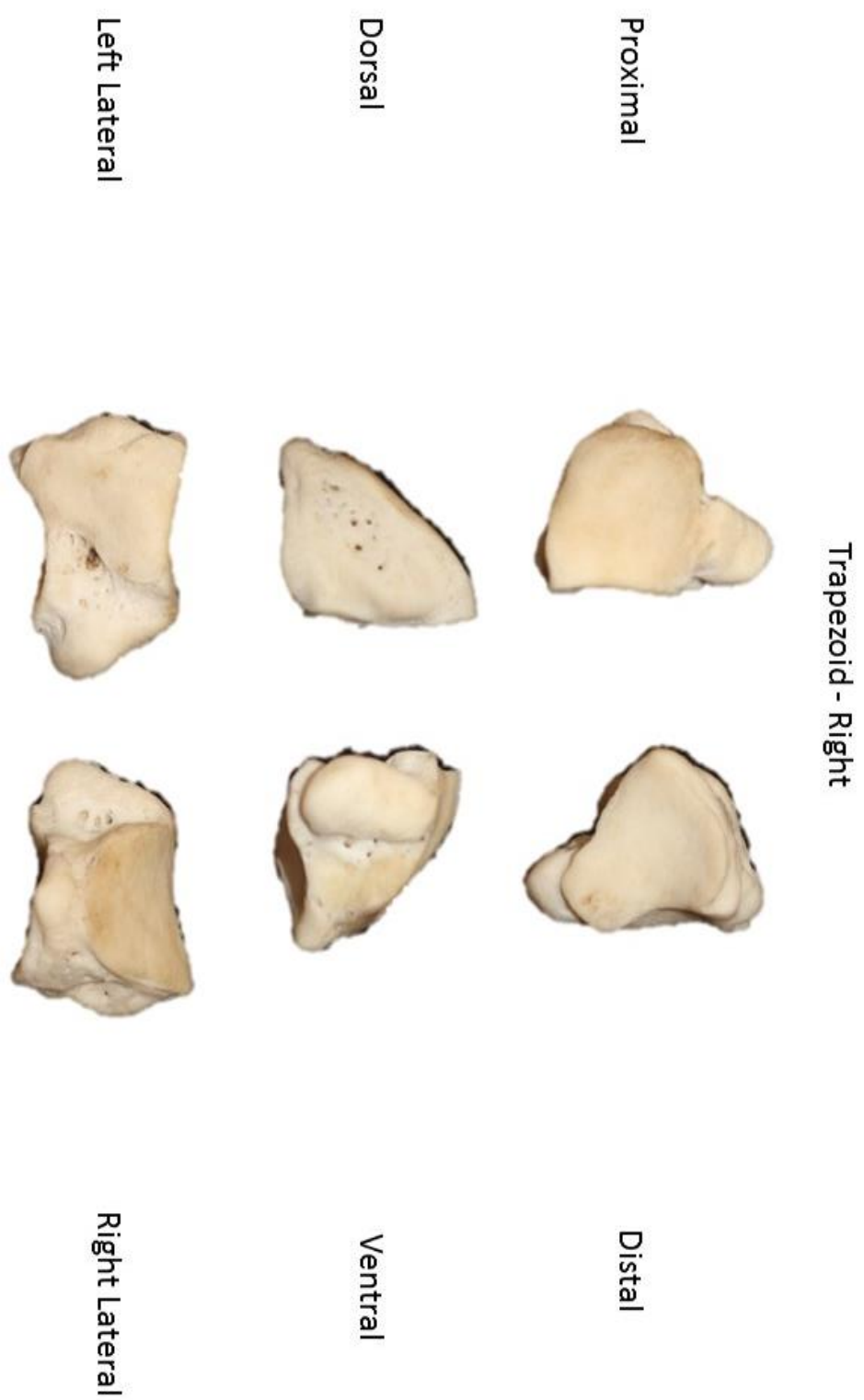


Figure 50: Cape fur seal trapezoid (R) (Photo Leesha Richardson).



Figure 51: Cape fur seal triquetral (R) (Photo Leesha Richardson).

