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Revisiting, redating, and reframing the earliest excavations at Paternoster, South African west coast: The archaeology of Fisheries Factory Midden

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ABSTRACT
The Holocene archaeology of the South African west coast is arguably the most studied among other coastal stretches in this country. It has helped to understand the shifts in the lifeways and technology of coastal hunter-gatherers in relation to their environment, climate changes and cultural contact with herder groups. Among the momentous and varied records, the appearance of very large shell middens known as 'megamiddens' stands out. They are discontinuously distributed along a ~125 km long stretch of coastline from Lamberts Bay and Elands Bay to Paternoster, and date to ca. 3200-2200 cal. BP. Megamiddens around Paternoster are less studied than the two former. The Fisheries Factory Midden in Paternoster is contemporary with two megamiddens in this locality and is the subject of this paper. This site was excavated by Pete Robertshaw in 1975, and here we expand on his observations to make them directly relevant to the megamidden period. New radiocarbon dates position this site a few centuries before 3265 cal. BP to ca. 2760 cal. BP, with last visits happening from ca. 1990 cal. BP to ca. 625 cal. BP. This study reveals a decrease in bovid foraging efficiency and a concomitant and dramatic increase in the procurement of a number of marine resources from the onset of the site occupation until ca. 2760 cal. BP. Several proxy indicators suggest an increasing occupational intensity at this site as group mobility and foraging range shrank to the coastal margin and adjacent plain during this period. This trend was largely reversed soon after ca. 2000 cal. BP.

Keywords: shell middens, foraging ecology, subsistence strategies, coastal exploitation, occupational intensity

1. Introduction

This paper reports new observations from the South African west coast site of Fisheries Factory Midden (FFM) and their bearing on a period (ca. 3200-2100 cal. BP) when very large shell middens, known as 'megamiddens', appeared on the Paternoster coastal landscape (Fig. 1; Yates 2004a, b; Smith 2006; Jerardino 2024; Jerardino et al. 2024, 2026). At least two Paternoster megamiddens have been identified thus far while at least a dozen of them are known for the Lamberts Bay and Elands Bay areas (hereafter referred to as the central west coast) (Fig. 1; Parkington 1976; Buchanan 1988; Parkington et al. 1988; Jerardino 2010, 2012). Robertshaw (1977, 1979a) did not report on FFM's surface extent, but he would have certainly commented had it been large. Therefore, FFM is likely to have been much smaller than a megamidden.

All megamiddens attest to a large-scale and intense hunter-gatherer exploitation of marine resources about 3200-2100 years ago, a unique economic and settlement behaviour never present before or after this period (Fig. 1; Buchanan 1988; Parkington et al. 1988; Jerardino 2010, 2012). There are important differences between the central west coast and Paternoster megamiddens, and their possible relationship is not yet clear (Yates 1998, 2004a, b; Smith 2006; Jerardino et al. 2024, 2026). The Paternoster

megamiddens contain a variety of artefacts and an array of fauna (mammals, seabirds and reptiles) and marine mollusc taxa (e.g., *Cymbula* sp. and *Scutellastra* sp. limpets, *Choromytilus meridionalis* mussel and *Burnupena* sp. whelks), while the megamiddens on the central west coast are depleted of cultural and faunal remains and a single species (*C. meridionalis*) dominates almost all their depositional units (Buchanan 1988; Parkington et al. 1988; Jerardino 2010, 2012; Jerardino & Navarro 2018a, b; Jerardino et al. 2024, 2026). Another difference is that Paternoster megamiddens seem to have started accumulating somewhat earlier than those from the central west coast, likely by a few centuries (Jerardino et al. 2024, 2026). However, the preceding and early stages of the megamidden period in the central west coast are better documented and therefore understood than that of Paternoster.

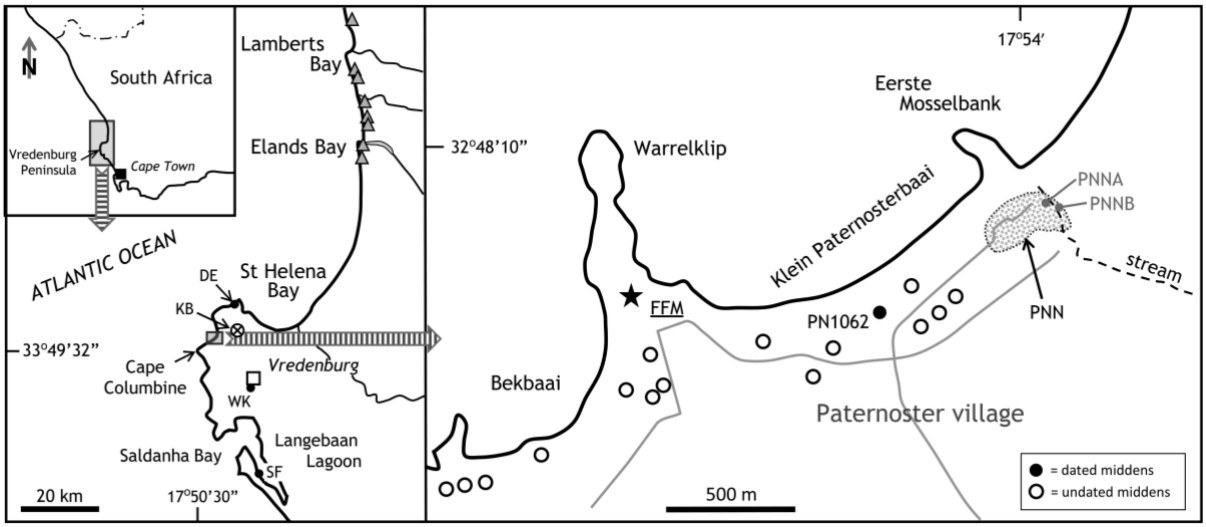

Figure 1. Composite map showing sites and localities mentioned in the text. The left map shows the location of the Vredenburg Peninsula within which Paternoster occurs (grey insets), towns, geographical features and other sites such as Duiker Eiland (DE), Kasteelberg (KB), Witklip (WK), and Stofbergsfontein (SF). The location of megamiddens in the Elands Bay and Lamberts Bay areas are indicated as dark-grey triangles. The right map shows Paternoster village and the location of Fisheries Factory Midden (FFM) with a black star, and the megamiddens PN1062 and Paternoster North (PNN) with its two sampled locations of PNNA and PNNB. Empty circles refer to single or groups of undated shell middens. Main access roads are shown with dark-grey lines.

Successive shifts in terrestrial prey preference were underway about 500 years before people focussed on marine resources on the central west coast. As human population numbers increased from ca. 3500 cal. BP, hunting of medium-large to large and highly mobile bovids was increasingly and completely phased out by the exploitation of small bovids with smaller territories, which in turn was replaced, but not entirely so, with the intense collection of slow-moving tortoises soon after ca. 3100 cal. BP (Jerardino 2010, 2012; Jerardino et al. 2021). Isotopic observations on central west coast human skeletal remains and archaeological data reflect increased consumption of marine foods ca. 3000-2000 cal. BP in tandem with group mobility largely restricted to the coast and immediate coastal plain (Lee-Thorp et al. 1989; Jerardino 2010, 2012, 2013; Loftus & Pfeiffer 2023). Hence, a decline in the foraging efficiency of terrestrial resources and a reduction of diet breadth started 500 years before and continued throughout the megamidden period. While the intensified procurement of coastal resources is common to both northerly and southerly megamiddens during the third millennium BP, the early transitional stages before then are not known for Paternoster, largely because older deposits have yet to be documented. Nonetheless, there is still much to be understood about the megamidden period in Paternoster, which the FFM sequence is reassessed here to help clarify.

