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Cape Rock Lobster (*Jasus lalandii*) Remains from South African West Coast Shell Middens: Preservational Factors and Possible Bias

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Cape rock lobster (*Jasus lalandii*) remains in South African west coast shell middens are represented by calcareous mandibles, and by fragments of exoskeleton when preservation is good. Quantification of MNIs and observations on ody size of Cape rock lobsters have been based on counts and measurements on the surviving mandibles. Little is known of the importance of this resource in precolonial hunter-gatherer subsistence, and even less is known about the possible preservational bias affecting the recovery of representative quantitative data from Cape rock lobster mandibles. The latter problem is crucial to resolve in order to understand issues about coastal hunter-gatherer subsistence. Left and right mandibles are not exact mirror images of each other, with left mandibles being consistently larger and thicker than the right mandibles. Moreover, small mandibles measuring between 4·5 and 7·5 mm are much thinner and delicate than large specimens. Due to their small size, however, small mandibles can escape attrition by falling within protective spaces, such as those created under large whole shells. In order to ascertain whether or not left mandibles survive in larger number than right ones, and whether or not smaller mandibles (left and right) break more frequently than larger ones, we conducted basic statistical procedures with quantitative data (frequency and mean size of mandibles) from a variety of depositional contexts. The results show that left and right mandibles break with the same frequency, and that breakage does not bias measurements of mandibles towards the larger or smaller end of the size range. Similar studies will need to be conducted when recovering Cape rock lobster mandibles from depositional contexts different to the ones encountered in the study area.

Keywords: SHELL MIDDENS, COASTAL SUBSISTENCE, CAPE ROCK LOBSTER, CALCAREOUS MANDIBLES, EXOSKELETON, PRESERVATIONAL FACTORS, TAPHONOMY, SOUTH AFRICA.

Introduction

The study of crustacean remains in archaeological sites world-wide has received little attention despite massive research efforts undertaken along coastlines and freshwater systems over the last 40 years (Waselkov, 1987; Bailey & Parkington, 1988; Marquardt, 1992; Trigger, 1992; Erlandson, 1994, 2001; Claassen, 1998). Studies have shown that crustaceans (barnacles, fresh water and marine crabs, lobsters and shrimps) were a resource of variable importance for aboriginal people in different parts of the world during the precolonial past (Leach & Anderson, 1979; Adams, 1985; deFrance, 1989; Jerardino *et al*., 1992; Jerardino, 1995, 1996; Báez, 2000). In geographic areas where the contribution of crustaceans to people's diet was significant, the exploitation of these taxa appear to have undergone marked changes through time (Leach & Anderson, 1979; de France, 1989; Jerardino, 1995, 1996). In other parts of the world, the presence and importance of crustaceans in aboriginal subsistence still needs to be investigated or re-assessed with the aid of improved recovery methods (Walker, pers. comm.; Quitmyer, 1985: 87). This undertaking is important, because it is not clear whether the scarcity or absence of crustaceans in the archaeological record is the result of their inaccessibility and/or avoidance by aboriginal people, or the outcome of sampling bias.

Coastal hunter-gatherers along the west coast of South Africa exploited at least two species of crustaceans among a dozen other invertebrate species. One species is the large subtidal barnacle *Austromegabalanus cylindricus*. Unlike non-sessile crustaceans, the

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presence of this barnacle in archaeological deposits is easy to detect by virtue of the large calcareous plates, terga and scuta. *A. cylindricus* was probably transported to campsites attached to black mussels (*Choromytilus meridionalis*) and limpet species (*Patella barbara* and *P. argenvillei*), both of which were collected from the low intertidal rocky shores (Parkington *et al*., 1988; Yates, 1989; Jerardino, 1995). The other species of crustacean found in South African west coast shell middens is the Cape rock lobster (*Jasus lalandii*), a species that lives at depths of between 1–45 m (Heydorn, 1969). The calcareous mandibles of Cape rock lobsters preserve relatively well in many west coast shell middens (Grindley, 1967; Robertshaw, 1977, 1979; Jerardino, Navarro & Nilssen, 2001), and fragments of exoskeleton are frequently detected in deposits where preservation is good (Parkington, 1992, in prep.; Jerardino, 1996). Small mandibles are also recovered when fine screens are used to sieve the material, and when care is taken with the sorting of excavated material. As with other faunal remains, in order to gain a meaningful insight into the role of Cape rock lobsters in precolonial subsistence, it is not only important to improve the recovery methods. It is also vital to reach some understanding of the possible bias inherent in the observed archaeological record of this species.

