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SHELLFISH ASSEMBLAGES FROM TWO LIMESTONE QUARRIES IN THE PALAU ISLANDS

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ABSTRACT.—Archaeological excavation at two limestone quarries in the Rock Islands of Palau, Micronesia, yielded extensive shellfish assemblages. Both sites were inhabited by Yapese Islanders during the last several hundred years while they quarried limestone deposits for stone money disk production, but there are considerable differences in the preservation and types of shellfish recovered. Comparative analysis of shellfish from Omis Cave (B:OR-1:35) and Metuker ra Bisech (B:IR-2:24) show these differences can be attributed to site location (coastal versus inland), engineering activities associated with quarrying, and possibly cultural preference. This is the first report of faunal material recovered from Yapese stone money quarries and one of the few for Palau. These data have implications for understanding local subsistence strategies and how quarrying activities influenced the preservation of shellfish assemblages.

Key words: shellfish, taphonomy, stone money, Yap, Palau, Micronesia.

RESUMEN.—Las excavaciones arqueológicas en dos canteras de caliza en las Islas Rock de Palau, Micronesia, muestran extensas acumulaciones de conchas marinas. Ambos lugares estuvieron habitados por isleños yapeses durante los últimos varios cientos de años, como muestran los depósitos de tallado de caliza para la producción de dinero discoidal de piedra. Sin embargo, existen diferencias considerables en la preservación y tipos de conchas que han sido recuperados. Un estudio comparativo de las conchas de la Cueva Omis (B:OR-1:35) y de Metuker ra Bisech (B:IR-2:24) muestra que estas diferencias pueden ser atribuidas a la localización del lugar (en la costa versus en el interior de la isla), a actividades de ingeniería asociadas con la explotación de las canteras, y posiblemente a preferencias culturales. Este es el primer informe sobre material faunístico recuperado de las canteras de dinero de piedra yapese y uno de los pocos en Palau. Estos datas poseen implicaciones para la comprensión de las estrategias de subsistencia local y de cómo las actividades de explotación de cantera influyeron en la preservación de las acumulaciones de conchas.

RÉSUMÉ.—Les fouilles archéologiques de deux carrières de calcaire dans les Rock Islands de Palau en Micronésie, ont révélé de vastes collections de coquillages. Les deux sites étaient occupés par les populations de l'île de Yap au cours des siècles derniers. Ils exploitaient les gisements de calcaire pour la taille de disques de monnaie circulaires. L'état de préservation et les espèces de coquillage trouvés varient considérablement. Les analyses comparatives des coquillages provenant des cavernes Omis (B:OR-1:35) et Metuker ra Bisech (B:IR-2:24) montrent que ces différences peuvent être attribuées à l'emplacement du site (zone côtière/intérieur des terres), aux techniques d'exploitation des carrières, et peut-être, aux préférences culturelles. Ce compte rendu et le premier rapport consacré aux matériaux fauniques récupérés dans les carrières que les habitants de Yap exploitaient pour la fabrication de monnaie en pierre, et l'un des rares documents concernant Palau. Ces informations permettent de mieux comprendre les stratégies de subsistance locales et la façon dont les techniques d'exploitation des carrières ont influencé la préservation des collections de coquillages.

INTRODUCTION

Faunal material from archaeological sites provides a wealth of information regarding environment, human subsistence, and cultural processes through time. In Palau, Micronesia, there are numerous midden sites that testify to the importance shellfish played in prehistoric diets (Carucci 1992; McNamara 1991). However, the study of faunal remains here has received relatively limited attention and has focused almost exclusively on fish remains or materials collected using fairly crude recovery techniques. For example, both Osborne (1979) and Masse (1989), who conducted some of the earliest and most substantial excavations in Palau, relied extensively on ¼-inch screen, residuals of which have long been shown to underestimate certain faunal classes (Nagaoka 1994). Due to the high concentration of faunal remains found during his excavations, Masse (1989) only sampled material from every other arbitrary level. His research, concerned mostly with fish remains, was a major contribution to our understanding of prehistoric subsistence in Palau. Unfortunately, the importance of shellfish for understanding local subsistence strategies and site taphonomy was diminished due to these sampling issues, despite Carucci's (1992) detailed analysis of a portion of the assemblages.

To help remedy this situation and provide additional faunal data for the Palauan Rock Islands, I discuss shellfish remains recovered from excavations at Omis Cave (B:OR-1:35) and Metuker ra Bisech (B:IR-2:24), two sites used by Yapese Islanders for quarrying large limestone 'money' disks. Intensive archaeological research from 1998–2000 provides the first detailed analysis of shellfish remains from stone money quarries in the Rock Islands and one of the few for Palau (see Carucci 1992 for the most thorough study to date).

I first begin by briefly describing the processes involved with stone money quarrying in Palau, the radiocarbon chronology, and the archaeological assemblages from each site. I then evaluate shellfish taxa richness and assess the level of fragmentation at Omis Cave and Metuker ra Bisech. These lines of inquiry have implications for determining the underlying reasons behind discrepancies in shellfish taxa, site formation processes, and how these differences compare with other sites in Micronesia.