Robertshaw (1975, 1979a) excavated FFM as part of his PhD research with the explicit interest "…in the prehistory of pastoralism in the Cape…" (Robertshaw 1979a: 4), and he chose to excavate this site because it was "…the only one on the Vredenburg peninsula offering a vertical sequence of deposits possibly spanning the pre-pottery/pottery interface…" (Robertshaw 1979a: 62). While Robertshaw's questions were about the arrival of the stock-keeping economy and pottery technology to the Cape, and

the possible consequences on the local hunter-gatherer populations (Robertshaw 1979a), the focus of this paper is instead the period preceding this socio-cultural event to better understand megamiddens in Paternoster. We revisit the FFM record and reframe its published data with a methodology different from that employed by Robertshaw (1977, 1979a), and we present new radiocarbon dates, new data and previously unpublished contextual information. In this way, our new observations shed light on the megamidden period in Paternoster. This new set of evidence complements that reported by Robertshaw (1977, 1979a) and is discussed in light of contemporary observations from local sites.

2. Environmental background

Paternoster is located on the Vredenburg Peninsula about 145 km north of Cape Town (Fig. 1). It has a 1.3 km long beach flanked by dune sands and two granitic reefs. The western-most reef is Warrelklip where FFM is situated (Fig. 1). Fresh water is available from a seasonal stream that reaches the eastern-most reef of Eerste Mosselbank and from a few springs and briny pans (Fig. 1; Smith 2006; Sadr 2014). Paternoster has a Mediterranean climate, and the 250-300 mm of annual rain falls mainly in autumn and winter between April and October (Chase & Meadows 2007; Sadr 2014). Cool temperatures (6.7-16.3 ºC) characterise the winter months while much warmer conditions prevail in summer (14.3-29.1ºC) (Weather Atlas 2026). A variety of lithic raw materials are available in and around Paternoster, including quartz, quartzite, and quartz porphyry along the rocky shores while shale, sandstone, ferricrete, some quantities of quartz and quartzite, and silcrete is present a few kilometres further inland (Sadr 2014).

The vegetation is dominated by Fynbos and Karroid types that include dwarf shrubs with succulent leaves and geophytes (Mucina & Rutherford 2006). Among other species, small bovids (steenbok and grysbok [Raphicerus sp.], grey duiker [*Sylvicapra grimmia*]), tortoises (*Chersina angulata*), a variety of small mammals (porcupine, [*Hystrix africaeaustralis*], dune mole rats [*Bathyergus suillus*], mongooses [e.g., *Herpestes pulverulentus*] and small to medium-sized felines [*Felis* sp.]) occur near the coast. In the past, other mammals were also common on the coastal hinterland of the Vredenburg Peninsula, such as rock hyraxes (*Procavia capensis*) and large grazing antelopes (e.g., eland [*Taurotragus oryx*], hartebeest [*Alcelaphus buselaphus*]) (Robertshaw 1979a; Skead 2011).

The west coast marine flora and fauna is among the most productive in Africa (Branch & Branch 2018). Locally, it is supported by an upwelling cell near Cape Columbine (Fig. 1; Shannon & Nelson 1996). Kelp forests (*Ecklonia maxima*) maintain a food web with a high biomass of shellfish and other invertebrates and gives sanctuary to small fish and crustaceans that are preyed on by various larger predators (Branch et al. 2022). Also abundant along these shores are a diversity of shorebirds, including cormorants (*Phalacrocorax* sp.), and the African penguin (*Speniscus demersus*), many fish species and marine mammals such as Cape fur seals (*Arctocephalus pusillus*) and cetaceans that occasionally strand along these and other west coast shores (Branch et al. 2022).

After the mid-Holocene 2-3 m sea level high stand between ca. 7500 and 5500 BP, only small fluctuations of about a metre took place during the late Holocene (Compton 2006). Climatically, three cool and wet neoglacial episodes happen ca. 4200 BP, ca. 3000-2500 cal. BP, and ca. 600-150 cal. BP (the latter is known as the Little Ice Age), which brought more precipitation to the west coast (Chase & Meadows 2007). Higher overall terrestrial productivity would have been the likely outcome as primary productivity would have been enhanced for most of their duration, although more detailed palaeoenvironmental records ought to verify this scenario. However, the opposite climatic conditions and environmental repercussions dominated during the warm and dry Medieval Warm Anomaly ca. 1300-650 cal. BP.

3. Location and excavations

FFM is located on the landward edge of Warrelklip and close to the old Paternoster fisheries factory (Fig. 1). Although no specific geographic coordinates have been reported for this site before, its proximity to the old fish factory (Robertshaw 1977) suggests an approximate location at 32°48’27.43” S, 17°53’2.01” E).

Excavations were carried out in September 1975 (Fig. 2; Robertshaw 1977, 1979a), but surface slumped material from squares A2 to A3 kept at Iziko South African Museum have a date of 14 August 1975 on their respective bags. Either this is an unintended error or preparatory work for the field season was done a month before. Unfortunately, we are not able to validate either possibility as field notes and other records could not be recovered. Six layers over six contiguous square metres were excavated to the underlying sterile sands (Fig. 2). The shell midden deposit in squares B1 to B3 did not extend over full squares, however, this was not the case for squares C1 to C3 (Fig. 2; Robertshaw 1977, 1979a). See SOM 1 Figures 1 and 2 for images of section drawings of squares B/C and C/D interfaces, respectively, with the names of stratigraphic units included.

Stratigraphic units were identified and labelled and were later grouped into six larger depositional entities or layers according to their contents, degree of shell fragmentation, matrix colour and radiocarbon dates (Fig. 2; SOM 1; Robertshaw 1977, 1979a). However, the names of stratigraphic units and how they are grouped into the six layers remained unreported until now (Table 1). Apparently also not mentioned before is that square B2 was excavated in 10 cm spits on the 20th of September 1975, from 0-10 cm to 50-60 cm, as revealed by the labelling of the respective bags housed in the Iziko South African Museum. Each of these six spits equate roughly with each of the consecutive six layers.

Four radiocarbon dates were obtained by Robertshaw (1977, 1979a: table 4:1): Layer 1 on charcoal (870±50 bp [Pta-1615] and 855±45 bp [Pta-1616]), Layer 5 on marine shell (3510±60 bp [Pta-1717]) and Layer 6 on tortoise bone (1000±70 bp [Pta-1637]) (Robertshaw 1977, 1979a: table 4:1). These radiocarbon dates, their calibrations and associated observations, are reported alongside the new Accelerator Mass Spectrometry (AMS) dates presented in the following section.

Robertshaw (1977, 1979a) undertook an array of quantitative and metrical analyses of the excavated material in collaboration with archaeozoologists (Avery 1977; Robertshaw 1977). He reported a large range of observations, including cultural remains (lithic and bone artefacts, ostrich eggshell beads and pottery), vertebrate fauna (bovids and other smaller mammals, fish, birds and their likely season of catch, and reptiles), Cape rock lobster mandibles and marine molluscs (Robertshaw 1977, 1979a). Because our interest is on the third millennium BP (see above), we provide additional data on both terrestrial and marine resource procurement by calculating their densities where these have not previously reported, and by undertaking a more detailed metric analysis of Cape rock lobsters.

4. Methods

Size observations of Cape rock lobster (*Jasus lalandii*) carapace were reported for the entire FFM assemblage (Robertshaw 1977: fig. 4, 1979a: table 4:7) and compared with data from other west coast middens (Robertshaw 1977, 1979a). In the absence of intrasite temporal analyses, the Cape rock lobster calcareous mandibles stored at the Iziko South African Museum were reanalysed. Whole and broken left and right calcareous mandibles were counted, Minimum Numbers of Individuals (MNI) established, percentages of whole mandibles calculated, and carapace sizes reconstructed for each layer using morphometric equations specific to left and right whole mandibles (Jerardino et al. 2001). The following linear model (carapace.length~layer+layer:mandible.side) was fitted to test for possible significant differences in lobster sizes between layers (Venables & Ripley 2002). Note that the last term in the model (layer:mandible.side) indicates that mandible side is nested within the factor layer. The model was fitted using the base function lm in the R statistical software (R Core Team 2019).

Table 1. Fisheries Factory Midden layers, stratigraphic units, characteristics and excavated volumes.