Taphonomic studies designed to factor out preservational biases in vertebrate remains are abundant in the archaeological literature of the last 25 years (see Lyman, 1994). Related studies on invertebrate remains are mostly found in the palaeontological literature, much of which pertains to natural accumulations of shells in marine settings (Briggs & Crowther, 1990; Martin, 1999). Taphonomic perspectives on dry shell exposures in archaeological contexts have begun only in the last decade and a half (Stein, 1992; Claassen, 1999), and those on crustaceans are rare and basic when present in the palaeontological and archaeological literature (Lambers & Boekschoten, 1986; Báez, 2000). While the differential preservation of mandibles and exoskeleton of Cape rock lobsters is evident to excavators and analysts, little is known of possible bias in the preservation of the mandibles themselves.

The Problem

Early preliminary work and recent morphometric studies on fresh Cape rock lobsters established a tight correlation between measurements obtained from either left or right mandibles and animal body size represented by the length of the animal's carapace (Grindley, 1967; Jerardino, Navarro & Nilssen, 2001). Thus, metrical observations on body size of harvested Cape rock lobsters during precolonial times have been based on measurements of the surviving calcareous mandibles (e.g., Grindley, 1967; Robertshaw, 1977, 1979; Noli, 1988). These morphometric studies showed

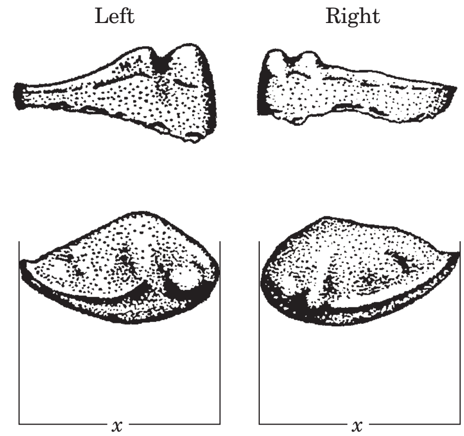

Figure 1. Left and right mandibles of Cape rock lobster (*Jasus lalandii*) showing standard measurements of their size (reproduced with permission from the *South African Journal of Science* 2001, vol. 97: 59–62).

also that left and right mandibles are not exact mirror images of each other (Figure 1); left mandibles are consistently larger irrespective of sex and overall body size. Mandibles measured from male animals show a mean difference of 0·99 mm and those of females show a mean difference of 0·63 mm; both these differences are statistically significant (Jerardino, Navarro & Nilssen, 2001). Along with this difference in size, the calcareous walls of left mandibles are thicker than those of right mandibles. Consequently, left mandibles can be expected to survive destructive processes better than right mandibles.

While conducting this morphometric study, it was also found that small mandibles (4·5–7·5 mm) are much thinner and more delicate than larger mandibles. This assessment, however, was not quantified. Being structurally weaker, small mandibles might be more prone to breakage than larger ones. On the other hand, small mandibles can avoid mechanical stress by falling within protective spaces (e.g. under a large limpet or mussel shell), which are often present within unconsolidated shell matrices (A.J., personal observation). Larger mandibles might also be subject to differential compressive forces than smaller ones. Consequently, small Cape rock lobster mandibles in shell bearing sites might actually break less often than large mandibles.

The above considerations pose some important questions: First, do right mandibles of Cape rock lobsters break more often than left mandibles during the formation of shell middens along the west coast (or vice versa), and, therefore, should the analyst's efforts in obtaining metrical data be concentrated in one type of mandible only? Second, do small mandibles (or larger ones) break more often during the accumulation of archaeological debris, and consequently, are the observed measurements on mandibles biased towards the larger or smaller end of the size range?

