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Changes in Species Composition of Archaeological Marine Shell Assemblages in Guam

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Abstract—Marine shell assemblages from archaeological excavations in Guam vary in species composition from one part of the island to another and from one time period to another. Cultural deposits dating to the Pre-Latte Phase (c. 3500 to 1000 years before present [BP]) in Tumon Bay and East Agana Bay have yielded mostly bivalves, while Latte Phase (c. 1000 years BP to AD 1521) deposits have yielded mostly gastropods, especially *Strombus*. However, in Latte Phase shell assemblages from southern Guam, bivalves consistently outweigh gastropods, but there are changes in the relative abundance of the various bivalve species. Relative sea level decline may explain the differences between the earlier and later shell assemblages from Tumon Bay and East Agana Bay. The geology of Guam probably accounts for the differences between the shell assemblages from Tumon Bay and East Agana Bay compared with assemblages from sites farther south.

Introduction

Archaeological research on Guam within the last 20 years has produced a wealth of data including information about the marine mollusks collected and consumed by the prehistoric and historic people. Changes have been observed in the species composition of marine shell middens from one part of the island to another and from one time period to another in the same area, and questions have been raised about the causes and significance of the changes.

When Leidemann (1980) inventoried the artifacts and marine shells from the Ypao Beach excavations on Tumon Bay, Guam, she found that shells of two families of bivalves greatly outnumbered shells of all other families in the farthest inland excavation units, while in the more seaward units shells of the gastropod family Strombidae were the most numerous. Based on the pottery types contained in the various excavation units, Leidemann assigned the farthest inland units to the Pre-Latte Phase (c. 3500 to 1000 years BP) and the more seaward units to the Latte Phase (c. 1000 years BP to AD 1521) of Marianas prehistory (Table 1).

Although Leidemann recorded the changes in frequency of shells from different families, she did not comment on the significance of the changes.

Table 1. Spoehr's (1957) broad phases of Marianas prehistory as subdivided by Moore and Hunter-Anderson (1996), based on changes in the pottery sequence. Dates are given in years before present (BP).

Pre-Latte Phase	
Early Pre-Latte	3500 to 2500 years BP
Intermediate Pre-Latte	2500 to 1600 years BP
Transitional	1600 to 1000 years BP
Latte Phase	1000 years BP to AD 1521

Reviewing Leidemann's data, Graves & Moore (1985:38) summarized the results of the Ypao Beach shell inventory:

> If we can infer, based on the previous discussion of pottery that the larger 4 × 4 m square preserves materials dating to the Prelatte Period, and that the upper levels of the other excavation units contain materials from later Prelatte components or the Latte Period occupation at the site, then the exploitation of shellfish changed over time at this prehistoric settlement. Initially, the population emphasized the collection of bivalves, but later gastropods increased in relative abundance, so that by the Latte Period the collecting strategy was overwhelmingly devoted to Strombidae.

Graves & Moore (1985) excavated 15 one-meter squares and one 1 × 2-m trench along Tumon Bay. In all but one of the units, gastropods outweighed bivalves. Even in the farthest inland units, which were radiocarbon-dated to the Pre-Latte Phase, gastropods weighed approximately five times as much as bivalves. The most abundant family of gastropods was the Strombidae, but the percentage by weight of strombids within the gastropods varied. In the Pre-Latte units, strombids made up 37 and 49 percent of the gastropods, while in two Latte Phase units, the strombids amounted to 89 and 91 percent of the gastropods (Graves & Moore 1985:Table 5.16).

The most abundant bivalve family in the Pre-Latte units was the Arcidae, which accounted for 61 and 45 percent of the weight of bivalves (Graves & Moore 1985:Table 5.18). This family was absent or rare in more recent units. Graves & Moore (1985:143) noted that this is in contrast with other areas of Guam such as Asan and Agana, where Arcidae shells are among the most abundant bivalves in Latte Phase deposits.

Taking into account Leidemann's shell analysis and their own, Graves & Moore (1985:145) concluded the following:

> Although a variety of shellfish was collected throughout the prehistoric occupation of Tumon Bay, bivalves were exploited early in time and were replaced by an emphasis on the collection of gastropods, particularly Strombidae, late in time. If Arcidae were at one time collected within the Bay, it appears they become locally extirpated by the Latte Period. Alternatively, Arcidae may have been collected from lagoons to the south, and over time as human population increased access to such areas may have been restricted.