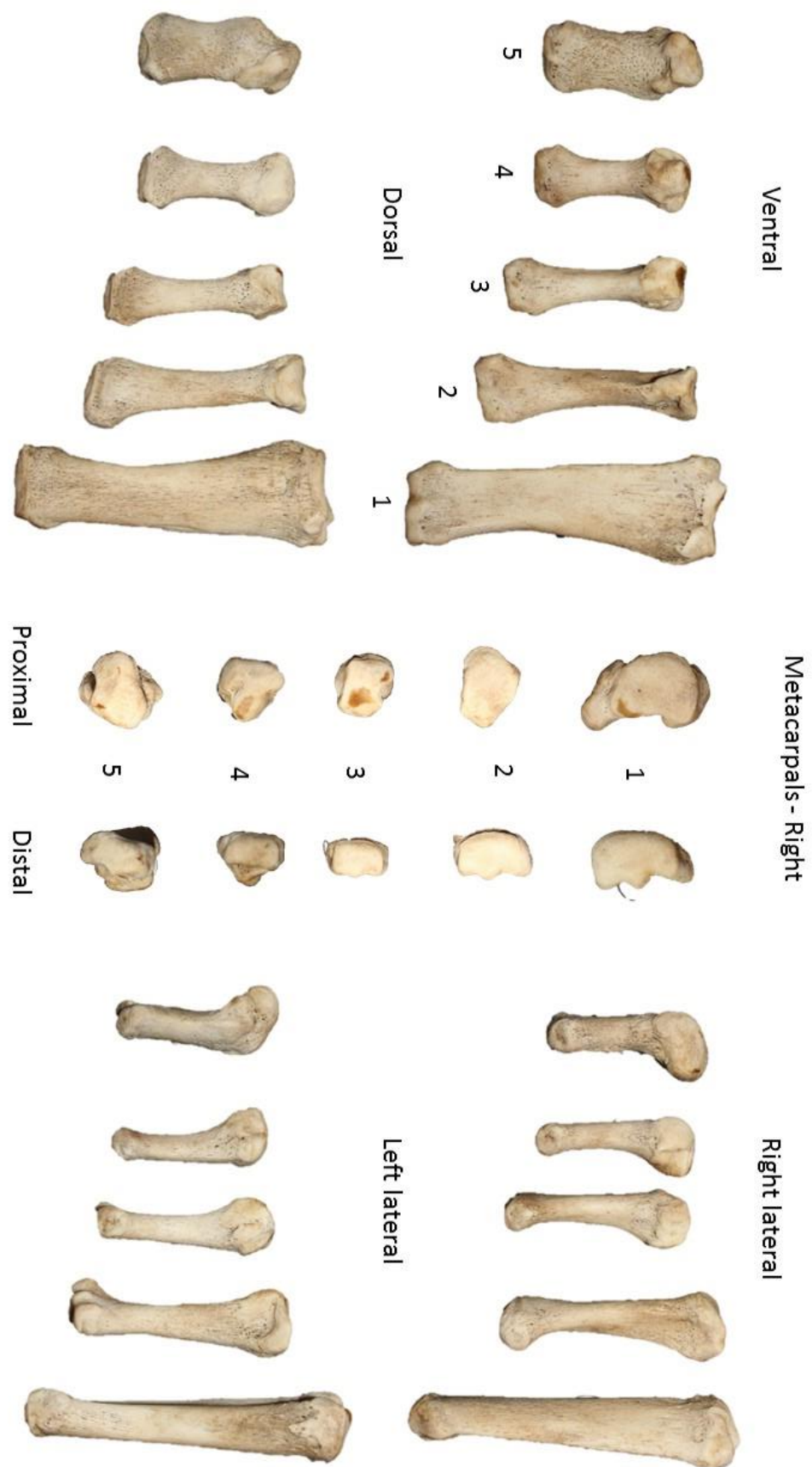


Figure 52: Cape fur seal metacarpals (R) (Photo Leesha Richardson).

