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RADIOCARBON CHRONOLOGY WITH MARINE RESERVOIR CORRECTION FOR THE RITIDIAN ARCHAEOLOGICAL SITE, NORTHERN GUAM

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ABSTRACT. Archaeological investigations at the Ritidian site in Guam provide a series of radiocarbon dates spanning the potential range of human presence in the region. Paired marine and terrestrial samples offer a basis for ΔR calculation, as well as evaluation of the utility of different types of marine samples for ^{14}C dating of archaeological contexts. The results indicate an early period of temporary fishing camp activity in the context of higher sea level and little or no stable beach, followed by larger-scale residential activity in the context of lower sea level and an extensive stable beach landform.

INTRODUCTION

A new radiocarbon chronology for the Ritidian archaeological site in Guam verifies earliest human presence around 1460–1300 cal BC, just slightly younger than the earliest known sites elsewhere in the Marianas region of the western Pacific around 1500 cal BC (Carson 2008). A series of 12 samples provides absolute dating of key points in the cultural sequence, matched with natural environmental change in sea level and coastal geomorphology. Paired marine and terrestrial samples within this series enables ΔR calculation, and evaluation of the utility of different types of marine samples for ^{14}C dating of archaeological contexts.

The Ritidian archaeological site comprises a present-day broad sandy beach, situated between the base of a steep limestone cliff and the Philippine Sea, within the Ritidian Unit of the Guam National Wildlife Refuge (Figures 1 and 2). The sandy beach landform consists primarily of bioclastic sand, deposited in beds more than 2 m thick over a coral limestone base. In some portions of the stable backbeach, an organic horizon is weakly formed near the surface.

An ambitious program of test pits (Carson 2010a,b) revealed multiple human occupation layers at Ritidian, in some cases separated vertically by thick (1+ m) beds of culturally sterile beach sand (Figure 3). This finding offers good potential for stratigraphically separated natural and cultural layers, ideal for chronological ordering of ^{14}C dates. The uppermost cultural layers contain abundant terrestrial charcoal and marine shells, but charcoal is increasingly scarce with depth and age. The deepest and oldest cultural layer originally was in an intertidal or shallow subtidal context, where charcoal is not available in sufficient quantity for ^{14}C dating.

Given the constraints of the material available for ^{14}C dating at the Ritidian site, calculation of a local marine reservoir effect (ΔR) was undertaken in support of a more accurate chronology. As Petchey (2009) has noted, this scope of work is desirable because most archaeological sites in the Pacific Islands contain abundant marine shells in secure contexts suitable for ^{14}C dating in direct association with cultural occupation layers or other anthropogenic features, yet a local ΔR is not always available or convincing for a given study area (see also Petchey et al. 2008). For example, only 3 pre-AD 1950 shell specimens from the Marianas region previously have been analyzed to calculate ΔR, and Petchey and Clark (2010) note these ΔR values are questionable due to problems with variable residence times and potential contamination from Miocene and Plio-Pleistocene limestone.

METHODS

The test excavation program included 40 test pits along the alignment of a proposed fence (Carson 2010a) and along the alignment of a proposed walking trail (Carson 2010b). Excavation proceeded