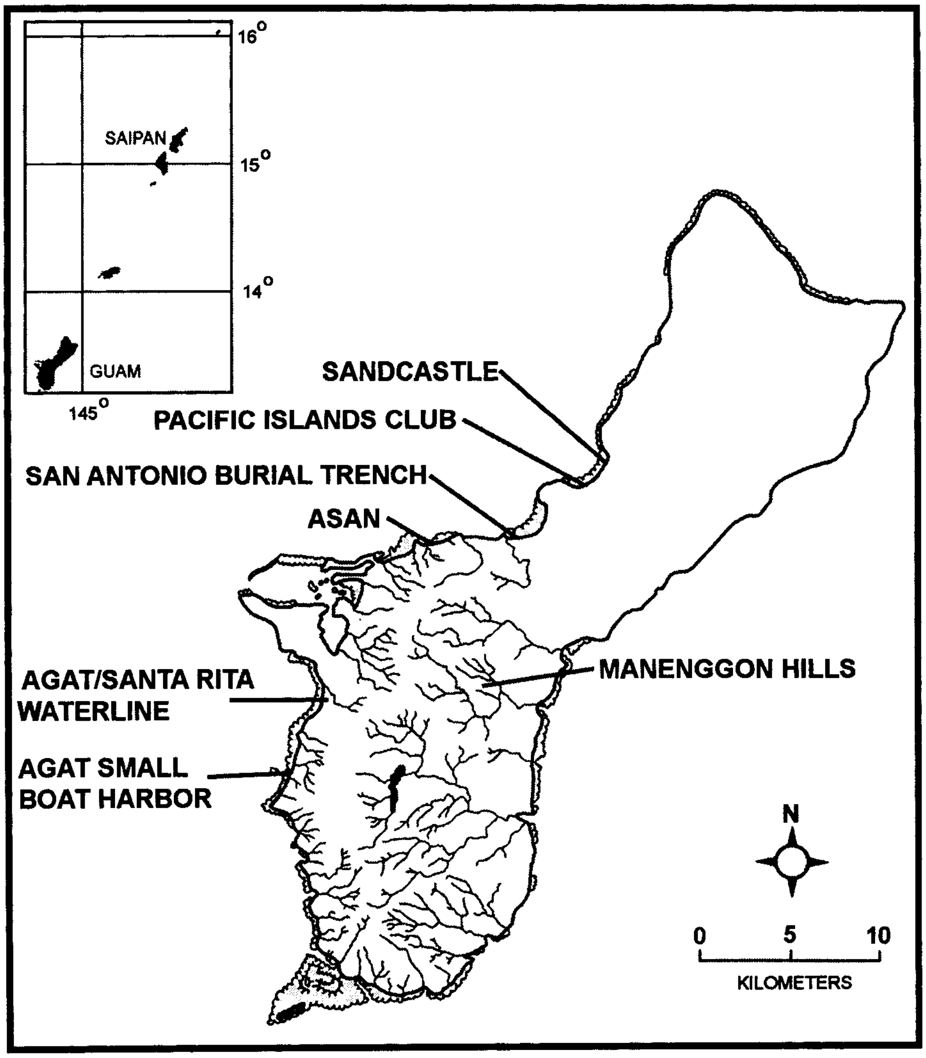

Figure 1. Guam, showing the location of the archaeological sites discussed and showing the drainage patterns. Inset: Southern arc of the Mariana Islands.

The work of Leidemann (1980) and Graves & Moore (1985) raised questions about the collection and consumption of shellfish during the Prehistoric Period. Was there, in fact, a shift through time from collecting of bivalves to collecting of gastropods? If so, was the shift a matter of human preference? Did the Pre-Latte people prefer clams, over-harvesting them to the point that it became necessary to eat snails? Or could some environmental change account for the changes in the species composition of the archaeological shell assemblages? Did that shift from collecting of bivalves to gastropods take place only at Tumon Bay or throughout

Guam? If the family Arcidae was collected in Tumon Bay, why was it eliminated there before the Latte Phase, while it continued to thrive in other parts of the island? Recent archaeological work in Guam has yielded information that helps to answer these questions.

Methods

Archaeological excavations took place at six sites along the west coast of Guam. From north to south, the sites are located at the Sandcastle and Pacific Islands Club properties in Tumon Bay, at the San Antonio Burial Trench in Agana, in Asan, and at the Agat/Santa Rita Waterline and Agat Small Boat Harbor (Fig. 1). Excavations were also conducted at the interior upland southern Guam sites of Manenggon Hills.

Marine shell was collected from the archaeological excavations with 1/8" screen (Amesbury et al. 1991, Hunter-Anderson 1989, Moore et al. 1990, 1993, 1995) or 1/4" screen (Graves & Moore 1986). In some cases, the shell collected with 1/8" screen was re-screened through 1/4" mesh (Moore et al. 1993, 1995).

The shells were identified to the family level and, when possible, to genus or species, and counted and weighed. Whole shells and fragments were counted and

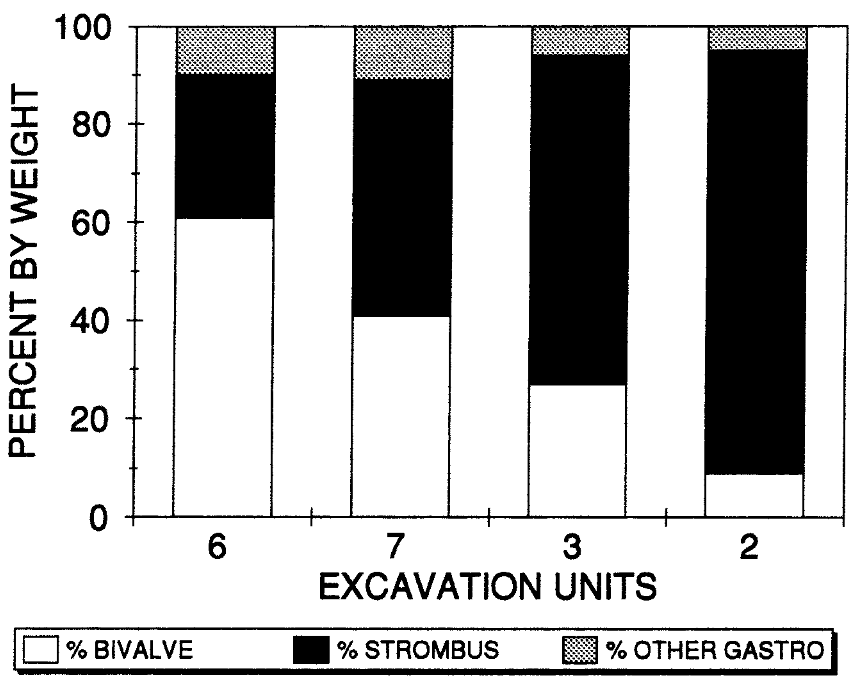

Figure 2. Percentages of bivalves, *Strombus*, and other gastropods from Excavation Units 2, 3, 6, and 7 at Sandcastle, Tumon Bay, Guam. The excavation units are shown in order of their proximity to the shoreline; Unit 6 is farthest inland and Unit 2 is closest to the shoreline.