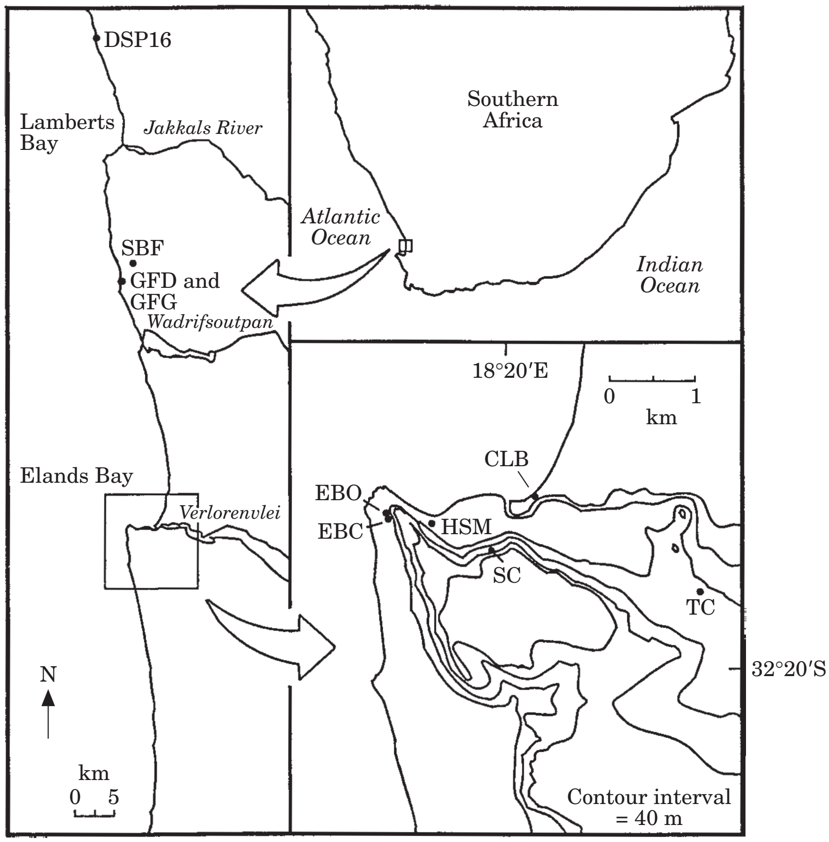

Figure 2. Map of the study area, showing sites mentioned in text. DSP16, Doorspring 16; SBF, Steenbokfontein Cave; GFD, Grootrif D; GFG, Grootrif G; EBC, Elands Bay Cave; EBO, Elands Bay Open; HSM, Hailstone Midden; CLB, Connie's Limpet Bar; SC, Spring Cave; TC, Tortoise Cave.

One way to answer this question is to conduct mechanical tests designed to measure the structural resistance of Cape rock lobster mandibles. Alternatively, and until these experiments are carried out, the archaeological record can provide the necessary data to answer the above questions through observations of the frequency of broken mandibles recovered from a variety of depositional contexts. The objective of this paper is to undertake such a study with observations collected from several archaeological shell middens (Figure 2). In doing so, basic statistical procedures are employed.