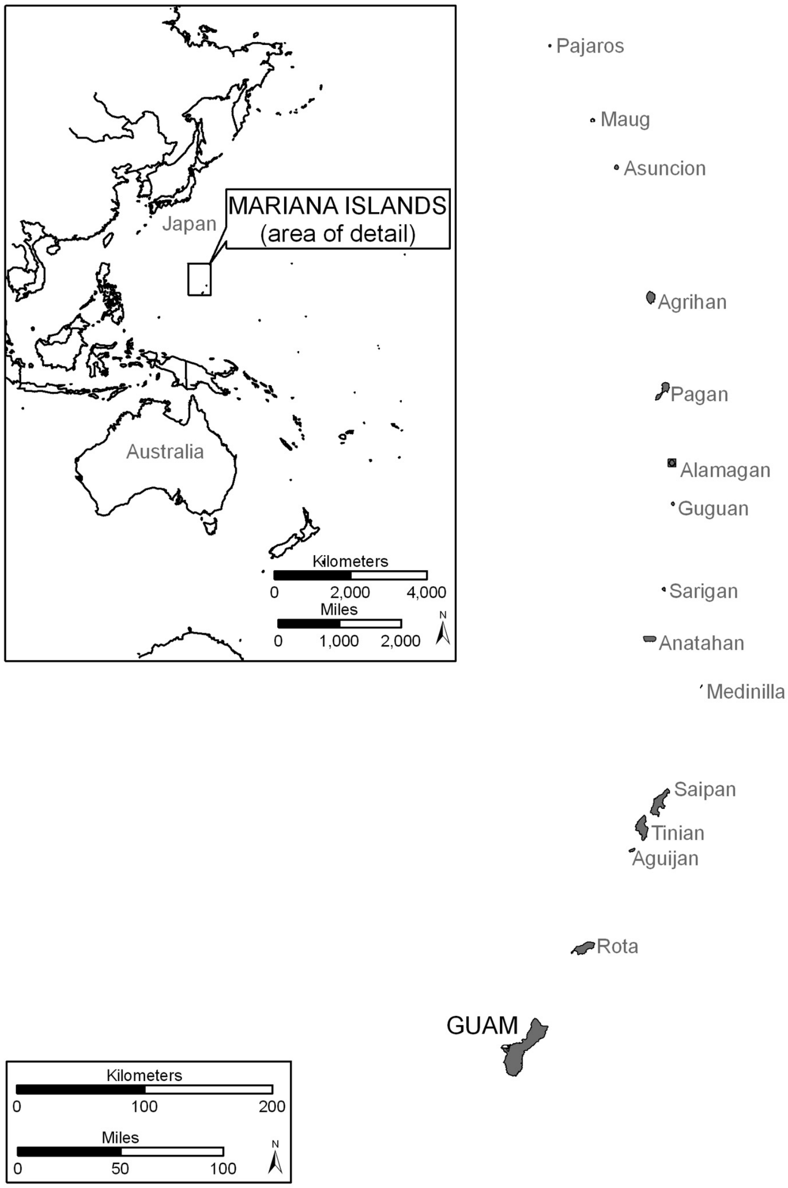

Figure 1 Location of Guam in the Mariana Islands, western Pacific

in 10-cm artificial levels within natural strata, and all contents were screened through 3-mm hardware mesh to ensure maximum recovery of archaeological materials. Bulk 10-L samples also were retrieved from each layer and wet-screened through very fine (1-mm) mesh to ensure maximum recovery of fine-fraction material. Provenience of each ^{14}C sample is shown in Figure 3 in relation to the overall sequence of natural and cultural strata. The excavation procedure allowed precision within 10 cm in all cases and sometimes within 1 cm. The methods ensured maximum recovery of archaeological material and especially of fine-fraction charcoal particles. However, insufficient charcoal for ^{14}C dating was available from the lower layers.