Table 2. Percentages by weight of bivalves and gastropods, as well as *Strombus*, in the total identified marine shell from excavation units dating to the Prehistoric Period and early Historic Period along the west coast of Guam. The sites are arranged from north to south.

	Bivalves	Gastropods	*Strombus*
1. Sandcastle			
Unit 2	9	91	86
Unit 3	27	73	67
Unit 7	41	59	48
Unit 6	61	39	29
2. Pacific Islands Club			
Scuba Pool Earth Oven	2	98	89
Biofilter Trench Layer IV	1	99	94
Biofilter Trench Layer V	5	95	92
Unit 3	11	89	82
Sample 5	37	63	52
Sample 7	57	43	26
Sample 8	42	58	30
3. San Antonio Burial Trench			
Unit 0	48	52	39
Unit 1	50	50	41
Unit 2	44	56	46
Unit 3	51	49	41
Unit 4	47	53	45
Unit 5	46	54	49
3-4 Ext.	46	54	44
4. Asan			
PSI-5	67	33	7
10-11	62	38	9
12-13	56	44	5
5. Agat/Santa Rita Waterline			
Sample 1	79	21	8
Sample 2	81	19	9
Sample 3	88	12	6
Sample 4	48	52	49
Sample 5	100	0	0
Burial 1	89	11	8
Burial 2	72	28	20
6. Agat Small Boat Harbor			
M9-Layer I	86	14	1
Layer IIa	96	4	1
Layer IIb	85	15	3
Layer III	82	18	2
O44-Layer I	88	12	4
Layer IIa	88	12	2
Layer IIb	87	13	1
Layer III	92	8	1

1. Moore et al. (1990)
2. Moore et al. (1993)
3. Amesbury et al. (1991)
4. Graves and Moore (1986)
5. Moore et al. (1995)
6. Hunter-Anderson (1989)

weighed separately. Percentages by weight of the total weight of identified shell were calculated for the various taxa.

Radiocarbon dates were obtained from Beta Analytic Inc., Miami, Florida. The dates are reported as radiocarbon years before present (present = AD 1950). Most were calibrated according to Klein et al. (1982). They have now been recalibrated according to Stuiver & Reimer (1993).

Results

Marine shell was analyzed from four excavation units at the Sandcastle property in Tumon Bay (Moore et al. 1990). The unit farthest inland had the highest percentage of bivalves, while the unit closest to the shore had the highest percentage of gastropods and the highest percentage of *Strombus* (Table 2, Fig. 2). The units in between had intermediate percentages, producing a continuum of decreasing bivalves, increasing gastropods, and increasing *Strombus* from the unit farthest inland to the unit closest to the shore. Radiocarbon dates indicated that the material farthest inland was older than the material closest to the shore. Layer I of Unit 6, the farthest inland unit, was older than Layer I of Unit 2, the most seaward unit (Table 3).

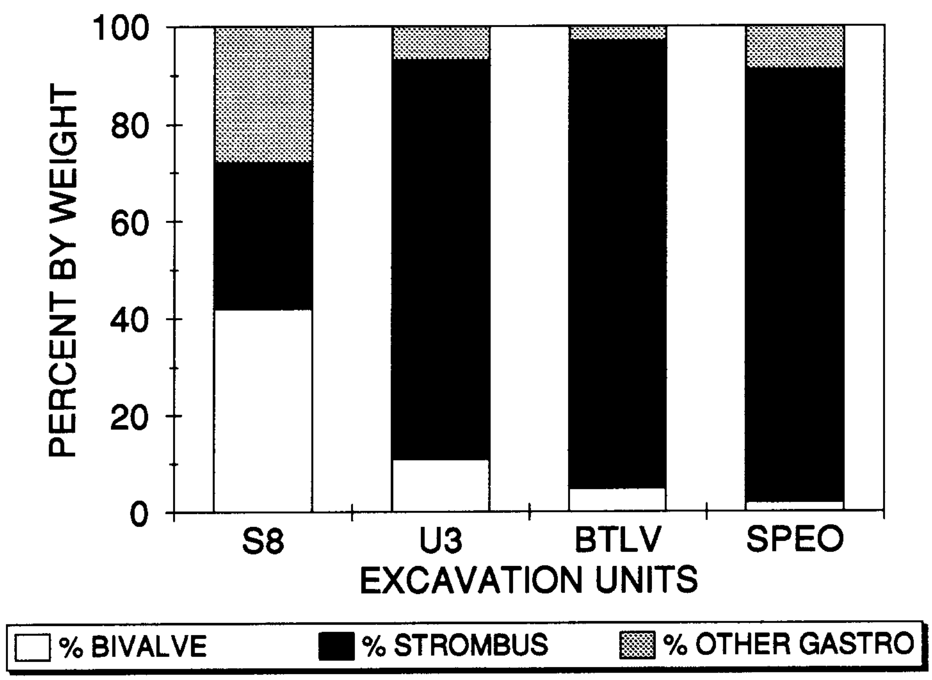

Figure 3. Percentages of bivalves, *Strombus*, and other gastropods from four dated samples or units at the Pacific Islands Club, Tumon Bay, Guam. Abbreviations stand for Sample 8, Unit 3, Biofilter Trench Layer V, and Scuba Pool Earth Oven. The units are shown in chronological order; Sample 8 is the oldest and the Scuba Pool Earth Oven is the most recent.

Table 3. Radiocarbon dates from excavation units along the west coast of Guam, sites arranged from north to south.