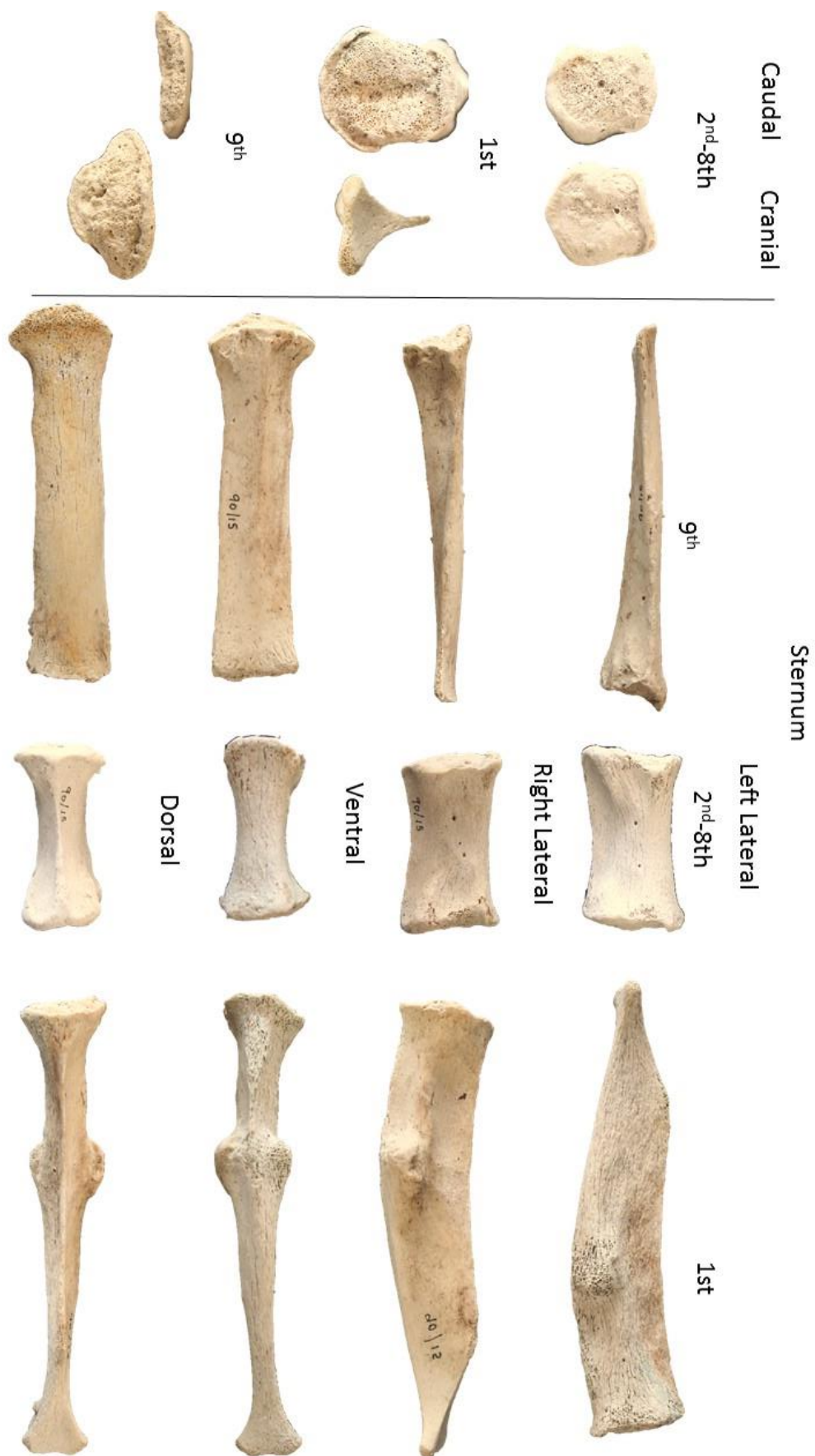


Figure 53: Cape fur seal sternebrae (Photo Leesha Richardson).



Figure 54: Cape fur seal ribs (R) (Photo Leesha Richardson).