BACKGROUND

Palau is located in the Western Caroline Islands of Micronesia, roughly 600 km equidistant from the Philippines to the west and New Guinea to the south (Figure 1). The main archipelago stretches 50 km in a northeast/southwest direction and is comprised of over 300 islands, most of which are coralline and locally referred to as the "Rock Islands." These islands are remnants of tectonically up-

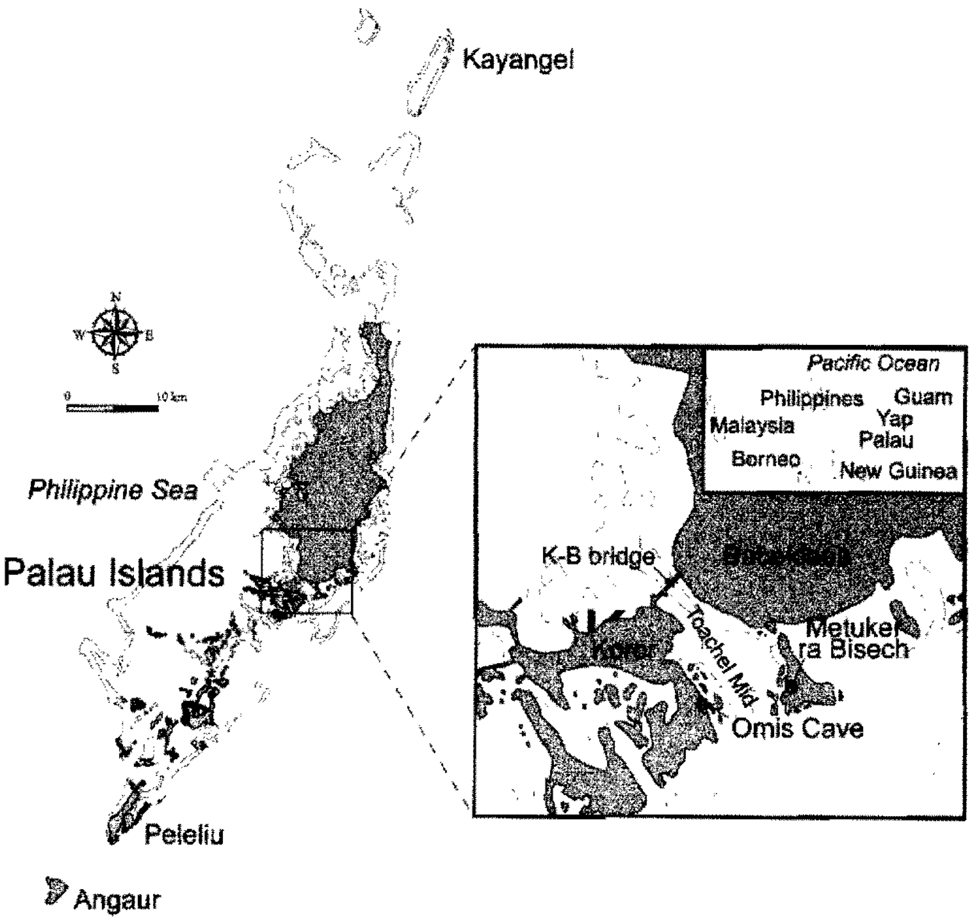

FIGURE 1.—Map of the Palau Islands.

lifted reef systems formed during the Pleistocene that have been chemically and physically weathered over the millennia, forming a rough karstic topography with caves, overhangs, and solution fissures that harbor crystalline limestone deposits (Sem and Underhill 1994). In these many flowstone and dripstone formations stone carvers from Yap quarried their famous stone money (Fitzpatrick 2001).

According to Yapese oral traditions, a navigator named Anagumang first found the stone in Palau and ordered his men to cut it into various shapes, including a fish and then a full moon (de Beauclair 1963; Gillilland 1975). They settled on a circular shape and perforated the large disks so they could be carried with wooden poles or beams (Figure 2). Transported back to Yap, 400 km northeast of Palau, these disks were highly valued exchange items. Their worth depended on the size, shape, quality of stone, and effort expended in quarrying and transporting the disk. Europeans who became involved in this exchange system introduced metal tools and transported disks back on larger vessels, often making stone money produced with traditional technologies (e.g., shell or stone tools;

FIGURE 2.—A stone money disk found on Orrak Island, Palau (photograph by author).

canoes and rafts) even more valuable (see de Beauclair 1963, 1971; Einzig 1966; Fitzpatrick 2001; Gillilland 1975; Nero n.d.).

Several stone money quarry sites have been identified, although the paucity of archaeological research has limited what we currently know of how Yapese used the sites and the social processes that surrounded this exchange system through time. Omis Cave and Metuker ra Bisech, two of the most well known quarries found thus far in Palau, were chosen to begin an intensive survey of stone money production. Analysis of shellfish recovered during excavation provides a foundation for interpreting site formation processes (e.g., engineering efforts that include mass movement of limestone debitage and large stone money disks), and the importance these resources had in the overall subsistence economies of site inhabitants. They also provide important information on the preservation of these and other archaeological remains from the two sites suggesting that a variety of taphonomic processes probably affected the assemblages.

Omis Cave (B:OR-1:35).—Omis Cave, located on the east side of Oreor island (part of Koror State and overseen by Ngermid Village) near the smaller Rock Islands of Itelblong and Ullemetamel, is approximately 3.3 km south of the Airai side of the K-B 'Friendship' bridge which connects the islands of Koror and Babeldaob. The cave encompasses an area of 780 m^2 and is oval-shaped in plan-view. The entrance is at sea level and faces north into a small lagoon where several smaller Rock Islands are visible (Figure 3).