The Archaeological Record

Ongoing archaeological excavations in the Lamberts Bay and Elands Bay areas (hereafter referred to as "the study area") have generated a large quantity of diverse faunal observations (Horwitz, 1979; Klein & Cruz-Uribe, 1987; Parkington *et al.*, 1988; Parkington, 1992; Cruz-Uribe & Klein, 1994; Jerardino, 1995, 1996, 1997; Jerardino & Yates, 1996), including those of Cape rock lobster remains. These remains consist mainly of whole and broken mandibles, and are present in variable quantities in most of the nearly 20 excavated or sampled sites. Until recently, quantification of Minimum Number of Individuals (MNIs) and metrical observations on Cape rock lobster mandibles were available for only two sites, both in the Elands Bay area (Noli, 1988; Parkington, 1992). Systematic quantification and measurement of Cape rock lobster mandibles from 15 sites were undertaken recently by the authors and others in an effort to complete the faunal observations for Cape rock lobsters in the whole of the study area. In this paper, we present data from 10 sites (Figure 2), where Cape rock lobster mandibles were encountered in the highest numbers. The depositional context of these sites is varied: three of the 10 sites accumulated in caves (Figure 2; SBF, EBC, SC); two were formed in semi-exposed environments, such as shelters and overhangs (TC, EBO); and five sites formed in the open air (DSP16, GFD, GFG, HSM, CLB). One of the cave sites (SBF) presents a stratigraphic component (Layer 4a) strongly affected by post-depositional burning (Jerardino & Yates, 1996). Further variability in the taphonomical contexts of the selected sites is shown by different deposition rates present between sites and along the occupational sequence of some of these sites (Jerardino, 1995, 1996; Jerardino & Yates, 1996; Parkington, in prep.).

Methods

Cape rock lobster mandibles were recovered from material sorted on site during excavations, and in many instances, additional mandibles and fragments of exoskeleton were recovered from unsorted samples brought back to be processed in the laboratory. Left and right mandibles were identified from whole and broken specimens. In only a few instances, refitting of fragments resulted in the reconstruction of whole mandibles. Metrical data were obtained from hundreds of whole mandibles and less than a dozen re-fitted specimens (Figure 1). Table 1 summarizes the relevant observations for Cape rock lobster remains in the study area.

In order to test for the independence of survival of whole mandibles and type of mandible, a 2 × 47 contingency table was built with the raw frequencies of left and right whole mandibles (2) observed in 47 stratigraphic layers (from a total of 62 layers: Table 1) where the number of observed whole mandibles is greater than 15. A chi-square statistic was used for analysing the data (Everitt, 1977; Zar, 1984). To ascertain whether smaller mandibles (left and right) break more frequently than larger ones (or vice versa), regression analysis were performed with separate sets of observations gathered from four stratified sites (Figure 2: SBF, EBC, TC, HSM) (Zar, 1984). These sites were chosen as a reasonably large number of mandibles were recovered from them. The percentage of whole mandibles was used as a measure of breakage frequency and was considered as the independent variable (X). The mean mandible size was regarded as the dependent variable (Y). If large or small Cape rock lobster mandibles were differentially affected by breakage, then a pronounced slope of regression and a good coefficient of determination (r^2) are expected to result from these analyses.

Results

With the exception of CLB, fragments of exoskeleton are almost absent from open-air sites, where the preservation of such fragile remains is expected to be poor as a result of their greater exposure to the elements. Overhangs offer some protection: fragments of exoskeleton are preserved only in the youngest deposits of EBO (Horwitz, 1979). In TC, exoskeleton fragments were encountered in deposits accumulated directly below the roof of the shelter and the immediate surrounding area, but not on the exposed talus slope. In cave sites (SBF, EBC, SC), where protection against the elements is greatest, fragments of carapace and appendices were encountered throughout most of the stratigraphic layers. The relevant observations for EBC, though, are limited.

According to the chi-squared test, the difference between the 47 layers with respect to proportions of left and right mandibles is not statistically significant (chi-square=38·1, df=46, P=0·7892). Significant differences were detected only when comparing the residuals from Layer 10a of EBC (Table 1). This single difference, however, did not affect the overall test results. Thus, with the exception of Layer 10a in EBC, there is no systematic bias in the breakage of left or right Cape rock lobster mandibles in the study area.

Following these results, the regression analyses included both left and right mandibles. The results show no close correlation between the percentage of whole mandibles and mandible size (Figure 3). The coefficients of determination for each of the four data sets are very small, the highest being that for TC (r^2=0·3003). The regression slopes are extremely small, and are not significantly different from zero (P<0·05).