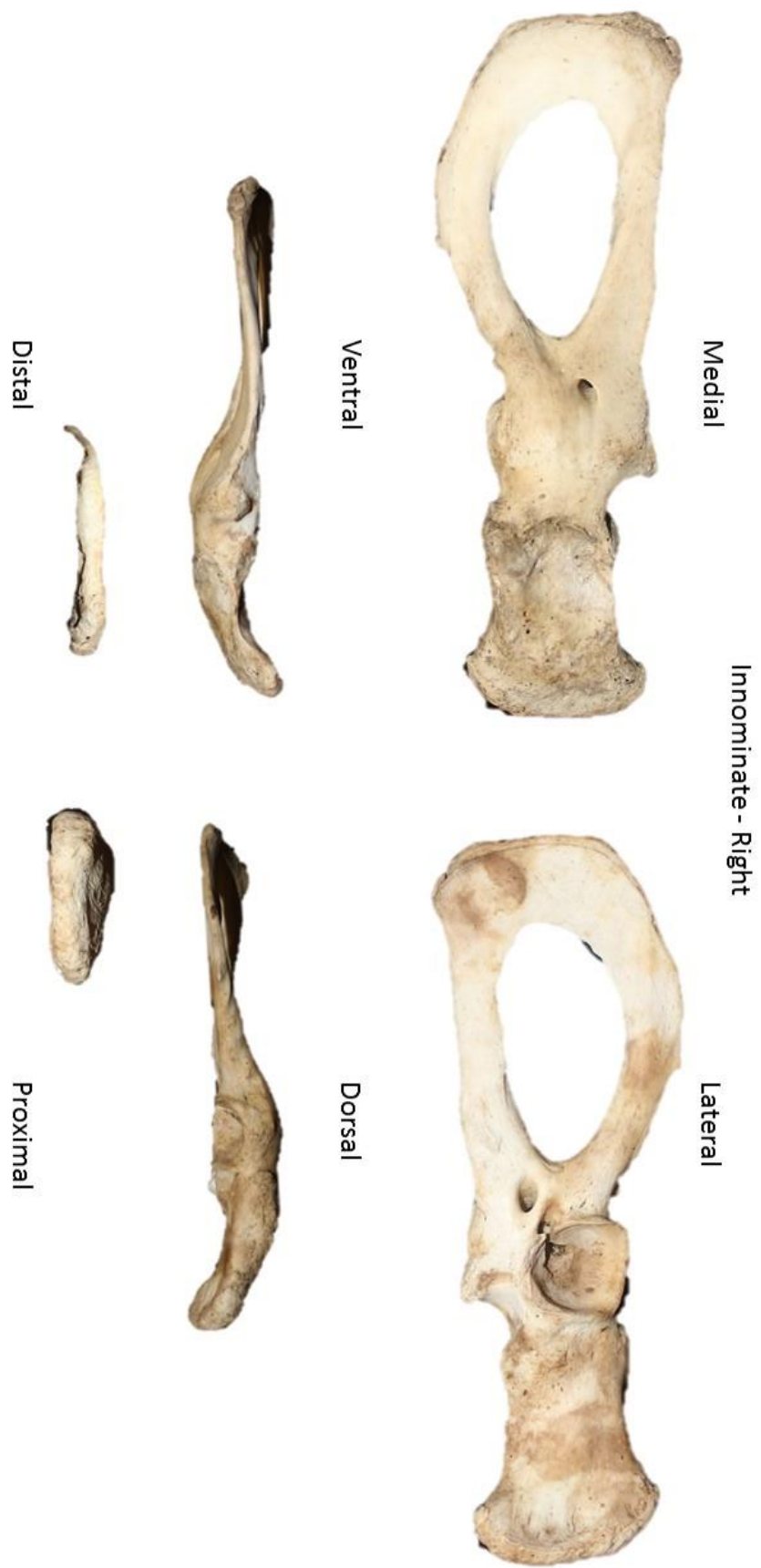


Figure 55: Cape fur seal innominate (R) (Photo Leesha Richardson).



Figure 56: Cape fur seal femur (R) (Photo Leesha Richardson).



Figure 57: Cape fur seal tubula and fibula (R) (Photo Leesha Richardson).