Metuker ra Bisech (B:IR-2:24).—Metuker ra Bisech is a large inland site with numerous caves, overhangs, and stone architectural features. The interior of the site

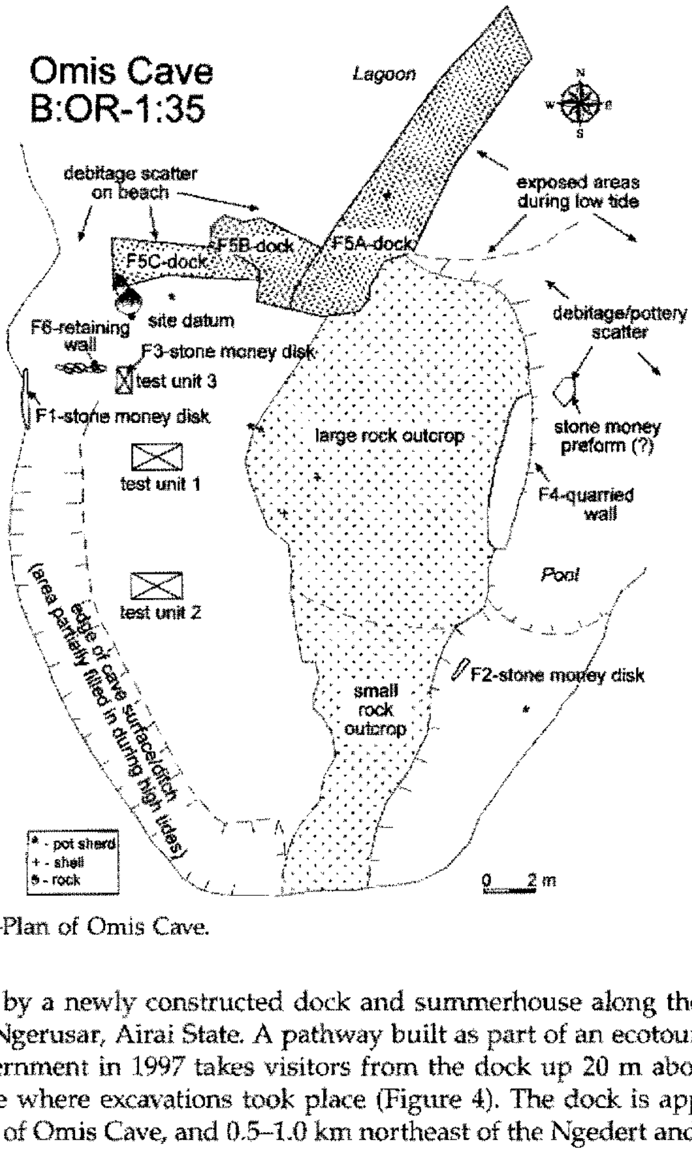

FIGURE 3.—Plan of Omis Cave.

is accessed by a newly constructed dock and summerhouse along the southwest portion of Ngerusar, Airai State. A pathway built as part of an ecotourism project by the government in 1997 takes visitors from the dock up 20 m above sea level into the site where excavations took place (Figure 4). The dock is approximately 2.5 km east of Omis Cave, and 0.5–1.0 km northeast of the Ngedert and Omelochel Rock islands. The Toachel Mid Channel separates Metuker ra Bisech from Omis Cave, roughly 4 km apart.

RADIOCARBON CHRONOLOGY

Nineteen conventional and AMS radiocarbon dates have been obtained thus far from Omis Cave (12) and Metuker ra Bisech (7) (Table 1; Fitzpatrick 2001, 2002). The chronology of Omis Cave suggests that people used the site for over 2,000 years. Four dates range from roughly 360 B.C to A.D. 560 and seven others date to the late historic period. Several older dates are intermixed with ones from the historic period, a reflection of the sloping and highly mixed stratigraphy found throughout the site (Figure 5). Overall, it is apparent that a high level of activity