Discussion and conclusions

The relatively short time that elapsed between the occupation of CLB and its excavation by archaeologists (ca. 400 years) must be considered when explaining the presence of exoskeleton fragments in this open site. Other contributing factors, such as minimal post depositional disturbance and fast burial of faunal remains by aeolian sand, may have played a role as well. After an apparently brief and single occupation at CLB, fragments of Cape rock lobster exoskeleton must have become buried faster than in other open sites (Horwitz, 1979; Jerardino, 1996, 2000). Fragments of exoskeleton were also recovered in SBF from Layer 4a, a deposit, comprised entirely of calcined material (Jerardino & Yates, 1996). As with deposits in CLB, Layer 4a in SBF accumulated relatively fast, leading to the quick burial of faunal remains shortly after their discard on the cave floor. This process ensured the preservation of fragments of exoskeleton, despite these having become even more brittle due to extensive burning of this deposit.

Basic statistical procedures show that, with the exception of ca. 8000-year-old mandibles from EBC, left and right mandibles break with the same frequency in a variety of depositional contexts. Consequently, the analysts should dedicate his/her efforts to counting and measuring both mandibles. If the sampling of the archaeological material generates an uneven number of left and right rock lobster mandibles in the absence of preservational bias, then metrical observations gathered from the type of mandible present in largest numbers should be used for further statistical analyses. In the event that metrical data from left mandibles (e.g., mean and standard deviation) of one occupation or site needs to be compared with those of right mandibles from another occupation or site,

Table 1. Summary table containing chronological, taphonomical and quantitative observations of Cape rock lobster mandibles from 10 archaeological sites of the study area