Figure 58: Cape fur seal astragalus (R) (Photo Leesha Richardson).



Figure 59: Cape fur seal calcaneum (R) (Photo Leesha Richardson).

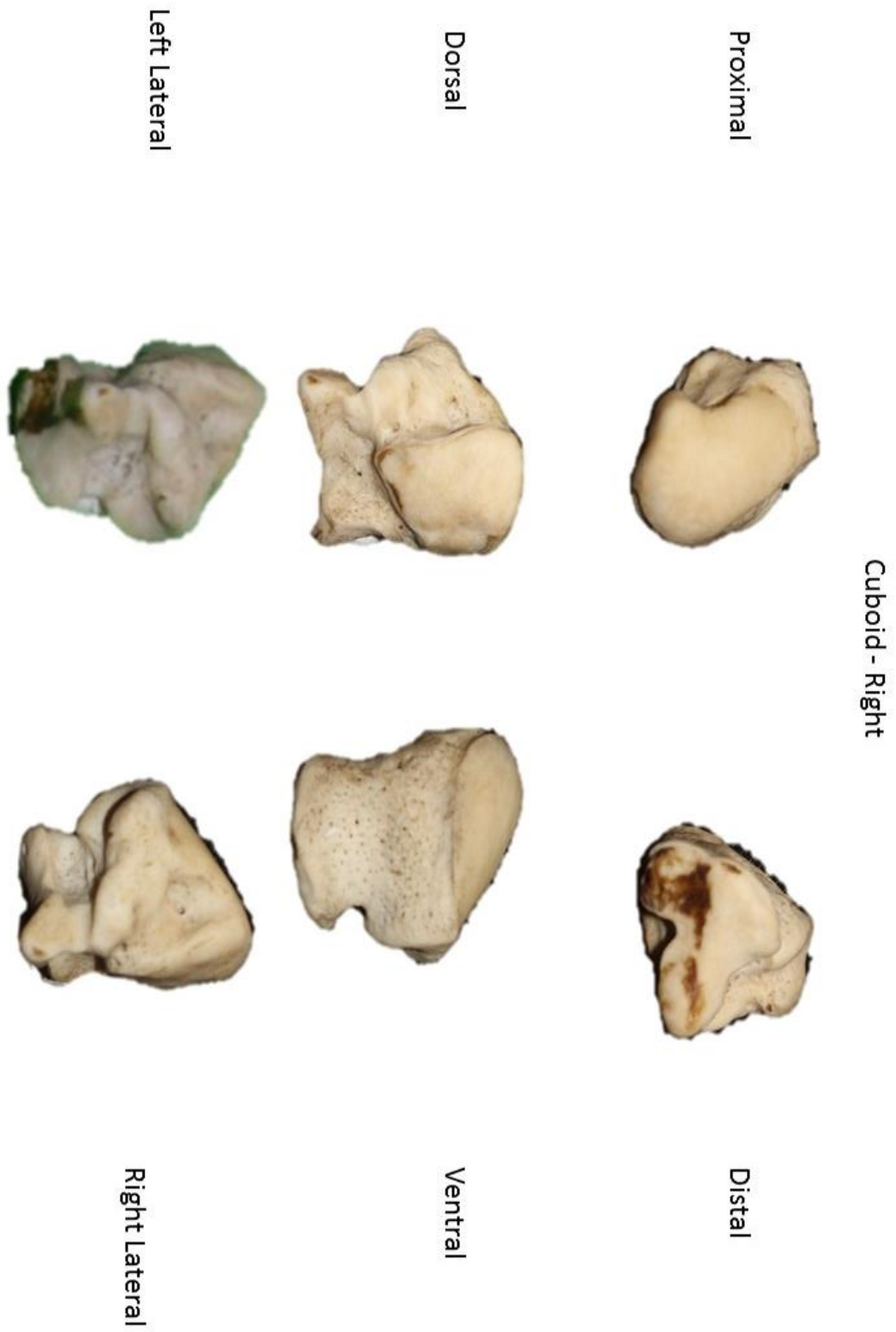


Figure 60: Cape fur seal cuboid (R) (Photo Leesha Richardson).