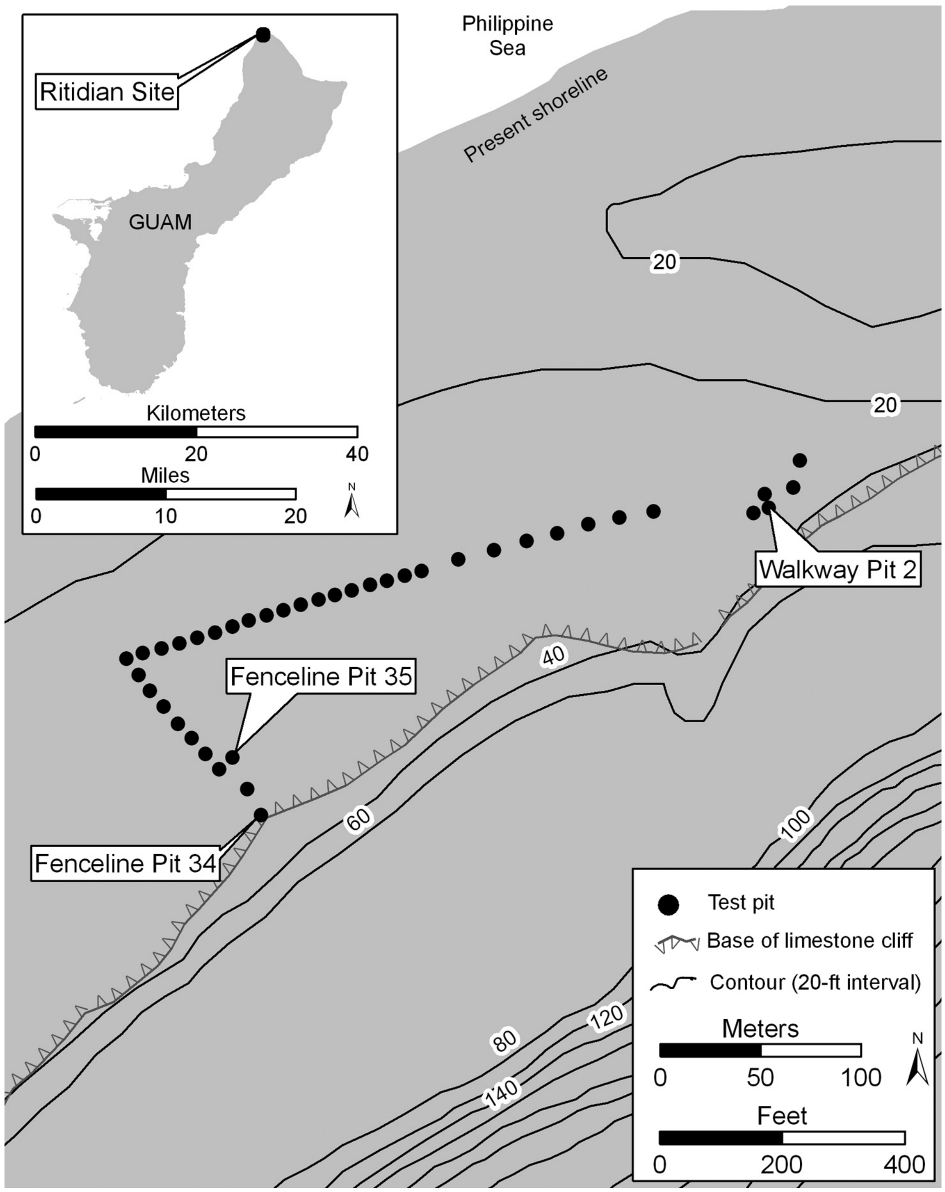

Figure 2 Ritidian site project setting in Guam, showing locations of test pits

Calculation of local ΔR was possible by ^{14}C dating of paired marine and terrestrial samples in the middle and upper layers. Different material types were selected in order to assess their suitability for ^{14}C dating of archaeological contexts.

ΔR calculations followed the procedure outlined by Ulm (2002) for paired terrestrial and marine samples. The conventional (isotope-corrected) ^{14}C age of each charcoal sample was converted to the equivalent global marine model ^{14}C age, using the atmospheric ages interpolated from IntCal09 to the equivalent year from Marine09 (Reimer et al. 2009). For each paired sample, the ΔR was calculated by deducting the equivalent marine model age of the charcoal specimen from the ^{14}C age of the

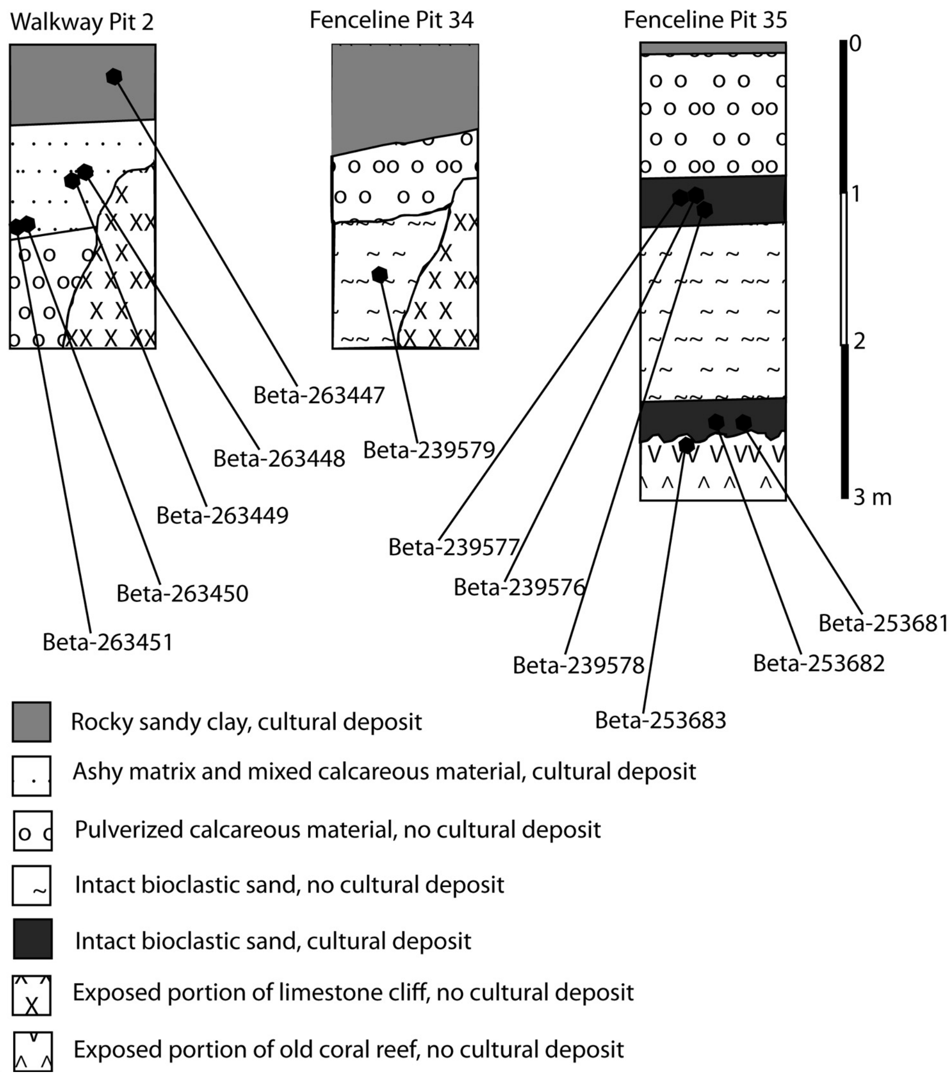

Figure 3 Profiles of test pits with ^{14}C sample provenience

paired marine sample. The formula is Rs(t) – Rg(t) = ΔR(s), where Rs(t) is the surface ocean value as represented by the marine sample material and Rg(t) is the marine model age as calculated from the paired charcoal specimen. The formula for calculating standard error is $\Delta R\sigma = \sqrt{(\sigma Rg(t)^2 + \sigma Rs(t)^2)}$.