Site	Layer	Age (uncal. yrs BP)	Presence/ absence of exoskeleton	Total number of mandib. (L)	Number of whole mandib. (L)	% whole mandib. (L)	Mean size (L)	Total number of mandib. (R)	Number of whole mandib. (R)	% whole mandib. (R)	Mean size (R)
DSP16	1	2360 ± 45	a	6	1	—	—	6	3	—	—
	2	3290 ± 50	a	91	18	19·8	11·7	68	15	22·1	12·6
	3	4400 ± 60	a	120	30	25·0	11·5	108	17	15·7	12·5
	4	4990 ± 70	a	72	24	33·3	10·7	61	16	26·2	12·7
SBF	1+2	2200 ± 60–2360 ± 45	p	62	42	67·7	11·4	66	46	69·7	12·3
	3	2490 ± 50–2690 ± 60	p	178	99	55·6	10·9	199	120	60·3	11·4
	4a	3510 ± 50–3640 ± 60	p	116	74	63·8	11·9	115	72	62·6	12·9
	4b	3990 ± 60	p	336	161	47·9	12·9	337	154	45·7	13·7
	5	4620 ± 70–8370 ± 80	p	42	23	54·8	13·1	54	32	59·3	14·4
GFD	1	2290 ± 50	a	18	10	—	—	12	8	—	—
	2	2470 ± 60–2540 ± 50	a	214	111	51·9	9·6	200	118	59·0	10·3
	3	2680 ± 60–2830 ± 60	a	66	42	63·6	10·4	61	38	62·3	12·1
	4	3030 ± 20	a	1	1	—	—	0	—	—	—
GFG	1	690 ± 40	a	162	116	71·6	11·5	182	115	63·2	11·6
EBC	1	undated	#	252	213	84·5	11·5	250	221	88·4	12·4
	2ab	320 ± 50–500 ± 45	#	89	71	79·8	10·8	77	55	71·4	11·9
	3a	undated	#	112	97	86·6	11·2	125	114	91·2	12·1
	3bc	1040 ± 50–1280 ± 50	#	67	59	88·1	10·7	81	79	97·5	12·3
	3d	1310 ± 40	#	143	140	97·9	10·8	125	117	93·6	11·8
	4b	undated (*c.* 1600)	#	119	98	82·4	11·1	123	96	78·0	11·7
	4c	1790 ± 50–2100 ± 20	#	284	254	89·4	10·9	293	263	89·8	11·8
	5ab	1520 ± 80–2190 ± 25	#	38	36	94·7	11·2	35	29	82·9	11·4
	6	3450 ± 50–3590 ± 60	#	218	204	93·6	10·5	215	195	90·7	11·2
	7ab	3290 ± 60–4160 ± 60	#	21	16	76·2	10·7	18	16	88·9	11·6
	8ab	3780 ± 60	#	58	47	81·0	13·5	56	49	87·5	13·1
	9	3940 ± 60–4370 ± 60	#	135	116	85·9	12·1	119	88	73·9	12·7
	10a	7910 ± 80–8110 ± 90	#	35	23	65·7	11·6	50	38	76·0	13·2
	10b	8860 ± 90	#	54	28	51·9	12·1	56	23	41·1	12·9
	10cd	undated	#	144	119	82·6	12·6	131	107	81·7	14·2
	11a	8920 ± 90	#	264	217	82·2	13·1	245	210	85·7	14·3
	12	9510 ± 90	#	50	42	84·0	12·1	53	39	73·6	13·2
	13	9600 ± 90	#	734	609	83·0	11·8	708	611	86·3	12·7
	14	10 000 ± 90	p	231	217	93·9	16·5	244	217	88·9	18·6
	15b	10 460 ± 80–10 660 ± 100	#	40	36	90·0	13·2	40	28	70·0	15·0
	15c	undated	#	53	44	83·0	11·9	40	35	87·5	13·6
	16ac	11 370 ± 110	#	18	10	—	—	18	13	—	—
EBO	1	590 ± 50	p	134	87	64·9	10·5	121	96	79·3	10·6
	2	705 ± 45	a	59	29	49·2	10·6	50	39	78·0	10·4
	3	1470 ± 50	a	46	29	63·0	11·0	47	24	51·1	10·0
	4	2920 ± 60	a	19	7	—	—	14	14	—	—
HSM	1	undated	a	45	38	84·4	10·1	53	33	62·2	10·9
	2	970 ± 20	a	57	26	45·6	12·5	50	31	62·0	13·0
	3	undated	a	176	117	66·5	10·3	173	118	68·2	11·2
	4	undated	a	90	56	62·2	11·1	87	48	55·2	11·4
	5	910 ± 40	a	41	27	65·9	11·4	54	21	38·9	11·2
CLB	1	390 ± 40	p	158	83	52·5	11·5	145	78	53·8	11·5
SC	1	undated	p	11	6	—	—	9	5	—	—
	2	460 ± 40	p	33	17	51·5	9·8	28	18	64·3	11·3
	3	840 ± 50	p	47	30	63·8	12·6	49	31	75·6	13·0
	4	1150 ± 50	a	10	6	—	—	12	8	—	—
	5	2970 ± 60	p	18	14	—	—	21	15	71·4	12·7
	6	3510 ± 60	a	1	1	—	—	0	0	—	—
TC	1ab	760 ± 50	p	17	15	88·2	9·5	17	14	—	—
	2ab	1580 ± 50–1660 ± 45	p	62	57	91·9	10·2	63	60	95·2	10·2
	3ab	1590 ± 50–1780 ± 50	p	82	70	85·4	9·8	98	88	89·8	10·9
	5abc	3160 ± 60–3410 ± 60	p	45	24	53·3	13·3	41	31	75·6	13·4
	6	3520 ± 60	a	42	20	47·6	11·5	37	22	59·5	12·5
	7+8	4020 ± 60	a	35	17	48·6	10·7	21	10	—	—
	9	non existent	—	—	—	—	—	—	—	—	—
	10+11+13a	4190 ± 60–4330 ± 50	p	31	18	58·1	11·3	21	10	—	—
	13b	6910 ± 80	a	2	0	—	—	0	—	—	—
	14	7700 ± 70	a	6	4	—	—	3	3	—	—

Hash (#) indicates no available observations; p = present, a = absent.

