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4 TESTING ARCHAEOFAUNAL COLLECTIONS FOR DIFFERENTIAL FRAGMENTATION
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Abstract

Body dimensions of animal remains provide evidence for subsistence technologies, seasonality of hunting and fishing, and generalized resource stress. Studies that rely on reconstructed body dimensions of fishes rarely address the possibility of differential preservation or recovery, which may result in inaccurate representations of size classes. We devise a method to test for differential fragmentation of archaeofauna specimens based on specimen size and location within the stratigraphic column. We also compare two methods for reconstructing animal size classes: one includes only complete specimens that can be measured accurately, and the other includes both fragmented and complete specimens. We use a collection of mullet (*Mugil* spp.) atlases from the McQueen Shell Ring, St. Catherines Island, Georgia (USA), many of which were included in a previous study of fish body size as evidence for fishing technologies. All atlases are sorted by size class and categorized as having complete or fragmented osteometric landmarks. There is a positive correlation ($\rho = 0.45$, $P = 0.07$) between atlas size class and proportion of specimens that are fragmented: smaller atlases are more likely to be recovered, identified, and measured without fragmentation compared to larger atlases. Size-based differential fragmentation may bias against the representation of larger-bodied individuals in this context. Frequency of fragmentation is not monotonically correlated with burial depth ($\rho = -0.19$, $P = 0.39$), and is higher in the upper-most and bottom-most levels of the stratigraphic column compared to intermediate depths. Depth-based differential fragmentation may bias results when stratigraphic sequences are used to evaluate change through time in animal body sizes.

53 Keywords: Zooarchaeology, Osteometrics, Fish remains, Shell middens, Taphonomy,
54 Southeastern United States
55

1. Introduction

Reconstructing body dimensions from archaeofaunal measurements is an important aspect of archaeological research. Researchers use osteometric data from archaeofaunal collections to make inferences about seasons of procurement, including fishing and shellfishing (Orr, 2007; Russo and Quitmyer, 2008); technologies employed (Balme, 1983; Colaninno, 2011; Greenspan, 1998; Hongo, 1989; Losey et al., 2008; Plug et al., 2010; Zohar et al., 1997); anthropogenic stressors on animal populations and communities (Broughton, 1997; Butler, 2001; Carder et al., 2007; Leach and Davidson, 2000; Rick et al., 2015; Wing and Wing, 2001); and site formation processes, such as natural versus cultural deposits (Butler, 1996). Such research advances our understanding of people and their relation with animal populations, communities, and subsequent deposition and recovery thereof.

The traditional approach to reconstructing vertebrate animal size classes, particularly fishes, relies on standard measurements of osteometric landmarks. Because only bones with complete landmarks can be measured accurately, fragmented specimens are excluded from such analyses. Numerous processes impact the recovery and representation of preserved, measurable specimens within populations and communities (see Lyman, 1994; Wheeler and Jones, 1989). For example, researchers note that in the context of shell-bearing archaeological deposits, small specimens are more likely preserved unfragmented compared to larger specimens of the same element (Jerardino and Navarro, 2002). Small specimens easily move within cracks of the shell matrix, while larger specimens are unable to fit between shells. These larger specimens become fragmented as shell deposits shift and settle (Jerardino and Navarro, 2002). Others hypothesize

that mechanical processes of burial can lead to fragmentation (Wheeler and Jones, 1989:63-64). For example, overlying weight of matrix could crush underlying vertebrate specimens leading to differential fragmentation through the stratigraphic column (Lyman, 1994:424). Alternatively, specimens closest to the ground's surface may be prone to fragmentation caused by trampling, burrowing, and other historical disturbances. Any process that impacts fragmentation rates differentially throughout the stratigraphic sequence can impact temporal interpretations of osteometric data.

In many cases, analyses that use osteometric data do not account for processes that could bias the representation of particular specimens or sizes classes. Here, we propose a simple method to test for size-based and depth-based differential fragmentation of a single skeletal element from two species of mullet (*Mugil* spp.) that were recovered archaeologically. First, we test hypothesis 1: small specimens, specifically fish atlases, within a dense shell matrix are better preserved than are large specimens. If small specimens are protected within the context of shell deposits, as suggested by Jerardino and Navarro (2002), we expect a greater proportion of small specimens to be unfragmented, that is, with complete and measureable osteometric landmarks, compared to large specimens. If this is the case, osteometric data will be skewed toward the overrepresentation of small specimens. Second, we test hypothesis 2: specimens will exhibit different rates of fragmentation based on their location within the stratigraphic column. If the weight of the overlying matrix crushes specimens, we expect to see relatively more unfragmented specimens recovered from the upper stratigraphic levels compared to deeper levels. If trampling, burrowing, and other historical processes cause fragmentation, we expect to see more fragmented specimens in upper levels compared to others.