	Material	Beta #	Years BP* ^{14}C	$^{13/12}C$	Calendar Date as Originally Reported	Two-sigma Age Range (Stuiver and Reimer 1993)
1. Sandcastle					(Klein et al. 1982)	
Unit 2, Layer I	charcoal	28524	570+/-70		AD 1325-1430	AD 1289-1449
Unit 2, Layer II	charcoal	28525	840+/-70		AD 1060-1275	AD 1027-1293
Unit 6, Layer I	bulk soil	28526	830+/-70		AD 1055-1270	AD 1031-1296
Trench 5	shell	28530	960+/-60		AD 460-645	not recalibrated
2. Pacific Islands Club					(Klein et al. 1982)	
Scuba Pool Earth Oven	charcoal	60870	400+/-60	400+/-60	AD 1405-1620	AD 1419-1648
Biofilter Trench L. V	charcoal	60869	640+/-50	620+/-50	AD 1265-1405	AD 1287-1422
Unit 3, 30-40cmbd	charcoal	59888	890+/-70	840+/-70	AD 1050-1265	AD 1027-1293
Sample 8	shell	59890	470+/-60	920+/-60	AD 930-1235	not recalibrated
3. San Antonio Burial Trench					(Klein et al. 1982)	
Grid 0, 62-72cmbd (Burial 6)	charcoal	33393	820+/-50		AD 1040-1275	AD 1069-1288
Grid 0, 82-102cmbd	charcoal	33394	1130+/-80		AD 770-1025	AD 691-1147
Grid 1, 52-72cmbd	charcoal	36692	620+/-70	610+/-70	AD 1265-1405	AD 1279-1439
Grids 3&4, 72-82cmbd (Burial 5A)	charcoal	36690	970+/-60	975+/-60	AD 905-1215	AD 904-1213
Grids 3&4, 82-92cmbd (Burial 5B)	charcoal	36691	1010+/-70	1000+/-70	AD 890-1185	AD 895-1212
Grid 4, 62-72cmbd (Burial 2)	charcoal	33392	600+/-60		AD 1270-1410	AD 1284-1437
4. Asan						
PSI-5 35-50cm	charcoal	11678	450+/-80		AD 1500	AD 1327-1645
10D 50-55cm	shell	11679	1370+/-80	1780+/-80	AD 170**	not recalibrated
13D 105-120cm	shell	11680	3030+/-80	3470+/-80	1520 BC***	not recalibrated
5. Agat/Santa Rita Waterline						
Burial Trench Layer V	charcoal	69315		170+/-80		AD 1527-1955
6. Agat Small Boat Harbor						(Klein et al. 1982)
M9-Layer IIa, 59-80	charcoal	25095	340+/-50	330+/-50	AD 1420-1655	AD 1443-1664
Layer IIb, 80-100	charcoal	25096	600+/-50	560+/-50	AD 1315-1420	AD 1296-1441
Layer III,152-174	charcoal	24554	350+/-50	300+/-50	AD 1430-1660	AD 1452-1955
O44-Layer III, 140	wood	25097	1420+/-50	1360+/-50	AD 580-780	AD 603-776

1. Moore et al. (1990)

2. Moore et al. (1993)

3. Amesbury et al. (1991)

4. Graves and Moore (1986)

5. Moore et al. (1995)

6. Hunter-Anderson (1989)

*BP reference date for ^{14}C, $^{12/13}C$ dates is 1950.

**Date does not correspond with associated Historic and Latte Period materials.

***Date is earlier than expected given depth and associated cultural material. (Graves and Moore 1986:81,90).

Although percentage by weight of gastropods was higher in the two units closest to the shoreline compared with the two units farthest inland, the number of gastropod families present was lower in the two units closest to the shoreline. While percentage by weight of gastropods increased through time, the diversity of gastropods decreased.

A very similar pattern was revealed at the Pacific Islands Club (PIC) property, also in Tumon Bay (Moore et al. 1993). Seven units or samples were analyzed, four of which had associated radiocarbon dates (Tables 2, 3). The oldest of the four dated samples had the highest percentage of bivalves and lowest percentages of gastropods and *Strombus* (Fig. 3). The youngest of the four dated samples had the lowest percentage of bivalves, the highest percentage of gastropods, and the next to the highest percentage of *Strombus.* The two most recent samples from PIC were made up almost entirely of *Strombus.*

Moving south along the west coast of Guam, it appears that the shift from bivalves to gastropods, especially *Strombus*, also occurred in East Agana Bay (Amesbury 1994a, Brown & Haun 1989). However, close to the Agana River, at the San Antonio Burial Trench site (Amesbury et al. 1991), excavation units dating to the Latte Phase yielded shell assemblages composed almost equally of bivalves and gastropods (Tables 2, 3). Although the Strombidae were by far the most abundant gastropods, *Strombus* accounted for less than 50 percent of the marine shell weight in every unit. The most abundant bivalve in every unit was *Gafrarium* spp.

Continuing south through Asan (Graves & Moore 1986) and Agat (Hunter-Anderson 1989, Moore et al. 1995), there are increasingly higher percentages of bivalves, lower percentages of gastropods, and percentages of *Strombus* that dwindle almost to zero (Table 2). Although it appears that bivalves predominate in archaeological marine shell assemblages from southern Guam throughout the Prehistoric and early Historic Periods, changes in the abundance of various families through time have been detected.

At Asan, Graves and Moore (1986) noted a decline in diversity and a shift from smaller to larger bivalve species over time. The inland zones yielded more varied assemblages, while the beach zone yielded the least diverse assemblage. In the farther inland excavation units, the smaller bivalves, especially the Tellinidae and Veneridae, occurred in greater frequency, but the two largest bivalves, *Anadara* (family Arcidae) and *Tridacna*, occurred in greater frequency closer to the beach. (*Tridacna* was not only a food source, but also a resource for the manufacture of shell adzes.) In certain Asan units there was a strong shift from a more diverse bivalve assemblage in the lower levels to a less diverse assemblage in the upper levels. The upper levels dated to the late Prehistoric and early Historic Periods. The beginning of the increase in *Anadara* in the Asan unit PSI-5 was dated to approximately AD 1500 (Graves & Moore 1986:14, 96, 151).