Layer	Stratigraphic units (this study)	Description of layers after Robertshaw (1977, 1979a)	Excavated volume (m^3) (this study)
1	Amstel, Amber (probably also 'HGBL1')	Visually dominated by black mussels	0.509
2	Beck's, Carling, Castle	Sandy deposit with many limpets	0.278
3	Farmer's, Frostie, Guinness	Limpet midden with greyish soil	0.564
4	Hansa	Highly compacted shell	0.365
5	Lion	Shell in blackish soil	0.366
6	Malt, Mild, Dune 'A', Dune 'B'	Shell in blackish to brown soil	0.675
Total excavated volume			**2.757**

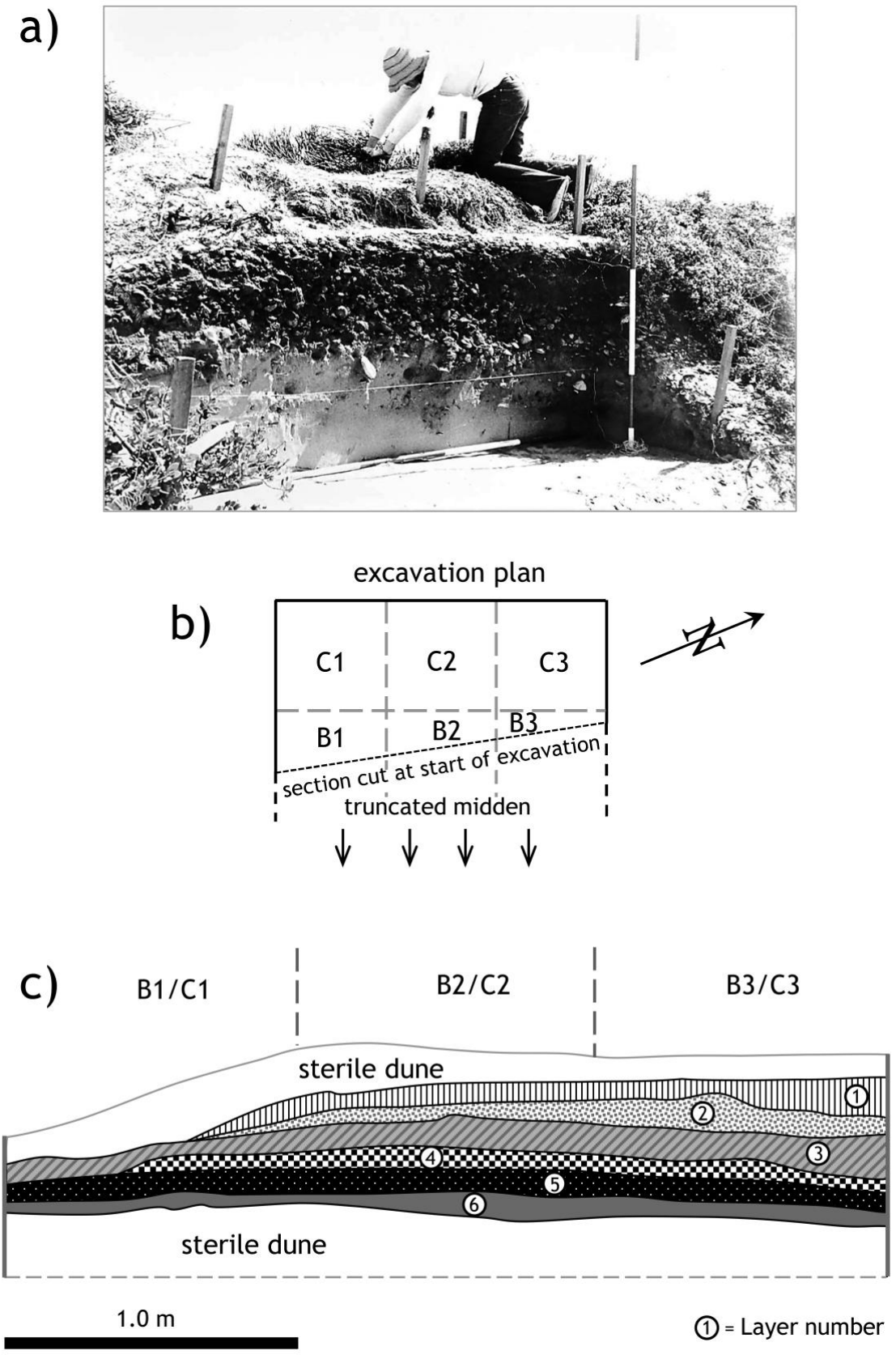

Figure 2. a) Previously unpublished photo of Fisheries Factory Midden excavation showing the exposed row of squares B1-B3 after cleaning amounts of eroded material (Robertshaw 1979a: plate 1); b) previously unpublished plan of excavation; c) drawing of B/C section after Robertshaw (1977: fig. 2, 1979a: fig. 4:3). See Figures 1 and 2 in SOM 1 for scans of this section and the C/D section drawing on graph paper.

Density measures are best suited for comparing faunal remains between layers with different volumes of deposit (e.g., Reynard et al. 2016; Jerardino et al. 2021 and references therein), particularly when deposition rates do not change significantly between them (Parkington 1988; Jerardino 2016). Unfortunately, density observations were only reported for Cape rock lobsters MNI and tortoise weights (Robertshaw 1977: table 6, 1979a: table 4:7). Obviously, volumes of excavated deposit for each layer are needed in order to calculate the densities of other faunal categories. Because excavated volumes per layer were not reported, these were retro-calculated from Cape rock lobster MNI and density data for each layer (Robertshaw 1977: table 6, 1979a: table 4:7). That is, excavated volumes for each layer were obtained by dividing the lobster MNI values by their associated density values (Robertshaw 1977: table 6, 1979a: table 4:7). Similar volume observations per excavated layer are obtained when the same exercise is done with tortoise weight densities (Robertshaw 1977: table 8, 1979a: table 4:9). Densities were then calculated for flaked lithics, fish (*Pachymetopon blochi*), coastal marine birds (penguins [*Spheniscus demersus*], Cape gannet [*Morus capensis*], cormorants [*Phalacrocoprax* sp.], black oystercatcher [*Haematopus moquini*], southern black-backed gull [*Larus dominicanus*], swift tern [*Sterna* cf. *bergii*], tern [a small, and an indeterminate large specimen]), and bovids (small to large) on the basis of MNI observations published previously (Avery 1977: table 1; Robertshaw 1977: table 7, 1979a: table 4:8).

It was not possible to locate FFM shell samples in the Iziko South African Museum where all other samples are stored, nor were they found at the University of Cape Town. This precluded their reanalysis and further radiocarbon dating. Consequently, small fragments of vertebrate fauna and charcoal found among the bone samples were selected for AMS dating. Calibrated dates are reported here as circa (ca.) single median values and sigma ranges.

5. Observations

Stratigraphy and dating

The names of stratigraphic units and their grouping into layers became apparent with the labelling of the bags and boxes containing excavated material and also with the documentation submitted for radiocarbon dating to the National Physical Research Laboratory in 1975. Table 1 lists the FFM's six layers, the names of their respective stratigraphic units, their distinguishing traits (Robertshaw 1977, 1979a), and excavated volumes. A total of ~2.8 m^3 was excavated over six square metres; but, because FFM's original surface area was never reported, it is not possible to determine what the proportion of the site was excavated. Stratigraphic changes are evident throughout this sequence, including:

- The presence of a highly compacted shell deposit that characterises Layer 4 (Table 1)
- The marked change from limpet-dominated shell lenses and relatively smaller *Scutellastra granularis* and *Cymbula granatina* limpets from Layers 6 to Layer 2, to a visually mussel-dominated deposit and larger limpet sizes in Layer 1 (Table 1; Fig. 3; Robertshaw 1977: tables 4 & 5, 1979a: table 4:5 & 4:6, fig. 4:5).
- The sandy deposit with shells in Layer 2 suggesting more sporadic visits to the site.
- The presence of greyish soil in Layer 3 perhaps reflecting a higher ash content.
- The darker soil colour of Layers 5 and 6 indicating a likely and important organic content (Table 1).