The method for testing size-based differential fragmentation involves sorting all specimens, both fragmented and unfragmented, into discrete size classes based on maximum diameter, rather than precise measurements of osteometric landmarks. These specimen size classes can also be used as a proxy for animal body size classes, in this case, standard length (SL) of fishes. This approach allows researchers to include data from fragmented specimens, which would be excluded from traditional size class analyses, to obtain more accurate, albeit less precise, reconstructions of fish body size classes. Finally, we compare two methods for reconstructing animal size classes: one includes only complete specimens that could be measured precisely, and the other includes both fragmented and complete specimens.

2. Materials and Methods

We test for evidence of differential fragmentation using mullet atlases. We chose to work with mullet atlases because they are represented in large numbers ($n = 903$) in collections from the Georgia coast (USA) (Figure 1) and particularly in the specific collection we studied: the McQueen Shell Ring (9LI1468). This skeletal element is prone to fragmentation in archaeological contexts. Furthermore, because mullet are a cosmopolitan genus from tropical and temperate waters of the Atlantic, Pacific, and Indian Oceans, they are recovered from coastal archaeological contexts around the world. Two species of mullet, striped (*Mugil cephalus*) and white (*Mugil curema*), inhabit estuarine waters adjacent to the McQueen Shell Ring (Dahlberg, 1972, 1975). Skeletal elements from these two species are difficult to distinguish, and visually are identifiable only to genus (*Mugil* spp.). Striped mullets generally are dominant in Georgia

estuaries, but the collection likely contains both species. Researchers have noted interspecies size variability in previous ichthyofauna osteometric studies (Braje et al., 2012). Striped mullet can reach somewhat larger sizes than white mullet with common lengths of 500 mm and 300 mm, respectively, but the two species have overlapping size ranges. Given the modern-day dominance of striped mullet, interspecies size variability likely does not impact size representation of mullet atlases in the studied collection.

The size of mullets within Georgia estuaries do vary seasonally (Dahlberg, 1972; Reitz et al., 2012). The fishers who deposited mullet remains at the McQueen Shell Ring appear to have fished Georgia estuaries during all four seasons of the year (Colaninno, 2012a). Contexts in which these mullet atlases were recovered do not appear to be highly seasonal (Colaninno and Reitz, 2015).

All mullet atlases included here were recovered from shell matrix contexts at the McQueen Shell Ring, St. Catherines Island, Georgia (Figure 1). This shell ring is located on the seaward side of St. Catherines Island, adjacent to rich estuarine resources that were utilized by prehispanic people for millennia (Reitz, 2014). Atlases from a portion of this collection were included in a previous osteometric study that inferred fishing technologies based on the frequency of individuals within size classes (Colaninno, 2011). In that study, we made inferences about fishing technologies based on estimates of the standard lengths (SL). SLs were estimated from the width of the anterior centrum (Figure 2), therefore only specimens with complete landmarks were included in that study. Effects of differential fragmentation based on element size or depth of burial were not tested at that time (Colaninno, 2011).

The McQueen Shell Ring site is a large, ring-shaped, feature that measures approximately 70 m across the exterior diameter and 47 m across the interior diameter. Shell ring matrix consists primarily of whole and fragmented American oyster (*Crassostrea virginica*) shells along with numerous other invertebrate and vertebrate taxa and other cultural debris (Colaninno, 2010, 2011; Colaninno and Reitz, 2015; Reitz, 2014; Sanger and Thomas, 2010). Multiple samples from within the shell-dense matrix of this ring date to between 2300–1950 cal. B.C. (Sanger and Thomas, 2010:66). Researchers do not agree on the processes by which the McQueen Shell Ring and similar shell rings along the coast of the southeastern United States formed, nor do they agree on their functions (Colaninno, 2012b; Thompson and Andrus, 2011). Researchers have argued that shell rings were seasonal macroband camps, feasting locales, sedentary villages, fish weirs, water entrapment areas, and/or monumental structures (Anderson et al., 2007:470; Colaninno, 2012b; Marquardt, 2010a, 2010b; Russo, 2004; Sanger and Thomas, 2010; Saunders, 2004; Thompson, 2006:267, 2007; Thompson and Andrus, 2011; Thompson and Worth, 2011; Trinkley, 1985; Waring and Larson, 1968). It is clear that the people who formed shell rings, and specifically the McQueen Shell Ring, routinely fished and harvested shellfish throughout estuaries (Andrus and Thompson, 2012; Colaninno and Reitz, 2015).