RESULTS

Samples for ^{14}C dating included 4 charcoal specimens and 8 marine specimens (Table 1), obtained from key points in the Ritidian site stratigraphic sequence (see Figure 3). The resulting ^{14}C chronology spans the range of known human presence in the Marianas region. The calibrated age distributions are depicted in Figure 4, including adjustments for ΔR as discussed here.

Table 1 Summary of new ^{14}C dating results from Ritidian, Guam.

Laboratory nr	Provenience	Sample material	Measured ^{14}C age (BP)	$\delta^{13}C$ (‰)	Conventional ^{14}C age (BP)	Calibrated 95.4% probability[a]
Time interval 5, youngest						
Beta-263447	Walkway Pit 2, 33 cm	Carbonized *Cocos nucifera* (coconut) endocarp	780 ± 40	–24.5	790 ± 40	AD 1170–1290 (95.4%)
Time interval 4						
Beta-263448	Walkway Pit 2, 92 cm	Carbonized *Cocos nucifera* (coconut) endocarp	2500 ± 40	–24.5	2510 ± 40	800–500 BC (94.2%); 440–420 BC (1.2%)
Beta-263449	Walkway Pit 2, 90–100 cm	*Anadara antiquata* shell	2370 ± 40	+2.1	2810 ± 40	750–450 BC (95.4%)
Beta-263450	Walkway Pit 2, 126 cm	Carbonized *Cocos nucifera* (coconut) endocarp	2490 ± 40	–24.0	2510 ± 40	800–500 BC (94.2%); 440–420 BC (1.2%)
Beta-263451	Walkway Pit 2, 128 cm	*Conus* sp. shell bead artifact	2710 ± 40	+2.7	3180 ± 40	940–620 BC (95.4%)
Time interval 3						
Beta-239576	Fenceline Pit 35, 98–105 cm	*Cellana* sp. shell	5340 ± 40	+3.9	5180 ± 40	940–600 BC (95.4%)
Beta-239577	Fenceline Pit 35, 98–105 cm	Carbonized *Cocos nucifera* (coconut) endocarp	2820 ± 40	–25.4	2810 ± 40	1090–840 BC (95.4%)
Beta-239578	Fenceline Pit 35, 105–110 cm	*Anadara antiquata* shell	2710 ± 40	+1.5	3140 ± 40	1130–750 BC (95.4%)
Time interval 2						
Beta-253682	Fenceline Pit 35, 255–260 cm	*Halimeda* sp. algal bioclast	2980 ± 40	+5.3	3480 ± 40	1510–1300 BC (95.4%)
Beta-253681	Fenceline Pit 35, 250–260 cm	*Anadara antiquata* shell	3030 ± 40	–0.7	3430 ± 40	1460–1240 BC (95.4%)
Beta-239579	Fenceline Pit 34, 150–155 cm	*Halimeda* sp. algal bioclast	3140 ± 40	–3.2	3500 ± 40	1540–1310 BC (95.4%)
Time interval 1, oldest						
Beta-253683	Fenceline Pit 35, 260–265 cm	*Heliopora coerulea* coral	3610 ± 50	+4.4	4100 ± 50	2370–2020 BC (95.4%)

[a]Calibrations are by OxCal v 3.0 (Bronk Ramsey 1995, 2001), using IntCal09 for charcoal samples and Marine09 for marine samples (Reimer et al. 2009). Calculations of ΔR are summarized in Table 2 and discussed in the text.