Table 2 reports previous and new radiocarbon dates for FFM, their calibrations and associated observations. The two earlier dates from the mussel-dominated Layer 1 (Robertshaw 1977, 1979a: table 4:1) gave the calibrated ages of ca. 635 and 625 cal BP. Unfortunately, not enough collagen was available in the bone sample from Layer 2 and this stratum remains undated. A new calibrated date of ca. 2760 cal. BP was obtained for Layer 3, and two other calibrated ages (ca. 3175 cal. BP and ca. 3265 cal. BP) are now available for Layer 4 (which is described as being shell-dense) (Table 2). The previous date on marine shell for Layer 5 has a calibrated date of ca. 3045 BP (Table 2; Robertshaw 1977, 1979a: table 4:1), showing a slight inversion relative to the dates from levels immediately above (Table 2). Layer 6 was also dated before (Robertshaw 1977, 1979a: table 4:1) and gave a calibrated date of ca. 745 BP. This inversion was interpreted as resulting from intrusive younger material in square C1 because "…the sample was taken from a point very close to the edge of the midden" (Fig. 2; Robertshaw 1977:

65, 1979a: 64). Despite our efforts to obtain bone samples from other squares to redate Layer 6, the faunal material recovered from them was too small for collagen preservation. Tortoise bones from other squares were also not selected as these also preserve inadequate collagen for radiocarbon dating. With no alternative but to use additional faunal remains from square C1, a bovid bone was dated to ca. 1420 cal. BP and a cormorant bone (*Phalacrocorax* sp.) yielded a date of ca. 1990 cal. BP (Table 2).

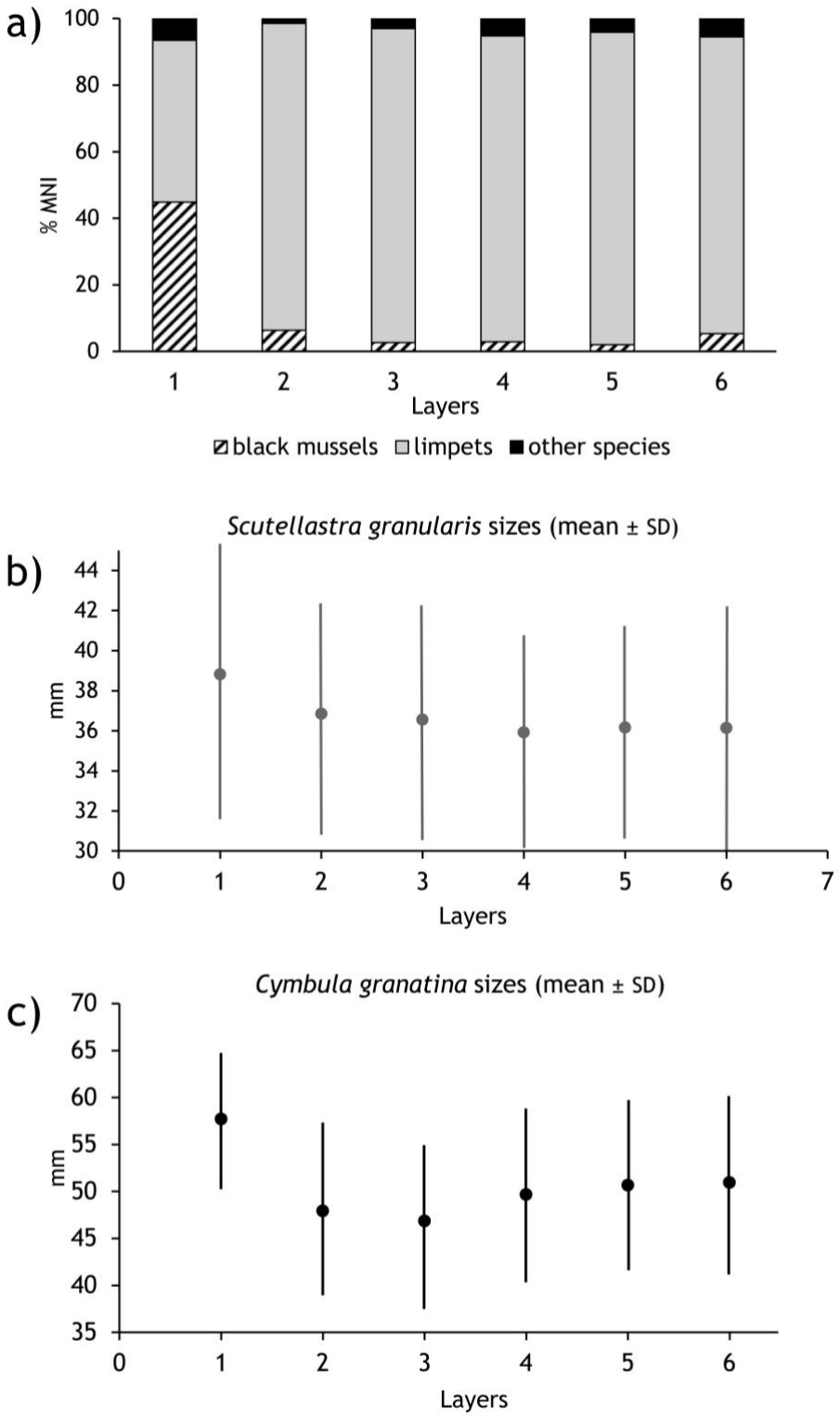

Figure 3. Observations on Fisheries Factory Midden marine molluscs per layer based on Robertshaw (1977: tables 4 & 5, 1979: tables 4:5 & 4:6); a) bar graph showing MNI-based percentages of mollusc taxa; b) mean sizes of granular limpet (*Scutellastra granularis*); c) mean sizes of granite limpet (*Cymbula granatina*). See text for mean size values.

Table 2. Radiocarbon dates obtained from the Fish Factory Midden (SU=stratigraphic unit, S=square; depths are approximate). Calibration for atmospheric variation in ^{14}C follows SHCal20 for the southern hemisphere (Hogg et al. 2020), and the marine shell date and marine bird bone are calculated with ΔR=146±85 ^{14}C years (Dewar et al. 2012) and Marine20 (Heaton et al. 2020). Radiocarbon dates were calibrated with Bronk Ramsey (2025) OxCal 4.4 software (version 176) and rounded to 5 years.

Layer	SU	S	Depth (mm)	Material	^{14}C (corrected for $\delta^{13}C$)	$\delta^{13}C$ ‰0	Cal. BP median	Cal. BP range (1σ)	Cal. BP range (2σ)	Lab Nr.	Reference
1	Amber	C3	30	Charcoal	870±50	-23.4	635	720-555	790-510	Pta-1615	Robertshaw (1977)
1	Beck's	C3	100	Charcoal	855±45	-23.5	625	680-550	765-505	Pta-1616	Robertshaw (1977)
2	Carling	C3	200	Bovid bone	Scant collagen	-	-	-	-	-	This study
3	Guiness	C3	300	Charcoal	2830±50	-26.7	2760	2915-2520	2995-2365	IT-C-5273	This study
4	Hansa	C3	320	Bovid bone	3030±50	-19.3	3175	3320-3070	3345-3000	IT-C-5420	This study
4	Hansa	C3	320	Bovid bone	3110±80	-19.5	3265	3375-3170	3450-3005	IT-C-5588	This study
5	Lion	C2	350	Marine shell	3510±60	+0.4	3045	3190-2885	3325-2760	Pta-1717	Robertshaw (1977)
6	Malt	C1	370	Tortoise bone	1000±70	-4.7	745	905-650	930-555	Pta-1637	Robertshaw (1977)
6	Malt	C1	370	Bovid bone	1700±70	-19.0	1420	1700-1425	1700-1175	IT-C-5589	This study
6	Malt	C1	370	Marine bird bone	2650±60	-15.1	1990	2135-1830	2295-1710	IT-C-5905	This study

Flaked lithics

Robertshaw (1977: table 1, 1979a: table 4:2) reported a range of flaked lithic artefacts on a variety of lithic raw materials, including quartz, quartzite, quartz porphyry, silcrete, shale, limestone, and granite. Although no numbers or percentages of raw materials are published or otherwise reported, quartz is identified as the most common raw material among formal tools and waste, while only a few silcrete artefacts were found (Robertshaw 1977, 1979a). Among formal tools, all 28 small scrapers and three backed pieces are made of quartz and only a single large scraper is made of silcrete (Robertshaw 1977). Table 3 and Figure 4a show the densities of flaked lithics based on their numbers throughout the FFM sequence. Lithic densities increase from Layer 6 to Layer 4 (the latter layer comprises highly compacted shell) and drop somewhat through Layer 3 and Layer 2. Lithic densities increase slightly again in Layer 1. Overall, the highest densities of flaked lithics are observed in Layer 4 (523.3/m^3) and Layer 3 (450.4/m^3).