Amesbury (1994b) found a pattern similar to that of Asan at the interior southern Guam sites of Manenggon Hills. There also, bivalves predominated in the marine shell assemblages. *Tridacna* was common in the marine shell found on

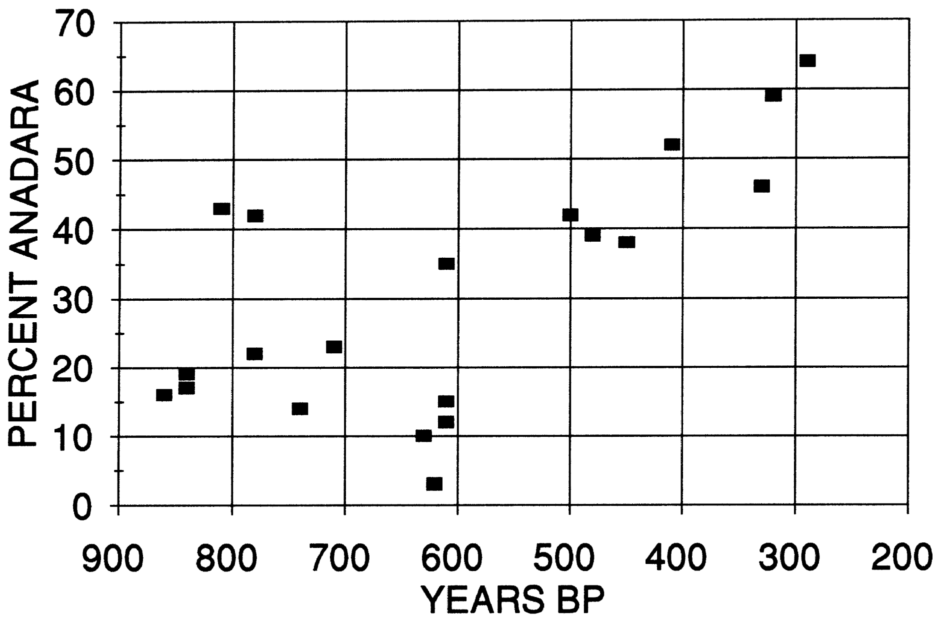

Figure 4. Relationship between radiocarbon dates in years BP ($^{13/12}C$ adjusted) and percentages of *Anadara* by weight in the analyzed marine shell of 20 midden units or features at Manenggon Hills, Yona, Guam.

the surface of sites. More than half the sites with surface shell had more than half the surface shell weight made up by *Tridacna.* The Arcidae and Veneridae composed the majority of subsurface (excavated) shell. These two families made up 50 percent or more of the subsurface shell weight from 30 of the 39 analyzed sites, units, or features.

It appeared that middens with higher percentages of *Gafrarium* (family Veneridae) dated to an earlier time than those with higher percentages of *Anadara* (family Arcidae), and that middens with relatively higher percentages of gastropods were earlier than those composed almost entirely of bivalves.

A significant negative correlation was found between the age of the unit and the percentage of *Anadara* by weight in the analyzed shell ($r = 0.673432$, d.f. = 18, $p < .01$, arcsine-transformed percentages), indicating an increase in the percentage of *Anadara* through time (Fig. 4). The increase was especially noticeable after about 500 years BP or approximately the same time as the beginning of the increase in *Anadara* at Asan. The relationships between the age of the unit and the percentages of *Gafrarium* and gastropods were not statistically significant, though the trend was for the percentages of both to decrease through time. Both *Gafrarium tumidum* and *G. pectinatum* are found at Manenggon, but *G. tumidum* appears to be the more abundant species there (Hunter-Anderson et al. 1994)

Discussion

Southwest Saipan

The changes in abundance of bivalves and gastropods at Tumon Bay, Guam, are similar to changes observed in southwest Saipan (Amesbury et al. 1996) (Figs. 5, 6). At the Chalan Piao excavations conducted by Micronesian Archaeological Research Services (MARS) (Moore et al. 1992), bivalves made up more than 90 percent of the weight of marine shell, and the genus *Anadara* (family Arcidae) accounted for more than 50 percent. Dates of 3210 ± 100 ^{14}C years BP (calibrated to 1731-1226 BC) and 2930 ± 90 ^{14}C years BP (calibrated to 1396-865 BC) were obtained from charcoal from the bottom and top of Layer 2, respectively. The calendar dates are the two-sigma calibrated age ranges (Stuiver & Reimer 1993).

A previous excavation at Chalan Piao, in Thomas & Price's (1980) Section C1, somewhat west of the MARS excavation, also yielded shell remains that were