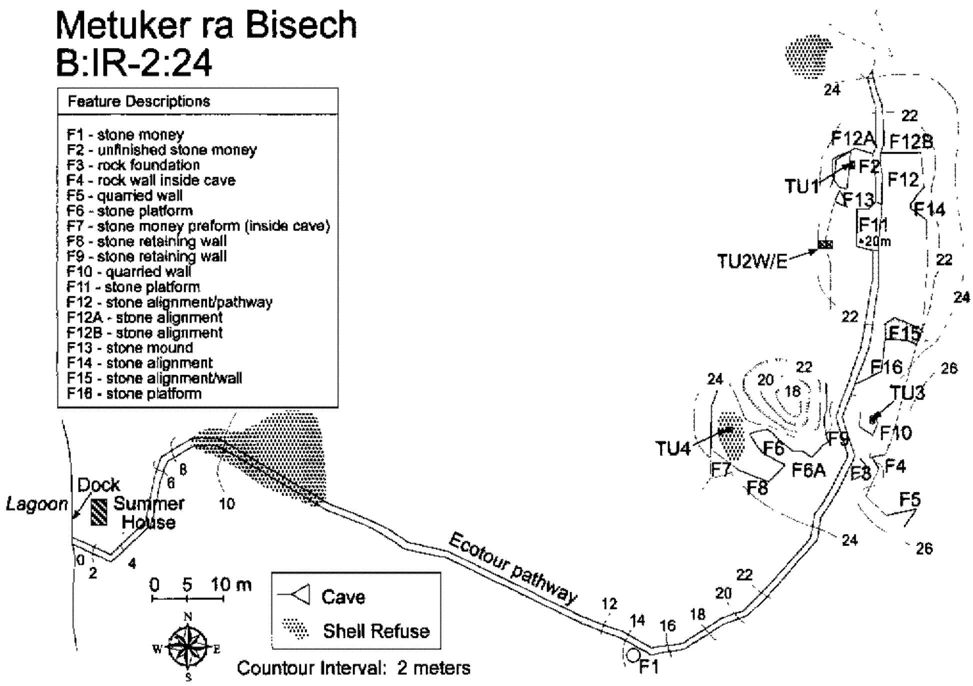

FIGURE 4.—Plan of Metuker ra Bisech.

was taking place within the last few hundred years around the same time that people began intensifying stone money quarrying. These activities drastically affected soil deposits at the site.

Radiocarbon dates from Metuker ra Bisech all post-dated roughly A.D. cal. 1700. In general, the artifact assemblages, quality of stone money disks (those obviously carved using metal tools), and radiocarbon dates indicate that Omis Cave and Metuker ra Bisech were primarily used during the historic period after European involvement when stone money quarrying intensified (Fitzpatrick et al. n.d.).

METHODS

Three test units were excavated at Omis Cave (two—2.0 × 1.0 m; one—0.6 × 0.5 m; total = 2.4 m^3 soil volume) and four at Metuker ra Bisech (one—2.0 × 1.0 m; three—1.0 × 0.5 m; total = 1.9 m^3 soil volume). Despite limited excavation at the sites, a substantial amount of shellfish remains was collected. This was in part due to the excellent preservation of shell in the coralline limestone environment. All excavated materials were water screened over ⅛-inch mesh. Following the methods described by Claassen (1998) and outlined by Grayson (1984) and Gilbert and Steinfeld (1977), total number of fragments (TNF), minimum number of individuals (MNI), and weight (g) were recorded for both assemblages. Shellfish taxa from Omis were identified using comparative collections at the University of Oregon's archaeological laboratory following Hinton (1972), Dance (1974), Wells

TABLE 1.—Radiocarbon dates from Omis Cave and Metuker ra Bisech (MB—Metuker ra Bisech; OC—Omis Cave; AA—Arizona AMS Facility; BA—Beta Analytic, Inc.).

Site	Lab No.	Material	Unit	Layer	Level	Wt. (g) ratio	$^{13}C/^{12}C$	Measured ^{14}C age	Cal. BC/AD (1 sigma)
MB	AA40969	charcoal	1	2	20–30	1.7	−27.6	116 ± 36	historic
MB	AA40970	charcoal	1	6	50–60	1.1	−29.4	143 ± 36	historic
MB	AA40971	*Cypraea* sp.	2	2	20–30	12.3	1.9	423 ± 37	historic
MB	AA40972	*Anadara* sp.	4	1	0–10	9	0.6	509 ± 36	AD 1720 (1820) 1950
MB	AA40973	*Cypraea* sp.	4	1	10–20	12	1.2	446 ± 36	historic
MB	AA40974	*Anadara* sp.	4	3	20–30	11.3	2.1	529 ± 38	AD 1700 (1810) 1840
MB	AA40975	*Venus* sp.	4	3	30–40	9.1	2.0	565 ± 47	AD 1680 (1710) 1820
OC	AA40959	charcoal	1	1	20–30	0.5	−25.2	96 ± 37	historic
OC	AA40958	*Chlamys* sp.	1	2	0–20	1.8	1.2	2379 ± 39	BC 100 (40) AD 1
OC	AA40960	charcoal	1	3	20–30	0.8	−25.6	1559 ± 45	AD 430 (530) 560
OC	AA40961	Cardiidae	1	3	20–30	15.3	2.1	2398 ± 39	BC 130 (70) 20
OC	AA40962	Strombidae	2	2	20–30	12.8	3.3	2519 ± 40	BC 320 (210) 170
OC	BA143445	*H. hippopus*	2	3	30–40	51.5	−2.3	2550 ± 70	BC 360 (300) 170
OC	AA40963	charcoal	2	3	30–40	0.6	−26.2	147 ± 36	historic
OC	BA143446	charcoal	2	4	40–50	1.4	−25.0	100.63 ± 1.12%	historic
OC	AA40964	*Anadara* sp.	2	4	50–60	7.0	2.2	616 ± 37	AD 1660 (1680) 1700
OC	AA40965	charcoal	3	1	20–30	2.7	−26.7	post-bomb	post-bomb
OC	AA40966	charcoal	3	2	30–40	0.6	−26.6	202 ± 37	historic
OC	AA40967	charcoal	3	2	60–70	0.6	−27.6	46 ± 58	historic
OC	AA40968	*Tridacna* sp.	ST1	—	—	7.3	1.9	post-bomb	post-bomb