Mullet atlases studied here are from four 1 x 1 m excavation units (N213 E198, N243 E233, N263 E179, and N272 E200) spanning the temporal range of the site. Colaninno's (2011) previous study worked with atlases from excavation units N213 E198 and N263 E179. We included atlases from N243 E233 and N272 E200 to increase our sampled population: archaeofaunal collections from these two excavation units are similar to those previously reported (N213 E 198 and N263 E179) (Colaninno and Reitz, 2015). Excavations units were placed

165 within the circumference of the ring at the highest topographic points of the shell deposits to
166 maximize sample volumes. Excavations were conducted in arbitrary 10-cm levels, from the
167 modern ground surface until excavations reached sterile subsoil. Final depth of each unit varies,
168 and ranges from 50 to 70 cm below current ground surface. All vertebrate remains, including the
169 mullet atlases studied here, were recovered by water-screening through a series of nested screens
170 with meshes ranging from 25.4 to 3.18 mm. The use of finer gauged-screens or dry-, rather than
171 wet-screening, likely would alter the size and fragmentation rates of recovered mullet atlases (see
172 Nagaoka 2005). All vertebrate remains were recovered consistently with the excavation methods
173 noted above and we cannot not test the relationship between recovery techniques and
174 fragmentation with these data. The approximate volumes excavated, total numbers of identified
175 specimens (NISP), total number of identified mullet specimens, and total number of mullet
176 atlases per unit are reported in Table 1.

177 All vertebrate archaeofaunal remains from the McQueen Shell Ring were identified by
178 Colaninno following standard zooarchaeological procedures (Reitz and Wing, 2008) at the
179 Georgia Museum of Natural History, Zooarchaeological Laboratory, University of Georgia,
180 Athens, Georgia (USA). We then examined all mullet atlases for completeness of the anterior
181 centrum—the landmark used in previous osteometric analyses of this species (Colaninno, 2010,
182 2011; Orr, 2007). Atlases with incomplete (fragmented) anterior centra were excluded from
183 those studies. Here, we test for biases related to the exclusion of fragmented atlases.

184 To test for size-based fragmentation, we sorted atlases into discrete size classes and
185 classified them as either having a "complete" or "fragmented" anterior centrum. We defined five
186 size classes based on the range of sizes observed in the collection. The diameters incrementally

increase by 1.19 mm for each size class: 1.98 mm (size class 1); 3.18 mm (size class 2); 4.37 mm (size class 3); 5.56 mm (size class 4); and 6.75 mm (size class 5). Using stencil circle templates, circles with these diameters were traced and the anterior centrum of each atlas was compared against these circles. Each atlas was assigned to the smallest circle (size class) within which the centrum fit completely (Figure 3). Specimens that did not have enough of the anterior centrum present to evaluate the total circumference or diameter were too fragmented to be confidently placed in a size class. These were assigned to a sixth class, "indeterminate size," and were excluded from the size-based analysis.

This allowed us to categorize the size of fragmented atlases that were excluded from the previous analysis because the osteometric landmark was damaged or not present (Colaninno, 2011). Specimen size classes also serve as proxies for fish body size classes, allowing both fragmented and complete specimens to be included in analyses of the sizes of fish caught and the fishing technologies people used. We then calculated the percent of fragmented atlases in each size class. If atlases from small-bodied individuals are protected in the context of a dense shell matrix, small atlases will be preferentially recovered unfragmented compared to larger atlases. We expect to find a positive correlation between atlas size class and the percent of fragmented atlases.

To test for differential fragmentation by sample depth, we calculated the percent of fragmented atlases, regardless of atlas size class, per level, by excavation unit. Excavations were conducted in arbitrary 10-cm levels, with level 1 containing materials from 0 to 10 cm below surface, level 2 containing materials from 10 to 20 cm below surface, and so on, down to the maximum depth of level 7. If there are differences in fragmentation rates caused by variation in

mechanical stresses throughout the stratigraphic column, then we expect to find atlases located in particular segments of the column to be more frequently fragmented compared to specimens from other locations within the stratigraphic sequence. There would be a correlation between stratigraphic level and percent of fragmented atlases.