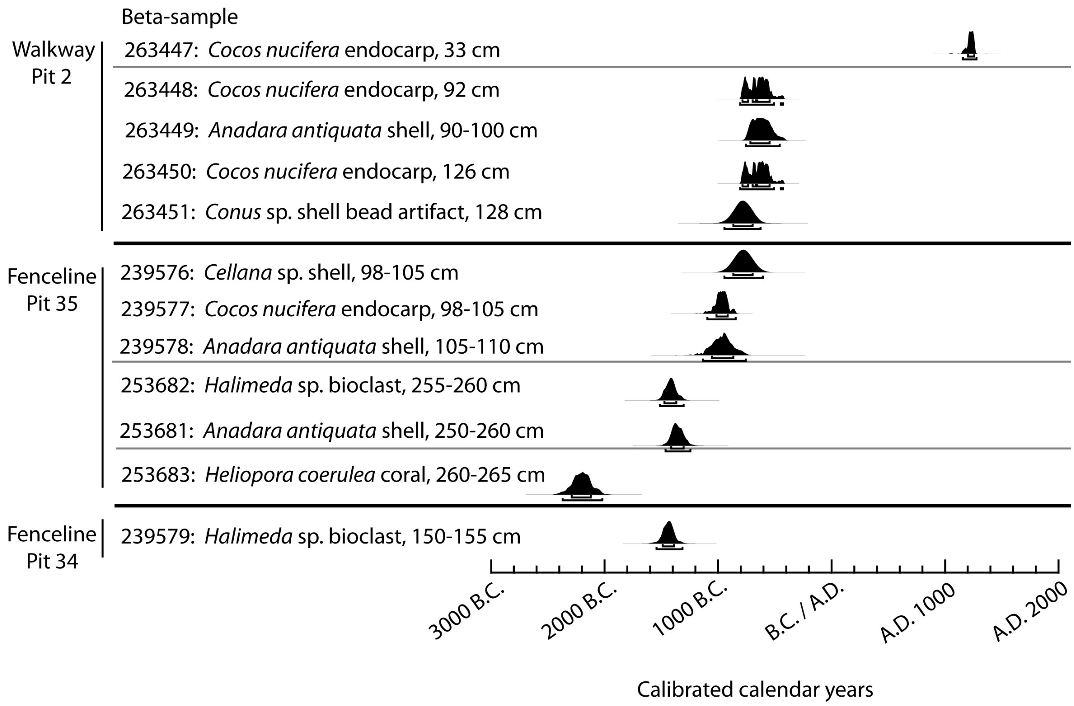

Figure 4 Probability distributions of calibrated ^{14}C dates. Calibrations are by OxCal v 3.0 (Bronk Ramsey 1995, 2001), using IntCal09 for charcoal samples and Marine09 for marine samples (Reimer et al. 2009). Calculations of ΔR are summarized in Table 2 and discussed in the text.

All 4 charcoal samples (Beta-263477, -263448, -263450, and -239577) were concentrations of carbonized *Cocos nucifera* (coconut) endocarp fragments. The consistent use of the same type of sample material provided more confidence in the comparison of results, especially when comparing the ^{14}C ages of multiple marine materials. Coconut endocarps are recognized as short-lived specimens, without significant in-built old age, ideal for ^{14}C dating of archaeological contexts when found in secure stratigraphic position (Allen and Wallace 2007). The Ritidian specimens were selected from dense concentrations unlikely to have moved or to have been contaminated by materials of varying ages. These particular concentrations ranged from 5 to 50 g in each occurrence, although only small fractions of each concentration were processed for ^{14}C dating.

The ΔR value was calculated for different paired marine and terrestrial samples, summarized in Table 2. On the basis of these findings, other non-paired samples could be evaluated for potential ^{14}C dating. One sample of *Cellana* sp. (limpet) shell (Beta-239576) was selected despite the taxon being known to reflect the age of localized substrates, potentially highly variable and thus unreliable (Dye 1994).

In northern Guam, for instance, limpet shellfish live on coral and fossil reef exposures of variable ages, presumably contributing to an unknown storage age. The *Cellana* sp. shell sample (Beta-239576) was paired with a coconut endocarp sample (Beta-239577). The ΔR value was calculated rather high at 2683 ± 58 ^{14}C yr. This result verifies expectations that limpet shells potentially can provide very old apparent ^{14}C ages. Moreover, this 1 ΔR value may not be appropriate for other specimens from the same region, so the utility of this result is probably minimal at present.

Table 2 Calculation of ΔR values for samples from Ritidian, Guam.

Lab nr (Beta-)	Provenience	Sample material	Conv. ^{14}C age (BP)	Equivalent marine model age (BP = Rg(t))	ΔR = Rs(t)–Rg(t)
263448	Walkway Pit 2, 92 cm	Carbonized *Coconos nucifera* (coconut) endocarp	2510 ± 40	2913 ± 43	—
263449	Walkway Pit 2, 90–100 cm	*Anadara antiquata* shell	2810 ± 40	—	–103 ± 59
263450	Walkway Pit 2, 126 cm	Carbonized *Coconos nucifera* (coconut) endocarp	2510 ± 40	2913 ± 43	—
263451	Walkway Pit 2, 128 cm	*Conus* sp. shell bead artifact	3180 ± 40	—	267 ± 59
239577	Fenceline Pit 35, 98–105 cm	Carbonized *Coconos nucifera* (coconut) endocarp	2810 ± 40	3127 ± 42	—
239576	Fenceline Pit 35, 98–105 cm	*Cellana* sp. shell	5810 ± 40	—	2683 ± 58
239578	Fenceline Pit 35, 105–110 cm	*Anadara antiquata* shell	3140 ± 40	—	13 ± 58

Of several *Conus* sp. shell bead artifacts, 1 bead was selected for ^{14}C dating (Beta-263451), paired with a coconut endocarp sample (Beta-263450). The ΔR was calculated at 267 ± 59 ^{14}C yr, evidently including some storage age in the *Conus* sp. shell bead. The apparent older age may be due to the habit or habitat of the *Conus* sp. shellfish, or it may be due to the possible multigenerational curation of the original beaded artifact as an heirloom. In any case, other research has shown that mobile gastropods such as *Conus* sp. potentially can yield variable ^{14}C age due to localized variation in substrates (Dye 1994), so this 1 ΔR value for a *Conus* sp. shell bead may be regarded as only a beginning for further study of potential variability in apparent ^{14}C age. Future results may prove useful for studies such as proposed by DeFant (2008) for ^{14}C dating of *Conus* sp. shell beads found as grave goods.