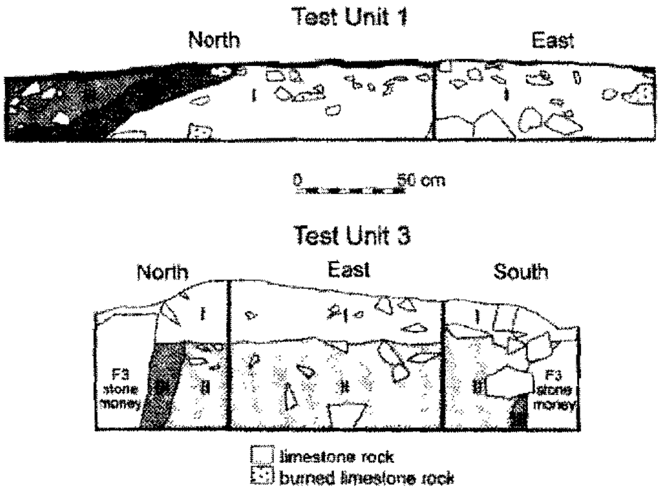

FIGURE 5.—Stratigraphic profiles from Test Units 1 and 3 at Omis Cave.

and Bryce (1988), and Wye (2000). Remains from Metuker ra Bisech were identified in the Palau field laboratory with help from University of Oregon field school students and Palau Bureau of Arts and Culture (formerly the Division of Cultural Affairs) staff using the same reference works.

ARTIFACTS

The most common artifact type found at the two sites was limestone debitage, including over 7,100 flakes and chunks from Omis Cave and nearly 6,000 from Metuker ra Bisech. Pottery was also recovered from Omis Cave and petrographic analysis of 28 of the 51 sherds suggests that they were all made with Palauan clays and tempers (Dickinson 2000; Fitzpatrick et al. 2003). Two fragments from a *Trochus* sp. shell ring were found at Omis Cave in Test Unit 1 and are similar to ones recovered from the Chelechol ra Orrak stone money quarry in 2000 (Fitzpatrick 2001). The only clearly identifiable tools found at the sites were two iron hatchet or blade implements recovered from Metuker ra Bisech in Test Unit 2 (Fitzpatrick et al. n.d.).

SHELLFISH REMAINS

Omis Cave.—From the three test units at Omis Cave, over 2,600 shell fragments (7.2 kg) representing 256 individuals were recovered. At least 50 shellfish taxa were identified from 34 different families (Table 2). Nearly all remains were recovered from Test Unit 1 and Test Unit 2. This is probably due to the location of Test Unit 3 adjacent to an unfinished stone money disk that had been placed upright for final carving and abrasion (Fitzpatrick 2001), an unlikely area for shell refuse deposits. Tridacnids (giant clams) are by far the most common family, representing 66% of the shell weight, 56% of the TNF, and 12% of the MNI. In other Rock Island assemblages analyzed by Carucci (1992), tridacnids were not as well represented, comprising 54.3% of the overall weight at Tmasch, 30.6% at East Beach, and 8.6% at Uchularois; overall, tridacnids make up only 15.6% of those assemblages.

Although we might expect tridacnids to be overrepresented in the overall weight of the assemblage given their large size, they are also quite robust and durable, one of the main reasons for their use in making tools in Micronesia and elsewhere (Moir 1986–87; Osborne 1979). The high fragmentation rate of tridacnids is perplexing, especially given what is already known about tridacnid remains recovered from other shellfish assemblages in Palau (Carucci 1992; Masse 1989; Osborne 1979) where larger and fewer fragments are typically found. Given the restricted area within which Yapese were quarrying stone money at the site and the evidence of large-scale limestone carving and movement of debitage to make room for further quarrying activities (shown most dramatically by slightly vertical, mounded stratigraphic profiles in Test Units 1 and 3), it is likely that tridacnids and other mollusks were effectively crushed during the quarrying process at Omis Cave. Although other uses of tridacnids may have included slaked lime for betel nut chewing (Carucci and Mitchell 1990) or for tools, the sheer quantity of limestone debitage and stratigraphic representations suggest that the fragmentation is due primarily to engineering tasks that included the movement of debitage (e.g., raking, piling, or pushing) and stone money (e.g., pulling, pushing, and lifting disks in armatures or rollers). I discuss alternate hypotheses regarding shellfish remains in the discussion section below.

Many shells found at Omis Cave are quite small, including whole and fragmentary Carditidae, Limidae, Noetiidae, Pandoridae, Architectonicidae, Cerithiidae, Littorinidae, Mitridae, Neritidae, *Strombus mutabilis*, Terebridae, and Trochidae specimens. Significant wave action could be a factor behind the deposition of these specimens. Following the arguments of Hughes and Sullivan (1974) and Gagliano et al. (1982), Carucci (1992:149) notes that materials "redeposited by storm waves generally include tiny and juvenile shells, species not considered food, water worn and fragmented shell, rounded pebbles, and flotsam such as pumice and charcoal." Consistent with Carucci's (1992) findings in the southern Rock Islands, the smaller specimens from Omis Cave include those that appear to be water worn and fragmented. High concentrations of charcoal and a few pebbles observed in site deposits could also be partly attributed to storm action. It is also possible that smaller taxa were boiled in soups or stews, or even entered the site attached to larger shells and other materials such as sea grasses.