To visually compare the percentages of fragmented atlases per (1) size class and (2) depth, we created box-and-whisker plots indicating the minima, median, maxima, and quartiles of observed values. We used Spearman's rank correlation coefficient (ρ) to test for monotonic correlations between the percent of fragmented atlases and (1) atlas size class, and (2) depth. Spearman's rank correlation is a non-parametric test of correlation based on ranks of observations. Values of ρ range from -1 to +1, corresponding to perfect negative and positive monotonic correlations, respectively. Variables with no monotonic correlation have $\rho \approx 0$.

3. Results

The four excavation units studied here contained 138,932 vertebrate specimens, of which 17,897 are identified as mullet (*Mugil* spp.) (Table 1; Colaninno and Reitz, 2015). The archaeofaunal collection includes 903 mullet atlases (Table 1). Five hundred eighty-one (64%) of these atlases are complete, while 322 (36%) are fragmented. Of the 903 atlases recovered, a total of 855 (95%) were assigned to a size class and are included in the size-based fragmentation portion of the study. The remaining 5% of atlases had anterior centra that were too fragmented to be confidently placed in a size class.

3.1 Size-based Fragmentation

Not every size class is represented in every excavation unit, but all excavation units provide specimens from at least four of the five size classes (Table 2). The three smallest size classes are well represented, but classes 4 and 5 consist of only five and three atlases, respectively (Table 2 and Table 3). Across all units, the percent of atlases that are fragmented generally increases from size class 1 to size class 5, with the exception of size class 4 (Table 3). Figure 4 represents these data graphically. The bi-plot shows percentages of each size class that are fragmented by excavation unit. The box-plot also shows that, with the exception of size class 4, larger size classes have relatively more fragmented atlases than smaller size classes. The Spearman's correlation coefficient, $\rho = 0.45$ ($P = 0.07$), indicates a moderate positive monotonic correlation between size class and percent fragmented that is statistically significant at $\alpha = 0.10$.

3.2 Depth-based Fragmentation

All 903 recovered atlases are considered in the analysis of fragmentation by depth, regardless of whether they could be assigned to a size class. Excavation units vary in total depth, so all levels, particularly deeper levels, are not represented by each excavation unit. Nor does every level contain mullet atlases (Table 4). Across all units, all excavation levels are well represented except for the upper-most and lower-most levels, levels 1 and 7 (Table 5).

Across all units, the percent of atlases that are fragmented is not correlated with depth (Figure 5). The bi-plot in Figure 5 shows the percentage of atlases in each level that are

fragmented against level, which is a proxy for depth. The Spearman's correlation coefficient, $\rho = -0.19$ ($P = 0.39$), suggests that depth and percent fragmented are uncorrelated variables. There is no directional trend in degree of fragmentation as depth increases or decreases. The boxplots indicate that atlases from both the upper-most and lower-most levels have higher incidences of fragmentation than do specimens from the central portion of the stratigraphic column (Figure 5).

4. Discussion

Our data cannot refute hypothesis 1: small atlases are more likely recovered unfragmented compared to their larger counterparts in the shell-dense matrix from the McQueen Shell Ring. There is a positive correlation between size class and degree of fragmentation (Figure 4). Smaller atlases are more likely recovered with complete anterior centra, while larger atlases are more likely recovered with fragmented anterior centra. This trend is clearest in size classes 1 through 3, which have large numbers of observations. In contrast, size classes 4 and 5 include very few atlases. These size classes may be more appropriately treated as outliers because the few atlases in these classes have a marked influence on the results. It is unknown whether a larger number of observations for size classes 4 and 5 would strengthen or weaken the correlation. There are collections from the southeastern United States that contain high counts of large mullet atlases (e.g., Orr, 2007). It is worth testing such collections for similar results.

One explanation for the size-based trend involves recovery due to screen size instead of preservation. The gauge of the screen used to recover these atlases was 3.18 mm. Size classes 1 and 2 are below this 3.18-mm threshold. Complete specimens of this size may not be recovered;

275 fragmented specimens are even more likely to be lost. Fragments of larger atlases, on the other
276 hand, are more likely to exceed this 3.18-mm threshold and be recovered. Furthermore, if highly
277 fragmented, small atlases are recovered, they may not be attributable to the taxonomic level of
278 genus (i.e., *Mugil* spp.), whereas larger atlases are more readily identifiable in fragmented
279 conditions. Testing collections recovered with finer gauged-screens may produce different
280 results.