Figure 61: Cape fur seal external cuneiform (R) (Photo Leesha Richardson).

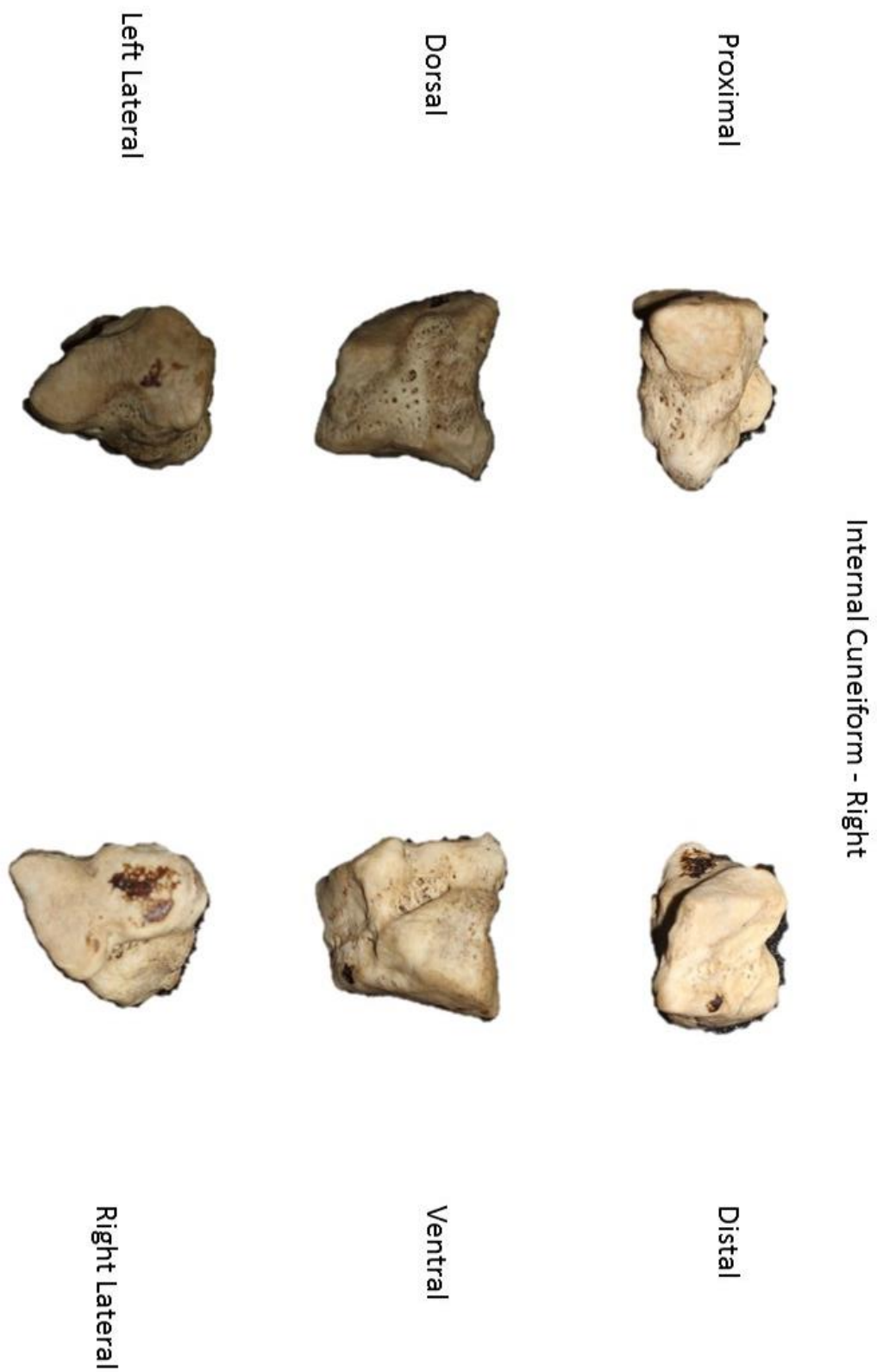


Figure 62: Cape fur seal internal cuneiform (R) (Photo Leesha Richardson).