Metuker ra Bisech.—A total of 1,019 shellfish fragments (24 kg) from 432 individuals was recovered from the surface and in stratified deposits at Metuker ra Bisech (Table 3). We identified 24 shellfish taxa from 16 families. Surface survey of the main site suggested that shellfish refuse would be found almost exclusively around or adjacent to the larger caves. Excavation of various locations within the site confirmed this pattern with only three marine shells recovered from areas away from these caves (Test Unit 1 and Test Unit 2W).

To examine the spatial distribution and preservation of shellfish remains, a 31.5-m^2 grid (Grid 1) was placed near the opening and to the west of a large cave along the southern portion of where the investigation was focused. Shellfish re-

TABLE 2.—Shellfish from Omis Cave.

	TU1 Total				TU2 Total				Total (includes TU3)*			
Taxon	TNF	MNI	Wt. (g)	Wt. (%)	TNF	MNI	Wt. (g)	Wt. (%)	TNF	MNI	Wt. (g)	Wt. (%)
Bivalves												
Anomiidae	6	2	3.55	0.0	—	—	—	—	6	2	3.55	0.0
Arcidae	1	1	0.10	0.0	—	—	—	—	1	1	0.10	0.0
Anadara spp.	—	—	—	—	10	2	14.00	0.2	10	2	14.00	0.2
Cardiidae	34	10	54.06	0.8	—	—	—	—	34	10	54.06	0.8
Fragum spp.	—	—	—	—	1	1	5.10	0.1	1	1	5.10	0.1
Carditidae	2	2	1.77	0.0	—	—	—	—	2	2	1.77	0.0
Chamidae	—	—	—	—	1	1	0.70	0.0	1	1	0.70	0.0
Crassatellidae	2	2	1.30	0.0	—	—	—	—	2	2	1.30	0.0
Donacidae	—	—	—	—	1	1	4.10	0.1	1	1	4.10	0.1
Limidae	1	1	0.59	0.0	—	—	—	—	1	1	0.59	0.0
Mactridae	4	3	2.70	0.0	—	—	—	—	4	3	2.70	0.0
Mactra spp.	—	—	—	—	3	3	4.10	0.1	3	3	4.10	0.1
Mytilidae	6	5	0.74	0.0	5	1	0.90	0.0	11	6	1.64	0.0
Noetiidae	1	1	0.23	0.0	—	—	—	—	1	1	0.23	0.0
Ostreidae	6	2	2.46	0.0	5	4	4.20	0.1	11	6	6.66	0.1
Pandoridae	1	1	0.61	0.0	—	—	—	—	1	1	0.61	0.0
Pectinidae	11	6	27.00	0.4	3	1	1.60	0.0	14	7	28.6	0.4
Chlamys spp.	—	—	—	—	4	3	3.20	0.0	4	3	3.20	0.0
Spondylidae	1	1	31.30	0.4	—	—	—	—	1	1	31.30	0.4
Tridacnidae												
Tridacna spp.	1067	10	3881.40	54.0	364	6	879.50	12.2	1431	16	4760.90	66.2
Hippopus hippopus	86	5	535.80	7.4	78	7	468.40	6.5	164	12	1004.20	14.0
(non-cultural)	24	3	190.20	2.6	2	1	222.70	3.1	26	4	412.90	5.7
Tellinacea	—	—	—	—	108	34	97.80	1.4	108	34	97.80	1.4
Tellinidae	170	12	99.50	1.4	35	12	37.40	0.5	205	24	136.90	1.9
Tellina spp.	15	4	14.10	0.2	—	—	—	—	15	4	14.10	0.2
Tellina virgata	1	1	0.10	0.0	—	—	—	—	1	1	0.10	0.0
Veneridae	4	4	3.53	0.0	—	—	—	—	4	4	3.53	0.0
Unident. bivalve	142	—	76.00	1.1	132	—	64.00	0.9	274	—	140.00	1.9

TABLE 2.—Continued.