Subsistence

All identified fish remains belong to the species *Pachymetopon blochi* (Robertshaw 1977: table 7; 1979a: table 4:8). Table 3 and Figure 4b report on the MNI densities of fish. Changes in marine coastal fish densities increase steadily from Layer 6 to the shell-dense Layer 4 where they reach their highest value (43.8 MNI/m^3). Thereafter, fish densities drop progressively, attaining lowest values in Layer 1.

Table 3. Densities of flaked lithics, fauna and Cape rock lobsters (*Jasus lalandii*) in Fisheries Factory Midden. The asterisk denotes an MNI=1 where no diagnostic countable bones but only fragments were reported by Robertshaw (1977: table 7, 1979a: table 4:8).

Layer	Volume (m^3)	Lithics (n/m^3)	Fish (MNI/m^3)	Cape rock lobsters (MNI/m^3)	Coastal birds (MNI/m^3)	Tortoises (kg/m^3)	Tortoises (MNI/m^3)	Bovids (MNI/m^3)
1	0.509	389.0	17.7	21.6	17.7	0.33	*2.0	11.8
2	0.278	334.5	21.6	100.6	50.4	1.11	18.0	3.6
3	0.564	450.4	28.4	232.3	42.6	1.45	14.2	5.3
4	0.365	523.3	43.8	194.3	27.4	2.99	41.1	8.2
5	0.366	393.4	27.3	128.4	38.3	5.45	54.6	16.4
6	0.675	371.9	22.2	69.6	13.3	2.38	14.8	1.5

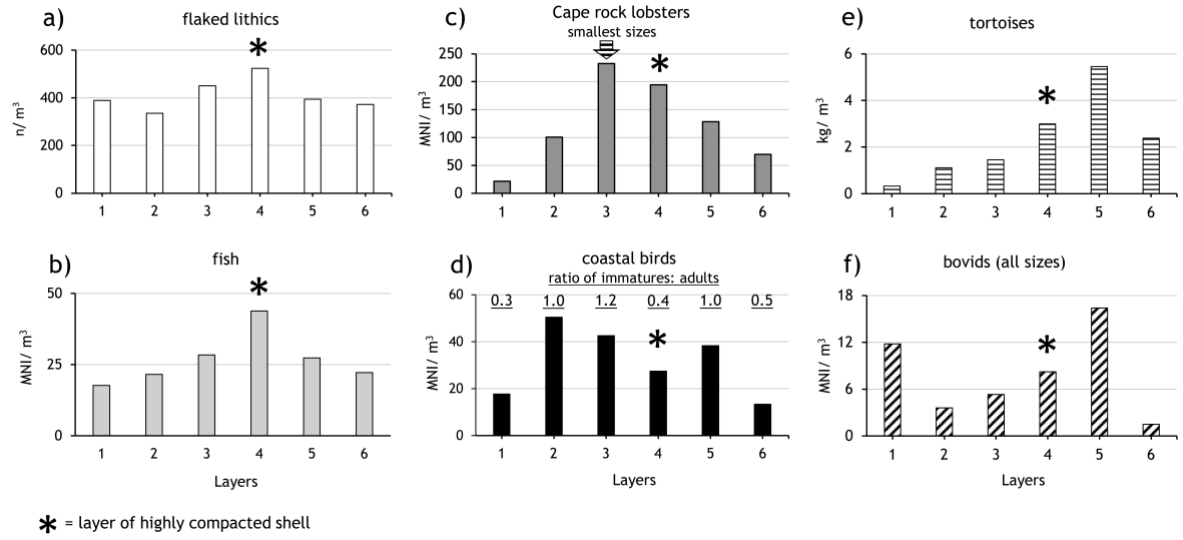

Figure 4. Densities of cultural and faunal remains and ratios from Fisheries Factory Midden: a) flaked lithics, b) sea bream fish (*Pachymetopon blochi*), c) Cape rock lobster (*Jasus lalandii*), d) various species of coastal birds and their ratio of immature to adult counts, e) tortoises, and f) bovids of all sizes.

Table 4 shows the Cape rock lobster carapace sizes based on measurements of left and right mandibles and the percentages of measurable (or percentage of whole mandibles for each layer). The percentage of measurable mandibles reflects the preservation of these subsistence remains. Only the size ranges are reported for Layer 1 due to its extremely small sample size of left and right mandibles (Table 4). Because of this, the other five layers are described in more detail. The sample sizes of lobster mandibles vary markedly among layers, with 30.4% (from a total of 364 left mandibles) and 35.7% (from a total of 372 right mandibles) found in Layer 3 (Table 4). The percentages of measurable left and right mandibles are highest (that is, proportionally more whole ones) in the shell-dense Layer 4 and Layer 3, suggesting relatively rapid burial (i.e., comparatively high accumulation rate) contributed to their increased preservation. The highly compacted shell deposit in Layer 4 also suggests the rapid vertical accumulation of shell.

Table 4. Statistical parameters of Cape rock lobster calcareous mandibles from Fisheries Factory Midden. Ranges are given for Layer 1 due to the small sample sizes.

Layer	Left mandibles				Right mandibles			
	n	% measurables	median	Carapace size (mm)	n	% measurables	median	Carapace size (mm)
1	4	-	-	77.7-111.1	9	-	-	74.6-106.4
2	41	39.0	87.2	90.4±20.3	32	46.9	79.4	80.8±17.8
3	111	47.7	74.6	80.0±20.8	133	55.6	67.9	74.6±18.2
4	66	65.2	77.8	90.7±25.5	73	61.6	70.9	79.7±21.0
5	41	58.5	94.7	97.0±26.2	62	48.4	82.7	87.5±21.9
6	52	38.5	81.9	83.7±20.8	37	56.8	67.3	74.8±20.8

Lobster mean carapace sizes reconstructed from left and right mandibles show the same trend through time despite some differences in the actual size values between them. The largest lobsters are observed in Layers 5 and 2 and the smallest ones are recorded in Layer 3 (Table 4). Despite the marked decrease in mean lobster size in Layer 3, no statistical differences were detected by the R statistical software linear model ($p<0.05$). MNI densities of lobsters for each layer based on Robertshaw data (1977: table 6, 1979a: table 4:7) are shown in Table 3 and Figure 4c. Their densities increase steadily from Layer 6 to Layer 3 where they not only reach their highest values (232.3 MNI/m^3) but also where the smallest mean sizes are recorded (Table 3). Thereafter, lobster densities drop sharply, with the lowest densities occurring in Layer 1 (0.33 MNI/m^3), and their mean sizes increase once again at the end of this sequence.