281 Our data refute hypothesis 2: there is no correlation between stratigraphic location and
282 the degree of atlas fragmentation. Fragmentation rates neither increase nor decrease
283 monotonically with depth. However, there appears to be a relative increase in fragmentation in
284 both the upper-most and lower-most stratigraphic levels compared to the rest of the stratigraphic
285 sequence. The median frequency of fragmented atlases is greatest in levels 1, 6, and 7 compared
286 to other levels (Figure 5), and overall, atlases from level 1 exhibit the highest frequency of
287 fragmentation (Table 5). This suggests that both top-down (e.g., trampling) and bottom-up (e.g.,
288 overburden) mechanical processes may influence rates of fragmentation and thus influence
289 animal size class reconstructions.

290 In the context of the McQueen Shell Ring, larger mullet atlases are more vulnerable to
291 breakage than are smaller ones. The entire assemblage is therefore biased against the recovery of
292 larger atlases, and hence, large-bodied mullets. In addition, fragmentation is greatest in the top
293 10 cm and the bottom 20 cm of the stratigraphic column. Large-bodied mullets are expected to
294 be especially under-represented in levels with greater frequencies of fragmentation. The
295 combined effects of size- and depth-based differential fragmentation could potentially skew
296 interpretations based on body sizes of fishes captured, particularly those studies examining

diachronic changes in fish body sizes where depth is used as a proxy for relative age of deposition.

Using measurements of complete anterior centra of mullet atlases from this collection, Colaninno (2011), suggested that the people who formed the McQueen Shell Ring and other shell ring sites used mass-capture technologies such as fine-gauge nets to capture mullet. This interpretation was based on the relatively small body sizes of mullets (mean SL from units N213 E198 and N263 E179 is 120.8 mm with a range of 68.9 to 287.4 mm, $n = 316$). The results of our size-based fragmentation tests suggest that larger atlases, and hence, large-bodied mullets, are more likely recovered in a fragmented condition and less frequently measured. Because Colaninno's (2011) study only included atlases with complete anterior centra, it is likely that larger mullet atlases were underrepresented due to fragmentation, which we expand upon below. McQueen Shell Ring fisherfolk may have taken larger mullets with different fishing technologies, apart from fine-gauge nets, such as large-gauge nets, spears, and possibly hooks.

Figure 6 compares the size classes of complete atlases against size classes for all atlases, both complete (unfragmented) and fragmented combined. This comparison demonstrates the effects of size-based differential preservation on mullet size class analyses at the McQueen Ring.

The allometric equation

$$Y = 63.533X^{0.852}$$

is used to estimate mullet standard length (Y) from the width of the atlas anterior centrum (X) (Colaninno, 2011). Therefore size class 1 includes individuals <113 mm SL; size class 2 individuals are 113–170 mm SL; size class 3 individuals are approximately 171–223 mm SL,

and so on. When only complete atlases are included in the size class analysis, size class 1 is overrepresented, and size class 3 is underrepresented (Figure 6). Combining complete and fragmented atlases changes the relative frequencies of size classes 2, 4, and 5 only marginally.

In the McQueen Shell Ring case study, there is evidence of size-based differential preservation that slightly skews the size class frequencies towards smaller-bodied fish. However, the exclusion of fragmented atlases does not dramatically change the frequency distribution of size classes, nor does it alter the interpretation of the data (Figure 6). Small-bodied individuals dominate the mullet sample, regardless of whether fragmented atlases are included in the analysis.

Over 81% of studied mullet atlases, both fragmented and complete, fall within the two smallest size classes, corresponding to individuals with SL <171 mm. Today, mullets mature at ca. 200 to 300 mm, around the second or third year of growth (Collins, 1985). These data clearly indicate that McQueen Shell Ring fisherfolk captured mainly juvenile, small-bodied mullets, which are most easily captured with fine-gauge nets and other mass-capture devices. Despite higher fragmentation rates among larger atlases, Colaninno's (2011) original interpretation of fishing practices remains supported.

We used this method to test for variation in fragmentation based on element size and depth of burial from the same skeletal element within one genus of two closely related species. This method should not be used exclusively to test for element fragmentation between different skeletal elements or among unrelated taxa without accounting for mechanical and chemical variation of the boney tissue. Organisms from different taxa form boney tissues through various biological processes (Lyman, 1994:77-78). Furthermore, various skeletal elements within a

single individual form differently (Wheeler and Jones, 1989:61-62). Variation in bone structure and microstructure within a skeleton and between taxa will impact preservation; however, we do not assume that this method can test for biases associated with mechanical and chemical bone tissue composition between unrelated taxa and skeletal elements.