Taxon	TU1 Total				TU2 Total				Total (includes TU3)*			
	TNF	MNI	Wt. (g)	Wt. (%)	TNF	MNI	Wt. (g)	Wt. (%)	TNF	MNI	Wt. (g)	Wt. (%)
Gastropods												
Architectonicidae	13	11	0.96	0.0	2	2	0.86	0.0	15	13	1.82	0.0
Buccinidae	—	—	—	—	1	1	0.40	0.0	1	1	0.40	0.0
Cerithiidae	3	3	0.07	0.0	—	—	—	—	3	3	0.07	0.0
Conidae	4	3	8.08	0.1	—	—	—	—	7	6	8.33	0.1
Conus spp.	3	1	2.15	0.0	—	—	—	—	3	1	2.15	0.0
Conus pennaceus	1	1	1.87	0.0	—	—	—	—	1	1	1.87	0.0
Conus tessulatus	1	1	1.24	0.0	—	—	—	—	1	1	1.24	0.0
Conus litteratus	2	2	117.69	1.6	—	—	—	—	2	2	117.69	1.6
Cypraeidae	4	2	25.81	0.4	3	3	8.71	0.1	7	5	34.52	0.5
Haliotidae	15	2	2.80	0.0	—	—	—	—	15	2	2.80	0.0
Littorinidae	—	—	—	—	4	4	0.65	0.0	4	4	0.65	0.0
Mitridae	—	—	—	—	1	1	0.49	0.0	10	10	1.05	0.0
Neritidae	3	3	2.98	0.0	1	1	0.21	0.0	2	2	0.35	0.0
Patellidae	1	1	0.33	0.0	—	—	—	—	1	1	0.33	0.0
Strombidae	1	1	110.92	1.5	2	2	35.52	0.5	3	3	146.44	2.0
Lambis lambis	1	1	0.76	0.0	1	1	19.57	0.3	2	2	20.33	0.3
Strombus spp.	6	6	16.86	0.2	—	—	—	—	6	6	16.86	0.2
Strombus mutabilis	—	—	—	—	—	—	—	—	2	2	0.37	0.0
Terebridae	1	1	0.03	0.0	—	—	—	—	1	1	0.03	0.0
Terebra spp.	1	1	0.04	0.0	—	—	—	—	1	1	0.04	0.0
Turbinidae	2	2	0.06	0.0	—	—	—	—	2	2	0.06	0.0
operculum	—	—	—	—	3	3	2.83	0.0	3	3	2.83	0.0
Turridae	—	—	—	—	1	1	0.40	0.0	1	1	0.40	0.0
Trochidae	12	9	15.95	0.2	—	—	—	—	12	9	15.95	0.2
Umbonium vestiarium	9	9	0.39	0.0	—	—	—	—	9	9	0.39	0.0
Undent. operuclum	5	5	0.25	0.0	7	7	3.98	0.1	12	12	4.23	0.1
Unident. gastropod	100	—	34.23	0.5	39	—	14.75	0.2	139	—	48.98	0.7
Total	1773	141	5270.51	73.3	817	103	1896.07	26.4	2602	256	7164.92	99.7

* TU3 is represented by only four taxa. Conidae: 3 TNF, 3 MNI, wt. 0.3 g, wt. % 0.0; Mitridae: 9 TNF, 9 MNI, wt. 0.6 g, wt. % 0.0; Neritidae: 1 TNF, 1 MNI, wt. 0.1 g, wt. % 0.0; *Strombus mutabilis*: 2 TNF, 2 MNI, wt. 0.4 g, wt % 0.4. Total: 15 TNF, 15 MNI, wt. 1.3 g, wt. % 0.0.

TABLE 3.—Shellfish data from Metuker ra Bisech.

Taxon	TU4 Total				Grid 1 Total				Total (includes TU1 and TU2W)*			
	TNF	MNI	Wt. (g)	Wt. (%)	TNF	MNI	Wt. (g)	Wt. (%)	TNF	MNI	Wt. (g)	Wt. (%)
Bivalves												
Anomiidae	—	—	—	—	4	2	109.3	0.5	4	2	109.3	0.5
Arcidae	17	3	102.4	0.4	2	1	70.6	0.3	19	4	173	0.7
Anadara spp.	147	78	5856.1	24.4	88	57	2969.1	12.4	236	136	8871.2	37.0
Cardiidae	2	2	67.8	0.3	—	—	—	—	2	2	67.8	0.3
Fragum spp.	167	87	3617.1	15.1	—	—	—	—	167	87	3617.1	15.1
Acrosterigma sp.	2	2	61.7	0.3	—	—	—	—	2	2	61.7	0.3
Chamidae	4	4	350.8	1.5	4	3	352.4	1.5	8	7	703.2	2.9
Mytilidae	41	2	114.3	0.5	—	—	—	—	41	2	114.3	0.5
Septifer spp.	4	2	4.4	0.0	—	—	—	—	4	2	4.4	0.0
Ostreidae	70	17	837.6	3.5	1	1	4.2	0.0	71	18	841.8	3.5
Pectinidae	2	2	91.9	0.4	3	2	102.1	0.4	5	4	194	0.8
Spondylidae												
Spondylus spp.	7	6	452.3	1.9	1	1	107.8	0.4	8	7	560.1	2.3
Tridacnidae												
Tridacna crocea	95	50	2919.4	12.2	13	13	604.5	2.5	108	63	3523.9	14.7
Veneridae												
Venus spp.	11	3	72.3	0.3	1	1	41.7	0.2	12	4	114.0	0.5
Unident. bivalve	71	—	55.2	0.2	—	—	—	—	71	—	55.2	0.2
Gastropods												
Conidae	—	—	—	—	2	2	88.0	0.4	2	2	88.0	0.4
Conus spp.	61	5	1047.2	4.4	19	14	474.2	2.0	80	19	1521.4	6.3
Conus litteratus	7	7	92.8	0.4	20	13	453.4	1.9	27	20	546.2	2.3
Cypraeidae	24	9	309.1	1.3	1	1	11.2	0.0	26	11	378.4	1.6
Cypraea tigris	18	6	240.9	1.0	3	3	99.3	0.4	21	9	340.2	1.4
Neritidae	—	—	—	—	—	—	—	—	1	1	2.3	0.0
Strombidae												
Lambis lambis	5	5	83.3	0.3	—	—	—	—	5	5	83.3	0.3
Strombus spp.	2	2	0.05	0.0	—	—	—	—	2	2	0.05	0.0
Terebridae	65	22	168.1	7.0	—	—	—	—	65	22	1681.1	7.0
Trochidae	—	—	—	—	1	1	225.0	0.9	1	1	225.0	0.9
Unident. gastropod	28	—	82.1	0.3	3	—	13.3	0.1	31	—	95.4	0.4
Total	850	314	18139.9	75.7	166	115	5726.1	23.9	1019	432	23972.4	100.0