Figure 63: Cape fur seal middle cuneiform (R) (Photo Leesha Richardson).

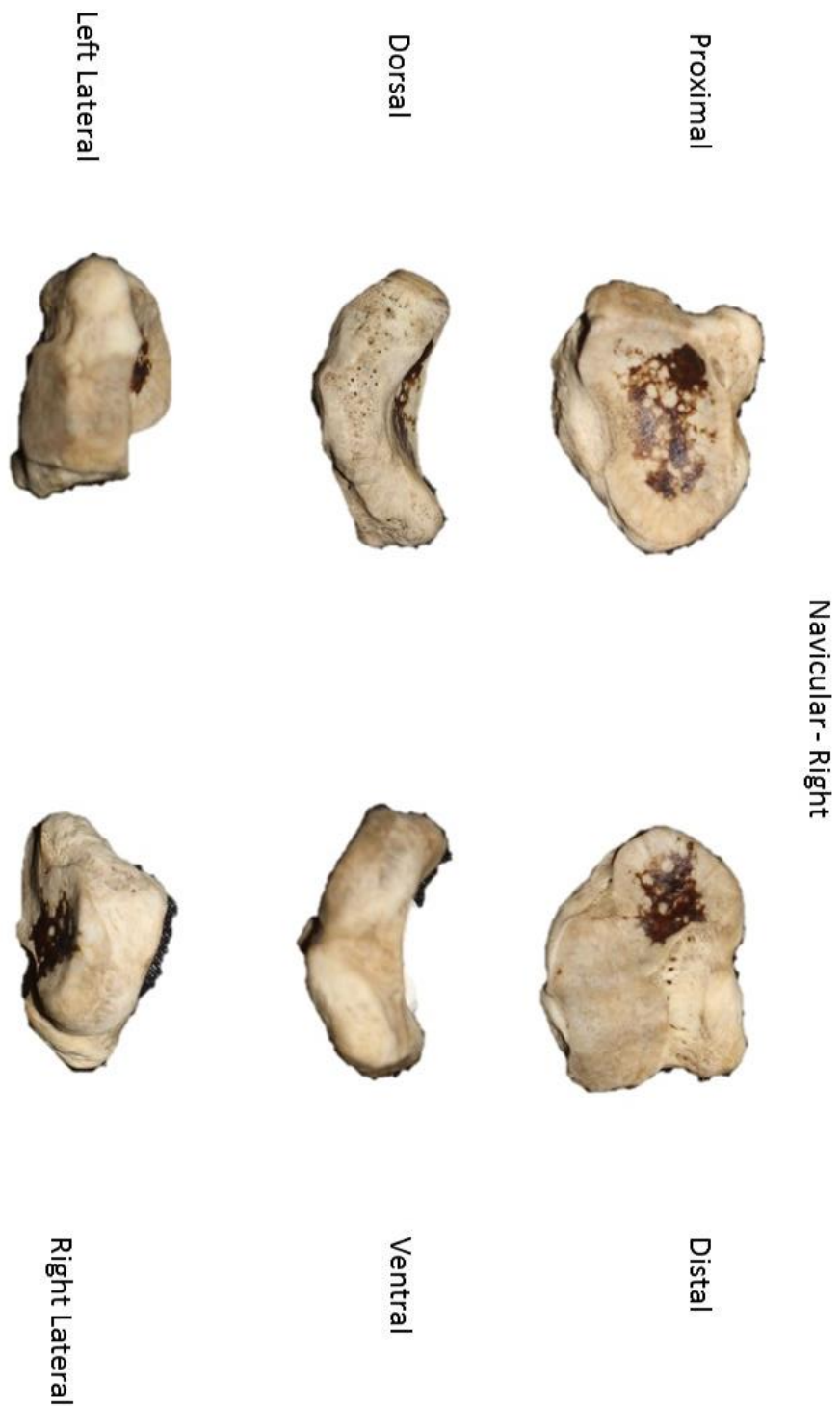


Figure 64: Cape fur seal navicular (R) (Photo Leesha Richardson).