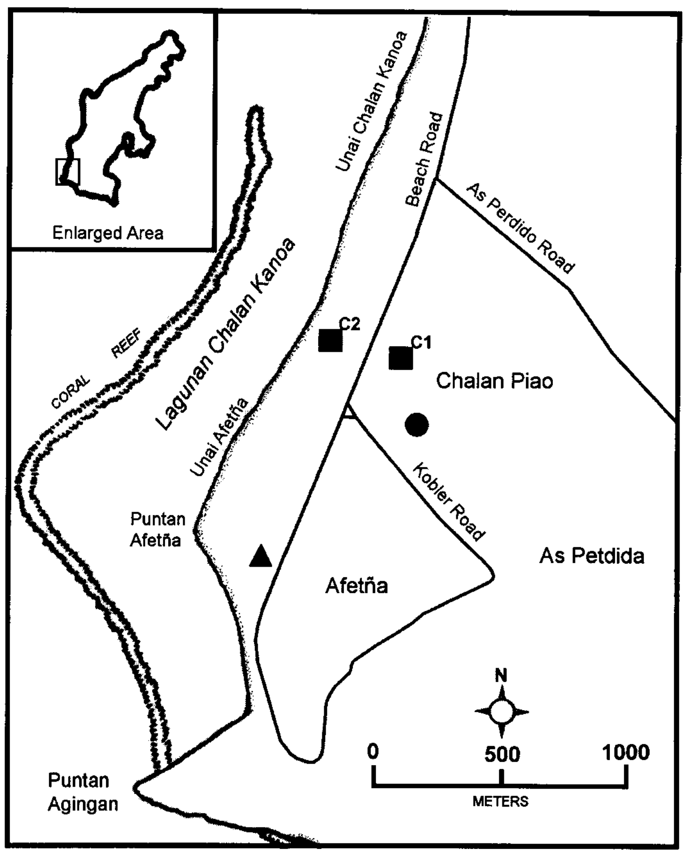

Figure 5. Southwest Saipan, showing four excavations in the vicinity of Chalan Piao. Circle = Moore et al. 1992; Squares = Thomas and Price 1980; Triangle = McGovern-Wilson 1989. Inset: Saipan.

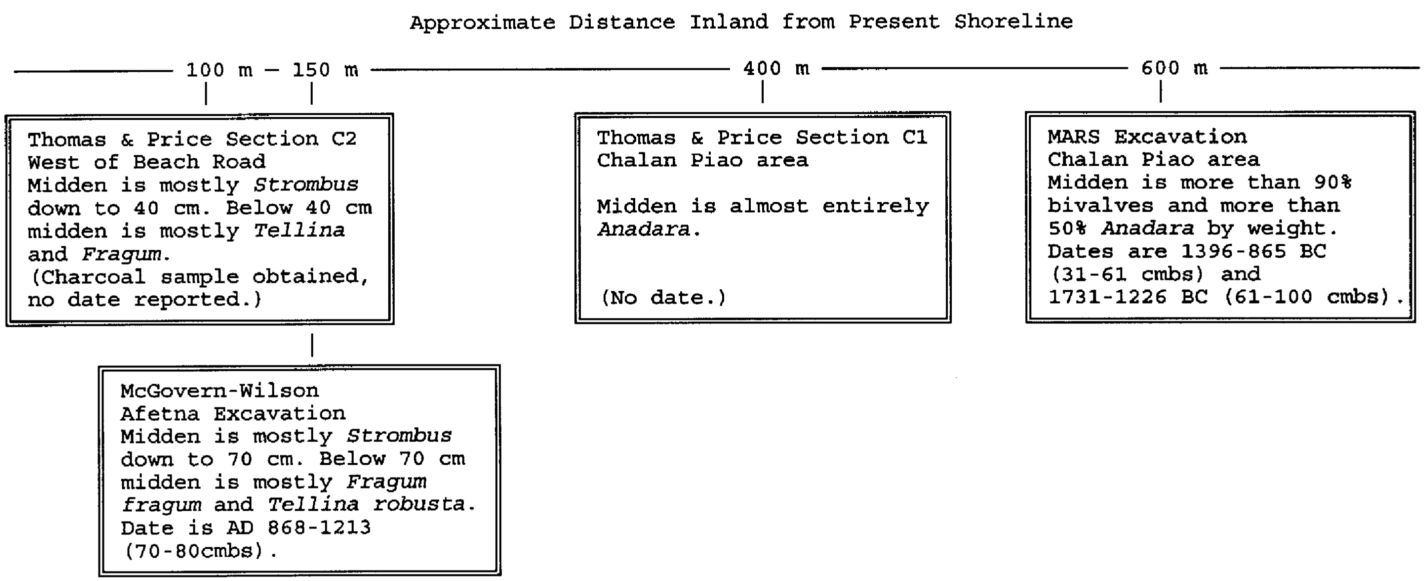

Figure 6. Comparison of marine shell midden from four excavations in southwest Saipan, showing changes correlated with distance inland from the present shoreline.

mostly *Anadara*. However, in an excavation unit in Section C2, a few hundred meters closer to the present shoreline, Thomas & Price (1980) found that *Strombus* was the most numerous shell in the top 40 cm. Below 40 cm, small bivalves, *Tellina* sp. and *Fragum fragum,* were the most numerous. No radiocarbon dates were reported for the Thomas & Price excavations, though charcoal samples were collected from the Section C2 excavation.

At the Afetna excavation, also closer to the present shoreline than the MARS Chalan Piao excavation, McGovern-Wilson (1989) found that *Strombus* was the most numerous shell in the top 70 cm, while *Fragum fragum* and *Tellina robusta* were the most numerous shells below 70 cm. McGovern-Wilson obtained three radiocarbon dates from small *Tridacna* shells (McGovern-Wilson 1989:70). He applied a marine reservoir correction of 450 ± 35 years, after Bonhomme & Craib (1987:99), and calibrated the dates according to Stuiver & Pearson (1986). Amesbury et al. (1996) recalibrated the dates according to Stuiver & Reimer (1993). The two-sigma age range for the 70-80 cm level, AD 868–1213 (Amesbury et al. 1996:56), indicates that the transition from a majority of bivalves to a majority of gastropods occurred in this area around AD 1000.

It appears, then, that in southwest Saipan, *Anadara* was harvested very early during the Pre-Latte Phase. By the Transitional Phase (c. 1600 to 1000 years BP), *Anadara* had been replaced by the smaller bivalves belonging to the Tellinidae and Cardiidae families. Finally by the Latte Phase, *Strombus* was the most commonly harvested shell.