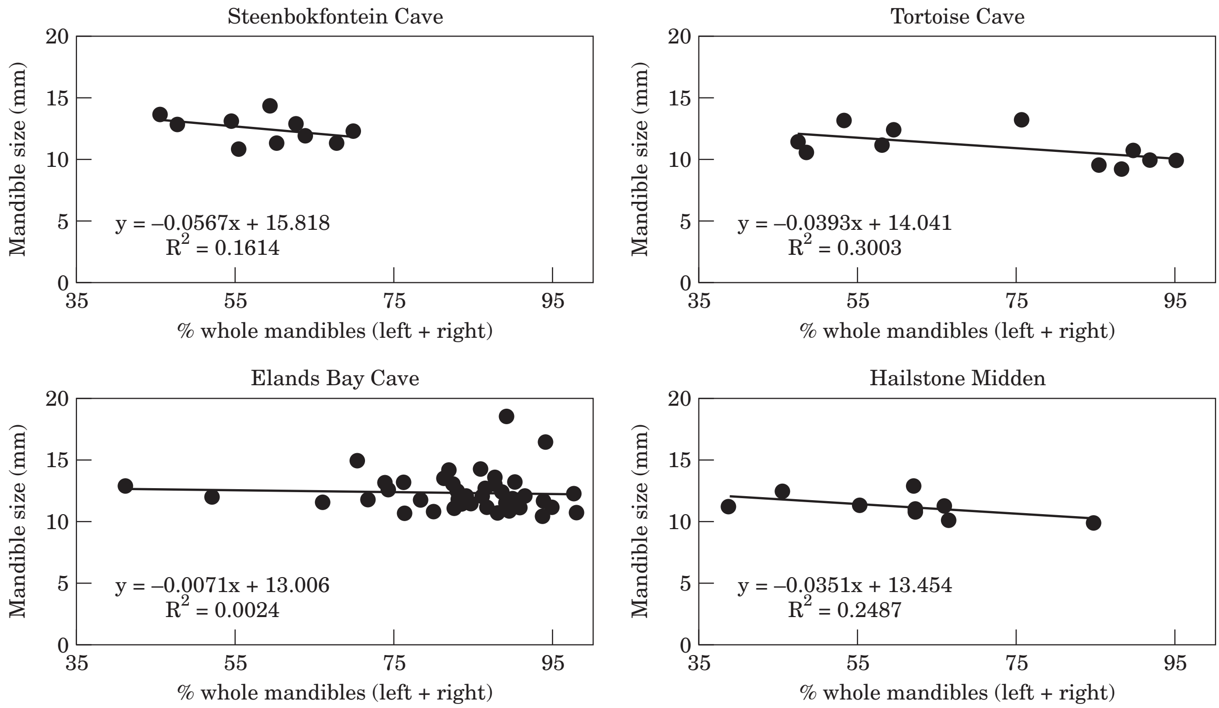

Figure 3. Plots and regression lines of mean sizes of left and right Cape rock lobster mandibles according to percentage of measurable mandibles for four archaeological sites in the study area.

the respective set of raw measurements should be converted into carapace length observations first (Jerardino, Navarro & Nilssen, 2001), in order to proceed with such comparison.

The small coefficients of determination for the regression analyses show that it is highly unlikely that metrical data on Cape rock lobster mandibles could be biased towards either the larger or smaller end of the size range due to breakage. It could be argued, however, that because all the regression slopes are negative, this is an indication that larger mandibles break slightly more often than small ones. Even in the case of Tortoise Cave (Figure 3), however, with the highest coefficient of determination of $r^2=0{\cdot}3003$, this argument does not have weight. Because the regression slopes are statistically not different to zero, it means that there is no statistically significant change in the mean size of mandible along the range of percentage of whole mandibles.

In sum, reasonably large numbers ($n\geq15$) of metrical observations on Cape rock lobster mandibles can be meaningfully compared within and between sites. Possible modification of this record due to taphonomic factors appears to be minimal in the study area. As archaeological research expands to other, unexplored, coastal areas, such possible relationship would need to be explored. This cautionary attitude stems from the possibility that the study area is unlikely to offer the full range of depositional contexts present in coastal sites along the west coast of South Africa. Studies similar to this will need to be carried out as new geographic frontiers are opened to archaeological research.

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