Three samples of *Anadara antiquata* shells (Beta-263449, -239578, and -253081) pertained to shellfish that presumably lived in marshy settings or grass beds, although this kind of habitat no longer exists in the study area today. The shells presumably were discarded as food refuse at the site.

Anadara spp. are filter-feeding shellfish that do not ingest particulate detritus problematic for ^{14}C dating, but potentially they could be affected by ^{14}C variation in the water. At the Ritidian site, the *Anadara* sp. shellfish appear to have lived in a shallow-water setting on a bed composed mostly of short-lived *Halimeda* sp. algae, posing little if any opportunity to introduce older ^{14}C age due to resident time, storage age, bicarbonate ions in hardwater, or other factors.

One of the *Anadara antiquata* shells (Beta-239578) was paired with a coconut endocarp fragment (Beta-239577), incidentally the same specimen as paired with the apparently very old *Cellana* sp. (limpet) shell (Beta-239576). The ΔR was calculated at a rather minor 13 ± 58 ^{14}C yr, reflecting a remarkably good match of materials in this case. Another *Anadara antiquata* shell (Beta-263449) was paired with a different coconut endocarp sample (Beta-263448). In this case, the ΔR was calculated at –103 ± 59 ^{14}C yr, notably different from the other pairing yet overlapping within the same potential error range. The third *Anadara antiquata* shell (Beta-253681) was from the deepest and oldest cultural layer, lacking sufficient charcoal for a paired ^{14}C dating. However, pooling of the other 2 ΔR values offers a possible value of –44 ± 41 ^{14}C yr.

Two samples of *Halimeda* sp. algal bioclasts (Beta-253682 and -239579) were selected from a sandy matrix composed mostly of these bioclasts. In this layer, the *Halimeda* sp. bioclasts retain fresh (non-eroded) edges and therefore closely match their age of deposition, whereas eroded or damaged bioclasts in other contexts would reflect an unknown time-lag between death of the *Halimeda* sp. organism and later deposition in the sandy matrix. *Halimeda* sp. generally exhibit a lifespan of 2 to 12 months, not including any significant in-built old age and most likely offering a close match with the ^{14}C content of the local surface ocean. Moreover, Holmes (1983) reported that *Halimeda* spp. are in equilibrium with ocean waters with no significant storage age or other contamination applicable to ^{14}C dating.

The 2 *Halimeda* sp. samples (Beta-253682 and -239579) were obtained from 2 separate locations in the lowest cultural layer that did not yield sufficient charcoal for paired ^{14}C dating. The 2 samples yielded nearly identical ^{14}C ages of 3480 ± 40 BP (Beta-253682) and 3500 ± 40 BP (Beta-239579). The virtually duplicate result from the 2 locations suggests contemporaneity of deposition of the fresh *Halimeda* sp. bioclasts across the site.

One of the *Halimeda* sp. samples (Beta-253682) was paired with a dated *Anadara antiquata* shell (Beta-253681) of almost the same ^{14}C age, 3480 ± 40 and 3420 ± 40 BP, respectively. Presumably, the same ΔR would apply to these 2 specimens. For example, a pooled ΔR value of –44 ± 41^{14}C yr was proposed for the *Anadara antiquata* sample as described above.

The deepest cultural layer at Ritidian had been emplaced directly over a coral reef formation of *Heliopora coerulea*, and a sample of the uppermost coral growth was selected for ^{14}C dating (Beta-253683). The coral reef material must predate (or perhaps be equal to) the earliest cultural layer at the site. A precise ΔR cannot be calculated directly for the *Heliopora coerulea* sample (Beta-253683), but perhaps the value –44 ± 41 ^{14}C yr is appropriate, equivalent to the pooled value of paired *Anadara antiquata* shells (Beta-263449 and -239578), with a result of 2370–2020 cal BC.

DISCUSSION

The ^{14}C dates from Ritidian relate to 5 time intervals, coordinated with distinct strata:

1. The oldest time interval predates human use of the area, when the *Heliopora coerulea* coral reef was growing. The most recent stage of coral growth was dated approximately 2370–2020 cal BC. This time interval coincided with the maximum higher sea level in the mid-Holocene, generally 1.8 m higher than present but with localized variations (Dickinson 2000, 2003).
2. The second time interval refers to the earliest site use in an intertidal or shallow subtidal zone over the coral reef, apparently beginning around 1460–1300 cal BC. During this time, *Halimeda* sp. algal bioclasts were accumulating rapidly over the reef, and the area appears to have supported short-lived and small-scale fishing camp activity. This scope of activity is suggested by low frequency of pottery fragments, soot-coated shellfish remains, and very little other cultural material.
3. Shortly following the massive build-up of bioclastic sand, the beach formation continued with a composition of mixed intact and pulverized reef-derived calcareous materials, including both intact and damaged (eroded) *Halimeda* sp. bioclasts clearly not freshly deposited as in the earlier time interval. A similar scope of fishing camp activity continued but with more numerous individual campsites. One such campsite was dated around 940–840 cal BC, very shortly after the mid-Holocene highstand and when sea level had just begun a drawdown stage.
4. At least some patches of stable backbeach were available near the base of the limestone cliff, supporting intensive residential activity as early as 750–620 cal BC. The archaeological mate-