What is the explanation for these changes? Did the prehistoric people prefer bivalves, especially the large *Anadara,* over-exploiting these populations until they were forced to collect the smaller bivalves and then mainly gastropods? Or was there some change in the habitats of the mollusk communities that favored *Strombus* over the bivalves?

Paulay (1992) concluded that while the *Anadara*-to-*Strombus* sequence could be the result of either a change in the environment or an increase in human harvesting pressure, the most likely explanation is environmental change caused by relative sea level decline, with human harvesting playing a minor role.

Randall (1992) found evidence at Chalan Piao and elsewhere around the island of Saipan for a higher than present relative sea level up until about 3000 years BP. The evidence from Chalan Piao included a number of massive *Porites* coral heads, the upper surfaces of which were higher than the present seawater level in the lagoon. A sample from the upper surface of one of the corals was dated by Geochron Laboratory to 4125 ± 115 years BP (GX-15327). More widespread evidence for relative sea level decline at Saipan includes emergent Holocene reef deposits at Laulau Bay and numerous +2.0 meter notches cut into rocky shorelines.

The *Anadara* in the Mariana Islands is *Anadara antiquata* (Linné, 1758) (Paulay 1996). Tebano & Paulay (n.d.) report that *Anadara antiquata* is preferentially associated with mangroves in Guam and Fiji, and the patchy distribution of the species in the central Pacific is probably related to the patchy distribution of its preferred habitat. On Guam, *Anadara* is presently found only in inner Apra Harbor where it inhabits silty sand seaward of a mangrove fringe (Paulay 1992). Because mangroves are sensitive to sea level change (Woodroffe et al. 1985), a relative decline in sea level about 3000 BP would explain the disappearance of *Anadara* after the early Prehistoric Period. Paulay (1992) also noted that falling sea levels would kill large areas of reef, which, when covered by shallow sands, would provide a habitat favorable to *Strombus.*

Tumon Bay, Guam

There is also evidence for relative sea level decline in Guam and at Tumon Bay. Based on their study of Merizo Limestone, Easton et al. (1978:9–10) conclude that there has been a relative sea level decline of about two meters within the last 3000 to 4000 years. Kayanne et al. (1993) think that the sea level rose gradually between 6000 and 4200 years BP and reached its highest position no earlier than 4200 years BP. According to these authors, sudden uplift occurred after 3200 years BP on Rota, north of Guam, and as late as 2350 years BP at Apra, Guam. This means that there has been a relative sea level decline at Guam after the beginning of human occupation about 3500 years BP. Bath (1986) has proposed various shorelines of Tumon Bay over the last 5000 years based on radiocarbon dates.

When Leidemann (1980) noted the spatial and temporal pattern of the cultural materials at Ypao Beach, she offered two possible explanations. One was that the people of the Pre-Latte and Latte Phases occupied different areas of the beach. The other was that the Latte Phase artifacts, lying stratigraphically above the Pre-Latte artifacts, had been moved closer to the shoreline by wave action. A more likely explanation is that the beach area closest to the present shoreline had not yet formed in Pre-Latte times. Beach areas of Tumon Bay on Guam’s west coast have emerged or prograded during the last 3000 years, as archaeological studies have shown (Bath 1986, Graves & Moore 1985).

If relative sea level decline is the explanation for the mollusk sequence (*Anadara* to smaller bivalves to *Strombus*) in southwest Saipan, it may also be the explanation for the transition from bivalves to gastropods in Tumon Bay and East Agana Bay, Guam.

Graves & Moore (1985) suggested that the *Anadara* shells recovered from the Pre-Latte Tumon Bay excavation units may not have been harvested in Tumon Bay, because *Anadara* did not occur in the later excavation units there. The Marianas species of *Anadara* prefers mangrove habitats and is not presently found in Tumon Bay, which lacks mangroves. Mangrove swamps may have been more widespread around Guam prior to the relative sea level decline within about the last 3000 or 4000 years.

Mangroves frequently occur in silty habitats at the mouths of rivers, and there are no rivers that drain into Tumon Bay. However, Woodroffe (1987) has described four environmental settings for Pacific island mangroves: (1) deltaic estuarine mangrove swamps, (2) embayment/harbor/lagoon mangroves, (3) reef flat mangroves, and (4) inland mangroves and depressions. If Lugo (1990:5) is correct in stating that "freshwater mixes with seawater at some point in time during the life history of stands" of all mangroves, then the seeps and springs along Tumon Bay (Jocson 1998, Matson 1993) may have provided sufficient freshwater.

In addition to *Anadara*, another silty-habitat bivalve, *Isognomon isognomum*, which may also be associated with mangroves, was found at Tumon Bay. *Isognomon* shells were used by the prehistoric people to make fishhooks, and fragments of the shells are found in virtually all prehistoric coastal sites of Guam (e.g., Amesbury et al. 1991, Graves & Moore 1986, Hunter-Anderson 1989, Moore et al. 1990, 1993, 1995). However, at Sandcastle, Moore et al. (1990) found a dense cluster of whole *I. isognomum* shells with both valves intact in a non-cultural context (Backhoe Trench 5) at a depth of 1.5 meters. The radiocarbon date obtained from the shells (Table 3) falls within the Pre-Latte Phase. Several factors, including the abundance and completeness of the shells, the depth at which they were found, and the lack of associated cultural material, argue that the shells had lived in the location where they were found. Like *Anadara*, *I. isognomum* does not presently occur in Tumon Bay.