Although it was not possible to generate new observations on marine shells, we further explore the shell counts and limpet sizes reported by Robertshaw (1977: table 4, 1979a: table 4:5). Marine shells were sampled consistently throughout the FFM sequence by keeping all shell retained in the larger 12 mm sieve from every third bucket of excavated deposit and taking one shell sample from both the 12 mm and 3 mm sieves excavated from each stratigraphic unit and square (Robertshaw 1977, 1979a). Assuming this sampling strategy could enable a reconstruction of the overall quantities of discarded shells and give an approximate reflection of shell densities in each layer, the following observations are made: the highest numbers of identifications are recorded for the shell-dense Layer 4 (n=3286) and the succeeding Layer 3 (n=3159), with the two levels also showing comparatively high accumulation rates on the basis of higher preservation of whole lobster mandibles (see above). Identifications for Layer 5 yielded less counts but are within the same order of magnitude (n=2640). Much smaller numbers were reported for Layer 6 (n=899), Layer 2 (n=1354) and Layer 1 (n=1438) (Robertshaw 1977: table 4, 1979a: table 4:5). Against this background, the reported mean sizes of limpet species are examined here. *S. granularis* mean sizes are comparatively small in Layer 6 and 5 (36.14-36.16 mm), and are smallest in the shell-dense Layer 4 (35.92 mm) by a few millimetres, and they then increase gradually from Layer 3 to 1 (36.55-38.82 mm) (Fig. 3; Robertshaw 1977: table 5, 1979a: table 4:6). On the other hand, *C. granatina* mean sizes are similar overall in Layers 6 and 5 (50.94-50.67 mm), drop in Layer 4 (49.68 mm) and Layer 3 (46.85 mm), and then increase gradually in Layers 2 and 1 (47.91-57.71 mm) (Fig. 3; Robertshaw 1977: table 5, 1979a: table 4:6). It is evident that the smallest mean sizes of the two limpet species correlate chrono-stratigraphically with the highest counts and, possibly, highest shell densities. Heavy resource extraction from human pressure on the FFM resources is likely during a few centuries from ca. 3265-3175 cal. BP to ca. 2760 cal. BP. However, it is not yet possible to confirm this because neither the written entries of shell measurements nor FFM's shell samples are currently available for quantitative verification and statistical testing.

Table 3 and Figure 4d display the MNI densities of coastal birds by layer. Bird densities rise steeply from Layer 6 to Layer 5, only to drop somewhat in shell-dense Layer 4, followed by two substantial increases in Layers 3 and 2 where the highest values are achieved (39.0 MNI/m^3 and 43.2 MNI/m^3, respectively). Thereafter, bird densities decrease sharply in Layer 1 (Fig. 4d). Based on reported bird numbers (Avery 1977: table 1; Robertshaw 1977: table 7, 1979a: table 4:8), the highest ratios of immature birds versus adults are observed in Layers 5 (1.0), 3 (1.2) and 2 (1.0). The ratio of 1.0 means parity in the numbers of adults and chicks and values above 1.0 indicate larger numbers of the latter. The incidence of immature coastal birds at FFM also presents seasonal information because of their regular annual breeding and fledging seasons (Avery 1977). According to Avery (1977), the time when different species of chicks were accessed, particularly cormorants, "…could be confined to the latter part of summer between December and March or April" (Avery 1977: 74-76, fig. 1). In sum, the largest quantities of coastal birds are recorded in Layers 3 and 2, a high proportion of which were sized as immature birds that are typically available sometime between the months of December and April.

Table 3 and Figure 4e show the weight densities of tortoises for each layer as calculated by Robertshaw (1977: table 8, 1979a: table 4:9). A sharp increase in their densities is observed from Layer 6 to 5 where the highest values are recorded (5.45 kg/m^3). Thereafter, densities drop markedly and progressively, reaching the lowest values in Layer 1 (0.33 kg/m^3). The same changes are observed when tortoise MNI densities are compared among the layers (Table 3). Robertshaw (1977, 1979a) also argued for a summer season of occupation between Layers 6 and 2 arguing that these animals hibernate during winter. However, angulate tortoises conserve energy during winter by hiding away and moving less in the open, thus becoming less visible during this season (Kogelberg Biosphere Reserve Company 2026).

The MNI densities of small to large bovids by layer are reflected in Table 3 and Figure 4f. Striking changes also manifest with this faunal category. Bovid densities rise steeply from Layer 6 to Layer 5 where the highest values are observed (16.4 MNI/m^3). Subsequently, densities drop sharply from Layer 4 to Layer 2, then rise abruptly again and achieve the second highest densities in Layer 1 (11.8 MNI/m^3). Faunal observations show that bovids of all sizes (steenbok/grysbok [*Raphycerus* sp.], grey duiker [*Sylvicapra grimmia*], eland [*Taurotragus oryx*], and other bovids of the size of a possible hartebeest [*Alcelaphus buselaphus*]) are present in Layers 5 and 1 where the highest densities are observed, while

only small to small-medium bovids (steenbok and grey duiker) are present in strata where densities are lowest, namely Layers 6, and 4 to 3 (Robertshaw 1977: table 7, 1979a: table 4:8).

6. Discussion

Chronology and settlement

The three dates obtained from Layer 6 are markedly younger by many centuries relative to the dates from the overlying strata (Table 2), and they are also inconsistent with one another, both of which needs to be explained. The first observation is that the date obtained by Robertshaw (1977) has a $\delta^{13}C$ value of -4.7‰ (this has been checked from the original laboratory analyses) which is incongruous with tortoise bone. Bone is always a difficult material to date because of the possibility of collagen degradation, and the untenable $\delta^{13}C$ value is either indicative of a mislabelled sample, or poor collagen preservation. The poor collagen preservation from bone in Layer 2 also indicates that preservation is problematic at this site, and bone dating is only possible for large fragments of cortical bone that are more likely to preserve collagen. The calibrations of the other Layer 6 dates do not overlap at the 2σ level, and must be considered as asynchronous. These samples were obtained from square C1 where the deposit is shallower close to the midden's edge (Fig. 2). It is also likely that they are affected by animal burrowing, which is noted in the original section drawings by Robertshaw (see Figure 2 in SOM 1). Although these samples are unlikely in their original context, the analyses still reflect the age of the source material. Both samples have 2σ calibration ranges that are younger than Layer 3 and older than Layer 1, and the fact that they were obtained from single bone fragments suggests that coastal groups did visit this site ca. 1420 cal. BP and ca. 1990 cal. BP. Whether the Layer 6 dates derive from intrusive material, from Layer 2, is difficult to say without re-dating Layer 2. However, the similarity in the percentages of shellfish species and mean sizes of limpet species between Layer 2 and those from Layers 3 to 5 (Fig. 3; Robertshaw 1977: tables 4 & 5, 1979a: tables 4:5 & 4:6, fig. 4:5) suggests that the actual calibrated age of Layer 2 is probably closer to that of Layer 3 dated to ca. 2760 cal. BP than to Layer 1 dated to ca. 635-625 cal. BP. Hence, the ca. 1420 cal. BP and ca. 1990 cal. BP material must either derive from Layer 1 or from another yet unidentified stratigraphic entity.

All the other radiocarbon dates were obtained from samples retrieved from squares C2 and C3 (Table 2) and seriate with depth, except for a slight inversion in Layer 5 (Table 2). Minor inversions of marine dates like this have been observed before for other west coast sites (Jerardino & Orton 2023; Jerardino et al. 2026) and are probably the outcome of an older reservoir effect (ΔR value) than the one used for calibrating the Layer 5 date. ΔR values over time can diverge considerably (362±59 to 112±144 ^{14}C years) from the calculated mean of 146±85 ^{14}C years applied to calibrate this shell date (Dewar et al. 2012). Considering that the 2-sigma ranges (2σ) of Layer 4 and 5 overlap substantially (Table 2), the real age of Layer 5 is probably only slightly older than that of Layer 4 dated to ca. 3175 cal. BP and ca. 3265 cal. BP.