rials consist of dense concentrations of pottery fragments, stone tools, shell beads, shellfish remains, fish bones, and bones of reptiles and birds in a charcoal-rich ashy matrix. Although this form of habitation was intensive, it could not have supported a large population in the small patches of stable backbeach available at the beginning of this time interval. Residential use appears to have continued uninterrupted, though, over the next several centuries as the beach prograded and offered increasingly larger habitable space.

5. A very broad and stable sandy beach was available and intensively used for residential habitation by cal AD 1170–1290. The archaeological evidence includes the same range of materials as in the preceding time interval but with 4 important new developments. First, the larger stable beach landform supported widespread habitation on a scale much larger than was possible previously. Second, the uppermost surface-visible layer is associated with megalithic stone architecture pillars and capstones called *latte* and thought to represent ruins of formal village systems. Third, stone food pounders and mortars reflect more intensive food production. Fourth, the pottery fragments were broken from large bowls and jars suitable for heavy use and large-scale storage, cooking, and serving as expected of a large population base.

CONCLUSION

The ^{14}C results verify the Ritidian site among the earliest securely dated archaeological sites in Guam and the Marianas region. First site use apparently occurred around 1460–1300 cal BC at Ritidian, as compared to 1500 cal BC as the approximate date of first human presence in the Marianas region (Carson 2008).

Paired terrestrial and marine samples provide a basis to calculate ΔR values for a few different types of marine materials and to evaluate their suitability for archaeological ^{14}C dating. *Anadara* sp. shells and intact *Halimeda* sp. algal bioclasts provided reliable results with confident control of factors involved in calculating ΔR. Items such as *Cellana* sp. (limpet) shells and *Conus* sp. shell beads are known in other cases to yield variable ranges of ΔR values depending on localized conditions, so the limited attempts of calculating their ΔR for the Ritidian case are not so helpful except to note that they differ greatly from the results for *Anadara* sp. and *Halimeda* sp. samples.

At least at Ritidian, *Anadara antiquata* shells provide a basis for a pooled ΔR value of –44 ± 41 ^{14}C yr. These shells apparently were not affected substantially by ^{14}C variation in the water or more than minimally by other factors. These same conditions may not apply for other sites, and a somewhat different ΔR value may need to be calculated for other cases.

Dating of other marine shells did not provide as much confidence as the results for *Anadara* sp. shells, partly due to the small number of samples in this study. One sample of *Cellana* sp. (limpet) shell offered a rather high ΔR value of 2683 ± 58 ^{14}C yr, but other samples may yield quite different results depending on local variations in substrate material. One *Conus* sp. shell bead artifact offered a ΔR value of 267 ± 59 ^{14}C yr, but additional dating of other such beads would be necessary in order to ascertain the potential variation in ΔR that is expected to be highly variable for *Conus* spp. overall (Dye 1994).

This study also showed the utility of ^{14}C dating of *Halimeda* sp. algal bioclasts, apparently most appropriate when found in freshly deposited, non-eroded condition, retaining intact morphology. Additional research, however, may be desirable to augment the present results, especially if suitable paired charcoal samples can be obtained from secure contexts.

Finally, the Ritidian research findings expose the possibility that the earliest archaeological evidence in Guam and the Mariana Islands may occur in similarly deep (2+ m) layers buried beneath culturally sterile beach sand. Previously, test pits have tended to be rather shallow (~1 m), and beds of culturally sterile sand often were interpreted as predating human use of an area. The new archaeological findings and ^{14}C results at Ritidian (see Appendix), however, demonstrate that early-period sites may be more numerous than has been ascertained by previous research methods.

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APPENDIX

Archaeological ^{14}C Dating Samples

All samples in this study were processed by Beta Analytic, Inc. (Beta-#), Miami, Florida, USA. Sample locations were recorded by survey-grade global positioning system (GPS), with sub-meter accuracy after post-processing. These locations are reported in Universal Transverse Mercator (UTM) Zone 55 North, using the World Geodetic Survey (WGS) datum of 1984. The study area was within the Ritidian Unit of Guam National Wildlife Refuge, coincident with Site 66-08-0012 as listed in the Guam Historic Preservation Site Inventory. Dates were calibrated using OxCal 3.0 (Bronk Ramsey 1995, 2001).

Beta-263447 Ritidian (66-08-0012) 790 ± 40 BP
Carbonized *Cocos nucifera* (coconut endocarp) fragment, collected from walkway pit 2, 33 cm below surface (Carson 2010b). Easting 268529.3, Northing 1510259.5, WGS84, Zone 55N.