Figure 65: Cape fur seal sesamoid (R) (Photo Leesha Richardson).

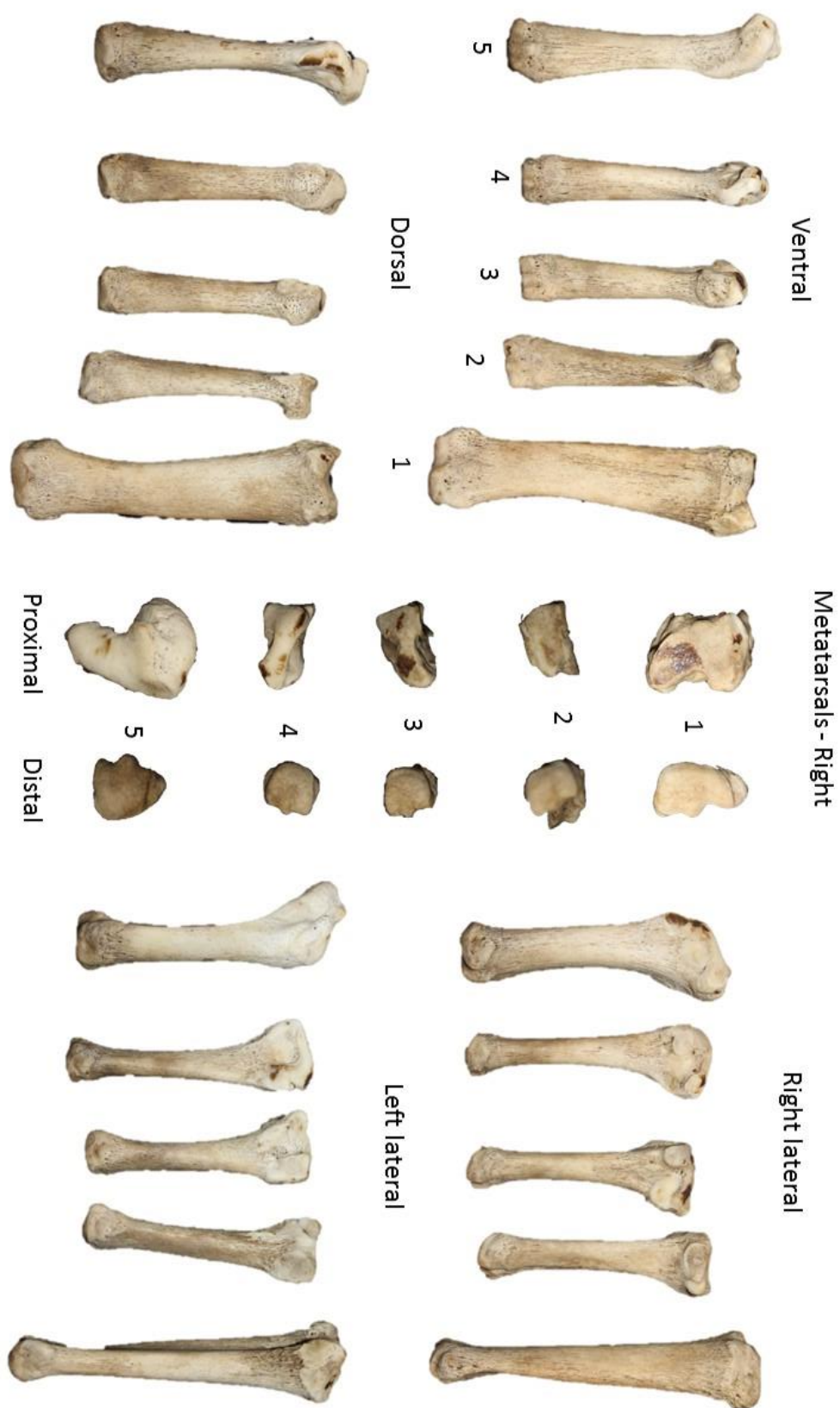


Figure 66: Cape fur seal metatarsals (R) (Photo Leesha Richardson)