Comparing the FFM ages with those of two other radiocarbon-dated Paternoster middens adds more chronological evidence for the use of the local landscape (Jerardino et al. 2024, 2026). The Layer 3 2σ range (Table 2: 2995-2365 cal. BP) overlaps significantly with that of unit AC from PN1062 (Fig. 1; Jerardino et al. 2024: table 1, 3150-2490 cal. BP). Also, the pair of 2σ ranges of Layer 4 (Table 2: ca. 3345-3000 cal. BP and ca. 3450-3005 cal. BP) overlap to a large degree with unit AM of PN1062 (Jerardino et al. 2024: table 1, ca. 3325-2780 cal. BP). Comparisons with Paternoster North midden (Fig. 1; PNNA & PNNB sampling locations) show some common chronologies. FFM's Layer 3 overlaps to an extent at the 2σ level with stratigraphic unit CS2 in PNNA (Jerardino et al. 2026: table 1, 3140-2765 cal. BP), and the pair of 2σ ranges of FFM's Layer 4 are closely contemporary with the oldest 2σ range from PNNB (Jerardino et al. 2026: table 1, 3480-2930 cal. BP).

Flaked stone artefacts

Densities of flaked lithics are of the same order of magnitude (several hundreds of lithics per cubic metre) throughout the FFM sequence. Nonetheless, lithic densities in Layers 4 (ca. 3265-3175 cal. BP) and 3 (ca. 2760 cal. BP) are, respectively, at least 24.8% and 12.7% higher than those from older and younger layers. Hence, the production of stone artefacts was emphasised during the accumulation of both these layers dating from ca. 3265 cal. BP to ca. 2760 cal. BP and at a time of fastest accumulation

rates as indicated by the highest preservation of whole lobster mandibles (see above).

Some similarities and differences can be observed in the lithic assemblages of FFM and PN1062. It is important to note that the volume excavated from FFM (~2.8 m^3) is double that sampled from PN1062 (1.31 m^3), which is retro-calculated by dividing all stone artefacts counts, including those of ochre and manuports, from all contexts (n=129) by their reported average density of ~98/m^3 (Yates 1998: table 5). PN1062 flaked lithics are heavily dominated by raw materials that are accessible along the coastline, such as quartz (75.0%), quartzite (19.7%), and granite (4.2%), while silcrete rocks present as outcrops in the interior of the Vredenburg Peninsula and cobbles at the Berg River mouth make only 1% (Fig. 1; Sadr 2009, 2014; Jerardino 2013). Among the four main categories of formal tools recovered from FFM (Robertshaw 1977: table 1, 1979a: table 4:2), none are present in PN1062 sample (Yates 1998: table 5; Jerardino et al. 2024); yet a few Miscellaneous Retouched Pieces (classified by Robertshaw as 'Other Retouched Tools') are present in both assemblages. It is thus possible that the lack of formal tools at PN1062 could be explained by its small excavated volume and perhaps an unaccounted variability in the spatial distribution of lithics within the midden.

Although no volume or density observations are available, the volumes excavated from Paternoster North are certainly larger than FFM and PN1062 because of the much deeper deposits there. Quartz (77.3-94.8%) also dominates heavily in Paternoster North, while quartzite is in variable quantities (3.1-15%) and silcrete is rare (1.0-2.4%) (Jerardino et al. 2026: tables 2 & 3). The two to four formal tool categories from this site are similar to those observed from FFM, and the choice of raw materials for their manufacture at these two sites are also alike. This is particularly the case for quartz backed pieces. Adzes, on the other hand, were only recovered from Paternoster North and were made on silcrete and quartz porphyry (Jerardino et al. 2026).

The heavy quartz dominance in the lithic assemblages of FFM, PN1060 and Paternoster North is in stark contrast with that of Witklip rock shelter, a site 9 km inland and in the central area of the Vredenburg Peninsula (Fig. 1; Smith et al. 1991). The stratigraphic level 'Pale Brown Sand' from Witklip with a median age of ca. 3215 cal. BP and a 2σ range=3370-3000 cal. BP (see uncalibrated date in Smith et al. 1991) is contemporary with Layer 4 from FFM (Table 2) and the oldest PNNB date (Jerardino et al. 2026: table 1; see above). Although most of these sites share similar categories of formal tools, the percentage of silcrete at Witklip (28.2%) is comparatively very high (Smith et al. 1991: table 1). This is probably because silcrete is accessible in the coastal hinterland of the Vredenburg Peninsula (see above) in the vicinity of Witklip. Unfortunately, no other dated observations for sites with a similar inland location are available for further comparisons.

Overall, quartz and other readily available coastal rocks such as quartzite and quartz porphyry were most regularly used at Paternoster. Silcrete was used much less but was selected for the production of a few formal tools. The quantities and range of formal tool types at Paternoster sites seem to vary with the volume of material excavated. The striking differences in silcrete utilisation between Paternoster sites and Witklip rock shelter around 3200 cal. BP may suggest separate areas of landscape use. This hypothetical scenario ought to be tested further as observations from other similarly dated sites from both the coast and the coastal hinterland become available.

Coastal and terrestrial resource procurement

The range of invertebrate and vertebrate taxa from FFM (Robertshaw 1977: tables 3-7, 1979a: tables 4:4-4:8) is similar to that of PN1062 and Paternoster North (Jerardino et al. 2024, 2026) and compares well to that of animal species procured elsewhere on the South African west coast (e.g., Parkington et al. 1988; Smith 2006; Dewar 2008; Jerardino et al. 2013).

Cape rock lobster data do suggest a decrease in their mean sizes in Layer 3 (Table 4); however, the fact that the observed changes were not statistically significant is likely to be the result of the effect of small sample sizes (Venables & Ripley 2002). This is exemplified by the differences observed in the reconstructed lobster sizes between left and right mandibles (Table 4). It is thus likely that statistically significant changes in lobster sizes would have been observed had the sample sizes been larger.

Limpets grow optimally within the many protected small bays along the extended Vredenburg Peninsula rocky shores and under similar conditions elsewhere on the South African west coast (see Branch et al. 2022). Their dominance in Paternoster megamiddens and FFM before ca. 2000 cal. BP is not limited to these sites in the Vredenburg Peninsula (Jerardino et al. 2024, 2026). They make about half or more of the shell assemblages of Kasteelberg, Witklip, Duiker Eiland, Stofbergsfontein and other local sites of more recent age (Fig. 1; Robertshaw 1978, 1979a, b; Smith et al. 1991; Smith 2006). Hence, sea surface temperatures or sea levels are unlikely to explain their dominance at FFM before ca. 2000 cal. BP and the black mussel dominance thereafter. The latter change may relate to particular choices when the hunting of large prey and terrestrial resources also contributed significantly to peoples' diet (Fig. 4f). As additional Paternoster sites of different ages are studied, the variability in local mollusc assemblages ought to be understood better.

The faunal changes from Layer 5 to Layer 2 (Fig. 4) happened during the second neoglacial episode. Numbers of large terrestrial prey (e.g., medium and large bovids) are expected to have thrived due to higher moisture levels during this period, but their densities are smallest from Layer 4 to Layer 2. Hence, the observed stepped changes in the emphasis with which terrestrial and marine preys were procured from Layer 5 to Layer 2 are likely to be unrelated to palaeoenvironmental causes. Also, the shift from Layer 5, with a mix of large bovids most likely hunted in the interior of the Vredenburg Peninsula and small bovids with a ubiquitous presence (*Raphicerus* sp. and *S. grimmia*), to Layers 4-2 with only small bovids (Fig. 4; Robertshaw 1977, 1979a) is also unlikely to be the outcome of palaeoenvironmental variability for the same reasons. Rather, this shift is more likely to relate to an initial large bovid procurement across comparatively wider hunting territories immediately before ca. 3265 cal. BP to an overall reduced mobility and procurement of smaller terrestrial prey along the coast and adjacent coastal plain from ca. 3265–3175 cal BP to immediately after ca. 2760 cal BP. Rising human population densities, as suggested by an increased occupation intensity of Paternoster from just before ca. 3265 cal. BP until ca. 2760 cal. BP and the possible formation of different landscape domains as signalled by drastically different lithic raw materials between the Witklip site and Paternoster middens, may explain reduced mobility at and near the coast, and a reliance on predictable resources such as abundant molluscs and small bovids. An analogous and slightly later scenario has been suggested for the central west coast (Jerardino 2010, 2013). It is also important to note that hunting large grazing bovids from Paternoster North and PN1062 happened a few centuries after ca. 3265 cal. BP when the occupation intensity peaked at both sites between ca. 3020-2820 cal. BP (Jerardino et al. 2024, 2026). Whether these differences with FFM could be explained in terms of: i) suboptimal faunal sampling, ii) deficient chronological resolutions, iii) contrasting seasons of occupation, and/or iv) differing aggregation/dispersal phases at any of the three Paternoster sites discussed here, may be possible to elucidate with further data from a site near FFM and other sampling locations within Paternoster North (Fig.1; see Halkett 1996; Yates 2004a). A return to a mix of small and large bovids in Layer 1 in the context of a herder period during the onset of the third neoglacial episode could be a response to a favourable climate and/or to a reformulation of terrestrial prey procurement by groups following different economic strategies.