Comment: cal AD 1170–1290 (2 σ); cal AD 1215–1270 (1 σ). δ^{13}C = –24.5‰.

Beta-263448 Ritidian (66-08-0012) 2510 ± 40 BP
Carbonized *Cocos nucifera* (coconut endocarp) fragment, collected from walkway pit 2, 92 cm below surface (Carson 2010b). Easting 268529.3, Northing 1510259.5, WGS84, Zone 55N.

Comment: 800–420 cal BC (2 σ); 780–540 cal BC (1 σ). δ^{13}C = –24.5‰.

Beta-263449 Ritidian (66-08-0012) 2810 ± 40 BP
Anadara antiquata marine shell, collected from walkway pit 2, 90–100 cm below surface (Carson 2010b). Easting 268529.3, Northing 1510259.5, WGS84, Zone 55N.

Comment: 750–450 cal BC (2 σ); 710–540 cal BC (1 σ). δ^{13}C = +2.1‰. ΔR = –103 ± 59.

Beta-263450 Ritidian (66-08-0012) 2510 ± 40 BP
Carbonized *Cocos nucifera* (coconut endocarp) fragment, collected from walkway pit 2, 126 cm below surface (Carson 2010b). Easting 268529.3, Northing 1510259.5, WGS84, Zone 55N.

Comment: 800–420 cal BC (2 σ); 780–540 cal BC (1 σ). δ^{13}C = –24.0‰.

Beta-263451 Ritidian (66-08-0012) 3180 ± 40 BP
Conus sp. marine shell bead artifact, collected from walkway pit 2, 128 cm below surface (Carson 2010b). Easting 268529.3, Northing 1510259.5, WGS84, Zone 55N.

Comment: 940–620 cal BC (2 σ); 860–690 cal BC (1 σ). δ^{13}C = +2.7‰. ΔR = 267 ± 59.

Beta-239576 Ritidian (66-08-0012) 5180 ± 40 BP
Cellana sp. (limpet) marine shell, collected from fenceline pit 35, 98–105 cm below surface (Carson 2010a). Easting 268263.7, Northing 1510144.4, WGS84, Zone 55N.

Comment: 940–600 cal BC (2 σ); 860–690 cal BC (1 σ). δ^{13}C = +3.9‰. ΔR = 2683 ± 58.

Beta-239577 Ritidian (66-08-0012) 2810 ± 40 BP
Carbonized *Cocos nucifera* (coconut endocarp) fragment, collected from fenceline pit 35, 98–105 cm below surface (Carson 2010b). Easting 268263.7, Northing 1510144.4, WGS84, Zone 55N.

Comment: 1090–840 cal BC (2 σ); 1010–910 cal BC (1 σ). δ^{13}C = –25.4‰.

Beta-239578 Ritidian (66-08-0012) **3140 ± 40 BP**
Anadara antiquata marine shell, collected from fenceline pit 35, 105–110 cm below surface (Carson 2010a). Easting 268263.7, Northing 1510144.4, WGS84, Zone 55N.

Comment: 1130–750 cal BC (2 σ); 1050–860 cal BC (1 σ). $\delta^{13}C$ = +1.5‰. ΔR = 13 ± 58.

Beta-253682 Ritidian (66-08-0012) **3480 ± 40 BP**
Halimeda sp. algal bioclasts, collected from fenceline pit 35, 255–260 cm below surface (Carson 2010a). Easting 268263.7, Northing 1510144.4, WGS84, Zone 55N.

Comment: 1510–1300 cal BC (2 σ); 1470–1365 cal BC (1 σ). $\delta^{13}C$ = +5.3‰. ΔR = –44 ± 41.

Beta-253681 Ritidian (66-08-0012) **3430 ± 40 BP**
Anadara antiquata marine shell, collected from fenceline pit 35, 250–260 cm below surface (Carson 2010a). Easting 268263.7, Northing 1510144.4, WGS84, Zone 55N.

Comment: 1460–1240 cal BC (2 σ); 1410–1300 cal BC (1 σ). $\delta^{13}C$ = –0.7‰. ΔR = –44 ± 41.

Beta-239579 Ritidian (66-08-0012) **3500 ± 40 BP**
Halimeda sp. algal bioclasts, collected from fenceline pit 34, 150–155 cm below surface (Carson 2010a). Easting 268283.5, Northing 1510126.1, WGS84, Zone 55N.

Comment: 1540–1310 cal BC (2 σ); 1485–1385 cal BC (1 σ). $\delta^{13}C$ = –3.2‰. ΔR = –44 ± 41.

Beta-253683 Ritidian (66-08-0012) **4100 ± 50 BP**
Heliopora coerulea coral, collected from fenceline pit 35, 260–265 cm below surface (Carson 2010a). Easting 268263.7, Northing 1510144.4, WGS84, Zone 55N.

Comment: 2370–2020 cal BC (2 σ); 2290–2120 cal BC (1 σ). $\delta^{13}C$ = +4.4‰. ΔR = –44 ± 41.