Anadara was less abundant in Graves and Moore's Tumon Bay Pre-Latte units than it was at Chalan Piao, Saipan, but the Tumon Bay Pre-Latte units yielded a later date. The earliest radiocarbon date from Graves & Moore's Pre-Latte units was 2290 ± 70 years BP (approximately 340 BC) obtained from *Strombus* shells (Graves & Moore 1985:125). It appears, then, that the MARS excavation of Chalan Piao sampled Early Pre-Latte (c. 3500 to 2500 years BP) deposits, but that the Graves and Moore Tumon Bay Pre-Latte units sampled Intermediate Pre-Latte (c. 2500 to 1600 years BP) deposits. The Anadara from Tumon Bay may have been harvested almost 1000 years after the more abundant *Anadara* from southwest Saipan.

The most numerous early bivalves at Ypao Beach belong to the family that Leidemann identified as Mactridae (Leidemann 1980:90), but is more likely Mesodesmatidae (Moore et al. 1990:112-113). Although no radiocarbon dates have been published for the Ypao Beach materials, Graves & Moore (1985:36) suggested that the earliest occupation there probably dates to at least 900–1000 BC. That would mean that the Chalan Piao and Ypao Beach Early Pre-Latte deposits are more nearly contemporaneous than the Chalan Piao and Graves and Moore Tumon Bay Pre-Latte units. Leidemann (1980) did record the family Arcidae at Ypao Beach, which occurred with greater frequency in the farthest inland units, but which did not outnumber the Mesodesmatidae and Veneridae.

Although the presence of *Anadara antiquata* and *Isognomon isognomum* in deposits dating to the Pre-Latte Phase in Tumon Bay does not definitely indicate mangrove habitat, it does indicate that Tumon Bay was siltier than it is now, and it raises the possibility that mangroves were present at Tumon Bay during the Pre-Latte Phase. Additional evidence, such as pollen or wood remains, is needed to determine whether mangroves existed there.

Southern Guam

The differences in abundance of mollusks from the west coast Guam sites north and south of the Agana River probably reflect geological differences between northern and southern Guam. The northern half of Guam is a limestone plateau, while the southern half is a volcanic upland (Tracey et al. 1964). A low mountain chain parallels the west coast 3–4 km inland in the southern part. There are no rivers or streams on the northern plateau, because rainwater quickly drains into the porous limestone. The volcanic south, however, is dissected by numerous streams, which empty into bays around the southern coast (Fig. 1). According to Paulay (1992), the rainfall runoff in volcanic southern Guam produces abundant deep sand marine habitats favorable to bivalves. The high percentages of bivalves in the archaeological marine shell assemblages from southern Guam reflect the abundance of bivalves found in the waters there.

Agana Bay appears to be the place on the west coast that divides northern Guam from southern Guam with regard to the archaeological shellfish trends. As was noted above, it appears that the bivalve-to-*Strombus* shift did take place in East Agana Bay, but archaeological marine shell collections made close to the Agana River are made up of almost equal weights of bivalves and gastropods. The sediments deposited by the Agana River, which is the northernmost river on Guam, provide good habitats for bivalves. This probably accounts for the relatively higher percentages of bivalves near the river.

The changes in abundance of the different bivalve families in collections from southern Guam remain to be explained. These include the changes at Asan from the smaller bivalves to the larger bivalves, including *Anadara*, as well as the similar increase in *Anadara* in the Manenggon Hills sites. If the disappearance of *Anadara* in southwest Saipan and in Tumon Bay early in the Prehistoric Period is linked to the disappearance of mangrove habitats due to relative sea level decline within the last 3000 or 4000 years, the later increase of *Anadara* at Asan and Manenggon may be indicative of an increase in mangrove habitats in southern Guam in more recent times. Pollen evidence supports this idea.

Athens & Ward (1995) obtained pollen samples and radiocarbon samples from Core 2 at Tipalao Marsh on the southern part of the Orote Peninsula, Guam. Those samples indicate the presence of a mangrove swamp about 5000 years ago. Pollen samples that contain more than 50 percent mangrove taxa have been found to represent mangrove swamps (Grindrod 1985), and the basal sample from Pollen Zone 2 of Core 2, which dated to more than 5000 years BP, contained more than 65 percent pollen from the mangrove genera *Rhizophora* and *Bruguiera*. Mangrove pollen dropped to 15 percent or less by 4000 BP. However, the uppermost meter of the core, representing approximately the last 2000 years, reveals an increase in mangrove pollen.

Ward (1995) also reports two peaks in mangrove pollen in the Laguas River Core 2 from southwest Guam. In the earlier Pollen Zone A2, *Rhizophora* pollen peaks at about 40 percent prior to 8000 years BP. But in the later Pollen Zone C2, *Rhizophora* pollen increases to about 30 percent just over 1000 years BP. If the mangrove pollen in the top portions of these two cores is indicative of an increase in mangroves in southern Guam, this would help to explain the increase of *Anadara* during the last 500 years.

Conclusion

The evidence reviewed above supports the following propositions. The changes in species composition of the archaeological marine shell assemblages in Guam are most likely linked to environmental changes. The change from bivalves to *Strombus* in Tumon Bay and East Agana Bay is probably related to the relative sea level decline that has occurred within the last 3000 or 4000 years. The differences in the shell middens from sites north and south of the Agana River are most likely related to the geological differences of northern and southern Guam. The significance of the changes in the shell assemblages is that they indicate the coastal environment of Guam was different in the past. Tumon Bay probably was siltier during the Pre-Latte Phase and may even have supported mangroves, which disappeared due to the relative sea level decline. In southern Guam, the increase in *Anadara* during the Latte Phase and early Historic Period may indicate an increase of mangroves within the last 1000 years, which is also indicated by the southern Guam pollen cores.

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Note: Most of the archaeology in Guam has been done in the last 20 years. Much of the work is not published, but is contained in contract reports prepared for the clients. Copies are deposited at the Historic Resources Division of the Department of Parks and Recreation, the Micronesian Area Research Center at the University of Guam, and the Nieves M. Flores Memorial Library, Agana.

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