Density of subsistence remains reflect a mix of terrestrial and marine prey procured during the accumulation of Layer 6 (Fig. 4). Thereafter, all prey densities increase from Layer 6 to Layer 5 in varying degrees, with tortoise and bovid densities doing so markedly (Fig. 2). This change could correspond to an initial increase in FFM occupation intensity supported also by an increase in marine shell counts (see above). Later, densities of marine resources (fish, lobsters and coastal birds) increase further from Layers 4 to 2 and show different and successive peaks in this sequence. Fish densities peak first in the shell-dense Layer 4 dated to ca. 3265-3175 cal. BP. While lobster densities are second highest in this level, they peak in Layer 3 dated to ca. 2760 cal. BP. Densities of coastal birds decrease somewhat in Layer 4, and they increase to their second highest values in Layer 3 while reaching their maximum values in Layer 2. It is important to note that the procurement of coastal birds able to fly (mostly cormorants) may well have required the use of nets and/or bows and arrows rather than clubs or bare hands that were used to seize penguins (Manhire et al. 1985; Avery 1987). In PN1062, quantities of birds also seem to increase from ca. 3025 cal. BP to the last occupation soon after ca. 2820 cal. BP (Jerardino et al. 2024: tables 1 & 2, see also text); however, a comparison with Paternoster North is

precluded by its small amounts of bird bone (Jerardino et al. 2026). Following a few centuries-long occupational hiatus in FFM soon after ca. 2760 cal. BP, a range of both marine and terrestrial prey, with an apparent emphasis on the latter, were procured at the end of this sequence ca. 635-625 cal. BP.

This trajectory of prey procurement matches other observations (Table 3, Figs 3 & 4). Highest densities and smallest mean sizes of lobsters happen together in Layer 3 (ca. 2760 cal. BP) and co-occur with the smallest *C. granatina* mean sizes and second highest counts of shells (Tables 2 & 3, Figs 3 & 4c; Robertshaw 1977: table 4 & 5, 1979a: tables 4:5 & 4:6). While the statistical test did not find significant differences in lobster sizes between layers, and bearing in mind their small samples, it is reasonable to suggest that large lobsters may have been overharvested ca. 2760 cal. BP. Moreover, second highest bird densities are also recorded ca. 2760 cal. BP (Layer 3) when immature individuals make up more than half of the sample; thereafter, densities increase further in Layer 2 and half of the birds are chicks (Fig. 4d; Avery 1977).

7. Conclusions

Shell middens provide a reliable source of dating material in the form of abundant marine shells. This is most convenient notwithstanding the need to correct for the apparent age of sea water. When marine shell is not available, then other organic remains could be dated such as animal bones. However, limited preservation of collagen can hinder its use for this purpose. Moreover, animal burrowing and other possible disturbances can seriously hamper efforts in establishing consistent chrono-stratigraphic sequences, as exemplified by FFM. Obtaining multiple radiocarbon dates ought to help in this regard.

The FFM chronology spans at least three millennia, from probably a few centuries before ca. 3265-3175 cal. BP (Layer 6) to ca. 625-635 cal. BP (Layer 1). However, the bulk of this midden is made of Layers 5 to 2 dated, respectively, to immediately before ca. 3265-3175 cal. BP and soon after ca. 2760 cal. BP. Layer 1 may include older material as a result of animal burrows that may account for the inverted dates in Layer 6 (Table 2: ca. 1420 cal. BP and ca. 1990 cal. BP); however, this is not possible to ascertain without further dating of samples from Layer 1.

The earliest visits to FFM (Layer 6) a few centuries before ca. 3265 cal. BP (Table 2) appear to have been occasional on account of generally low densities of marine and terrestrial fauna and the lowest preservation of whole lobster mandibles (Table 4, Fig. 4). The occupational intensity increased somewhat in Layer 5 immediately before ca. 3265 cal. BP as reflected by a variable upturn in the densities of both marine and terrestrial remains, with bovids of all sizes and tortoises contributing significantly to the subsistence base (Fig. 4). Soon thereafter, the occupational intensity reached the highest levels between ca. 3265-3175 cal. BP and ca. 2760 cal. BP (Layers 4 & 3) at a time when the production of lithic artefacts was highest, marine resources (fish, lobsters and coastal birds) became heavily exploited and only few small bovids were procured (Tables 1 & 4; Fig. 4). It is broadly during this time when groups of people also occupied PN1062 and Paternoster North, making the 1.3 km long coastal strip from Warrelklip to Eerste Mosselbank (Fig. 1: Klein Paternosterbaai) a focus of settlement. Group mobility appears largely limited to the coastal margin and immediate plain during this time as suggested by i) the small quantities of silcrete in all three of these sites and as hinted by ii) the apparent secession of hunting large grazers from the interior of the Vredenburg Peninsula and iii) a preference for small bovids with a ubiquitous distribution. The increase in occupation intensity from before ca. 3265 cal. BP until ca. 2760 cal. BP is likely to reflect steadily rising human population densities in Paternoster. Therefore, it is thus not surprising that lobsters and two species of limpets were probably overharvested from ca. 3265-3175 cal. BP to ca. 2760 cal. BP. It is precisely during this period when the exploitation of flying coastal birds intensified and increased to include chicks, mostly cormorants, that were easily accessible in late summer. The procurement of both adults and immature coastal birds increased further soon after ca. 2760 cal. BP (Layer 2); however, it is likely that visits overall became more sporadic by then as densities of all other faunal categories decreased and wind-blown sand made a greater contribution to the matrix of Layer 2 (Table 1, Fig. 4). After a centuries-long hiatus when a new socio-economic and cultural context dominated the west coast and southern Africa as a whole, the same range of marine and terrestrial resources contributed to people's diet, although the procurement of bovids of all sizes was strongly emphasised again.

Subsistence changes at FFM reflect a progressive decline in the foraging efficiency of terrestrial resources from hunting large and small bovids to focus on small bovids while the exploitation of marine coastal resources increases dramatically to include birds and fish in addition to shellfish. Although this sharp increase in the exploitation of marine resources could be understood as the widening of people's diet breath, it is important to note that this was to some extent possible by investing time and energy in the production and maintenance of technology that would have assisted the capture of flying coastal birds. Data also show that the reduction in bovid foraging efficiency is also common in central west coast sites a few centuries before ca. 3000 cal. BP (Jerardino 2010, 2012; Jerardino et al. 2021). While the overall diet breadth appears to have expanded at all Paternoster sites considered here from ca. 3265-3175 cal. BP to ca. 2760 cal. BP, it actually narrowed on the central west coast after ca. 2785-2550 cal. BP (Jerardino 2010, 2012; Jerardino et al. 2021). No later observations are available for Paternoster that might indicate whether this expanding diet breadth continues after ca. 2760 cal. BP. Dating and studying the faunal assemblages from other sampled areas near FFM and additional samples from Paternoster North (Halkett 1996; Yates 2004a) ought to increase our observations on the timing and direction of these changes. Hopefully, these studies could also expand our knowledge on the seasonal signatures near FFM and Paternoster North. Efforts in this direction are currently underway.

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Supporting online material
Jerardino et al. Supplementary Online Material File 1

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