5. Conclusions

The results of this study demonstrate that both specimen size and depth can influence the frequency of fragmentation and thereby bias osteometric data. Employing the method described here can be used as a protocol to evaluate the degree to which these potential biases have affected archeofaunal collections. Where depth- or size-based differential fragmentation is observed, such as the McQueen Shell Ring, specimen size classes can be used as a proxy for animal body size classes, allowing both fragmented and complete specimens to be used in the analysis. This method more accurately reflects the archaeological population by including fragmented specimens, but is less precise than traditional osteometric approaches to size class analysis.

Future studies that use archaeological osteometric data to infer human and animal behavior should consider adapting this method to ensure that elements, and subsequent measurements, have not been biased by taphonomic processes resulting in over- or under-representation of particular size classes or impacted by depth-based taphonomic processes. The method presented here could easily be adapted for use with elements other than mullet atlases. Mullet atlases are approximately circular, so we used a circular stencil to define size classes.

Other elements with irregular features, such as articular ends of mammalian or avian long bones, also can be judged against stenciled circles or other standardized shapes.

This method may be particularly important when comparing osteometric data of skeletal elements across multiple depositional contexts with varied taphonomic processes. Additionally, temporal trends in the reduction of body size among fished and hunted populations that evidence anthropogenic overexploitation can be strengthened or reevaluated by applying this method. Such studies have implications for fisheries and wildlife management and alternative explanations, such as size-based and depth-based differential fragmentation, should be explored fully. This method, although applied in the shell midden context can be applied to other depositional contexts; all buried animal remains may be subject to differential, size- and depth-based fragmentation.

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Table 1.
Unit summary.

Unit	Excavated Volume, m ³	Total Vertebrate NISP	Mullet NISP	Mullet Atlas NISP
N213 E198	0.60	12780	1436	75
N243 E233	0.61	13175	2016	112
N263 E179	0.80	30460	6975	361
N272 E200	1.50	82517	7470	355
Totals	3.51	138932	17897	903

Note: NISP is the number of identified specimens.

Table 2.
Counts of atlases per size class per excavation unit and percentage fragmented.

Excavation unit	Size class	# of atlases	# fragmented	% fragmented
N213 E198				
	1	18	4	22
	2	40	18	45
	3	11	8	73
	4	0	0	0
	5	2	1	50
	Indeterminate	4	4	100
N243 E233				
	1	32	6	19
	2	64	21	33
	3	11	6	55
	4	1	0	0
	5	0	0	0
	Indeterminate	4	4	100
N263 E179				
	1	146	13	9
	2	173	53	31
	3	30	22	73
	4	2	1	50
	5	0	0	0
	Indeterminate	10	10	100
N272 E200				
	1	63	10	16
	2	196	80	41
	3	63	30	48
	4	2	0	0
	5	1	1	100
	Indeterminate	30	30	100
Total		903	322	

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Table 3.
Total counts of atlases per size class and percent fragmented across all excavation units.

Size Class	Total # of atlases	Total # fragmented	% fragmented
1	259	33	13
2	473	172	36
3	115	66	57
4	5	1	20
5	3	2	67
Indeterminate	48	48	100
Total	903	322	

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Table 4.
Counts of atlases per level per excavation unit, and percentage classified as fragmented.

Excavation unit	Level	# of atlases	# fragmented	% fragmented
N213 E198				
	1	12	7	58
	2	34	13	38
	3	29	15	52
	4	—	—	—
	5	—	—	—
	6	—	—	—
	7	—	—	—
N243 E233				
	1	3	3	100
	2	37	10	27
	3	20	3	15
	4	23	8	35
	5	25	10	40
	6	2	2	100
	7	2	1	50
N263 E179				
	1	1	1	100
	2	25	12	48
	3	37	22	59
	4	46	16	35
	5	117	21	18
	6	130	26	20
	7	5	1	20
N272 E200				
	1	15	9	60
	2	73	26	36
	3	89	37	42
	4	78	36	46
	5	94	39	41
	6	5	3	60
	7	1	1	100
Total		903	322	

Table 5.
Total counts of atlases per level and percent fragmented across all excavation units.

Level	Total # of atlases	Total # Fragmented	% fragmented
1	31	20	65
2	169	61	36
3	175	77	44
4	147	60	41
5	236	70	30
6	137	31	23
7	8	3	38
Total	903	322	

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Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6