* TU1 had only one taxon, Neritidae: 1 TNF, 1 MNI, wt. 2.3 g, wt. % 0.0; TU2W has only two taxa—*Anadara* spp.: 1 TNF, 1 MNI, wt. 46.0 g, wt. % 0.2;

covered from the grid area consisted predominantly of *Anadara* sp. intermixed with mostly Chamidae, *Tridacna crocea, Conus litteratus,* and other *Conus* spp., similar to what was observed in other areas of the site with concentrated shellfish remains. Nearly all of the specimens were whole with only a small percentage of fragments.

To determine the depth of deposits, subsurface shellfish taxa, and taphonomic processes on these specimens, a small 1.0 × 0.5-m test unit was placed within the grid and excavated to a depth of 50 cm. A total of 850 individual fragments weighing 18.1 kg and representing 314 individuals was recovered. The assemblage consisted mostly of *Anadara* sp., *Conus* sp., and *Tridacna crocea,* with a small amount of Chamidae and *Conus litteratus.* This is similar to what was found in the surface collection. A large number of specimens that were not well represented in the surface grid were also recovered: Cardiidae (especially *Fragum* sp.), Cypraeidae, Mytilidae, Ostreidae, Spondylidae, and Terebridae. Overall, excavation revealed extensive shellfish remains primarily concentrated in deposits less than 30 cm deep, numerous taxa that were not visible on the surface, and no artifacts.

Other Shellfish and Faunal Remains.—Although mollusks dominate the Omis Cave and Metuker ra Bisech faunal assemblages, remains of fish, crustacea, echinoderms, and hawksbill turtle (*Eretmochelys imbricata*) carapace were at Omis Cave, and only a few crustacea fragments found at Metuker ra Bisech. Fish remains identified thus far include parrotfish (Scaridae), wrasse (Labridae), grouper (Serranidae), and sea bream (Lerithinidae). Analysis of faunal assemblages is currently underway at the University of Oregon and Kansai Gadai University, Japan.

DISCUSSION

The most common shellfish taxa at both sites would have been collected in intertidal zones or shallow reefs, including those from the families Arcidae (e.g., *Anadara*), Cardiidae (e.g., *Fragum*), Conidae (e.g., *Conus* sp., *Conus litteratus*), Terebridae (*Terebra* sp.), and Tridacnidae (e.g., *Tridacna* sp., *Hippopus hippopus*) (Table 4). Many of the species within these families are found in shell midden deposits elsewhere in the archipelago (Carucci 1992; Osborne 1979) and are food items still popular with present-day Palauans (Melson Miko, pers. comm.). Other genera, including *Tridacna* and *Terebra,* were used for making shell adzes (Osborne 1979), and *Conus* was modified for making beads, pendants, scrapers, peelers, or other ground objects (Carucci 1992:94; Fitzpatrick n.d.; Osborne 1979).

Unfortunately, there is little published ethnographic or ethnohistoric information regarding shellfish collecting in Palau and it remains an understudied aspect of Micronesian subsistence activities. Semper (1873) and Krämer (1926) provide brief accounts of traditional Palauan shellfishing practices, but these are only minimally descriptive and lack quantification. A comparative study by Lebar (1963) in Truk (Chuuk) gives some insight into the importance shellfishing has in the Micronesian diet, but is contemporary in perspective and does not necessarily reflect past food collecting behaviors. Thus, archaeology must be used to determine shellfish abundances and preferences and how this reflects past cultural behavior through time.

TABLE 4.—Habitats of mollusks found at Rock Island limestone quarry sites, Omis Cave (O.C.) and Metuker ra Bisech (M.B.).

Taxon	Common name	Present O.C.	Present M.B.	Habitat
Bivalves				
Anomiidae	Jingle shells	X	X	usually attached to rocks or coral in shallow water
Arcidae	Ark shells	X	X	muddy or coral sand or attached to rocks in intertidal zones
Cardiidae	Cockle shells	X	X	muddy or coral sand in intertidal zones
Carditidae	Cardita clams	X		attached to the undersurfaces of rocks or coral in intertidal zones
Chamidae	Jewel boxes	X	X	cements to rocks or reefs in intertidal zones or shallow water
Crassatellidae	Crassatellas	X		muddy or sandy bottoms
Donacidae	Donax or Wedge clams	X		exposed sandy beaches in intertidal zones (often shallowly buried)
Limidae	File clams	X		under rocks or coral in intertidal zones
Mactridae	Mactra clams	X		muddy or coral sand in intertidal zones
Mytilidae	Mussel shells	X	X	usually attached to rocks or wood in shallow water; some bore into rocks or burrow in sand or gravel
Noetiidae	Noetias	X		muddy bottoms in shallow water
Ostreidae	True oysters	X	X	cemented to rocks or shells in intertidal zones
Pandoridae	Pandoras	X		generally live in sandy or pebbly bottoms
Pectinidae	Scallop shells	X	X	rock crevices or sandy areas in shallow water; avid swimmers
Spondylidae	Thorny oysters	X	X	attached to rocks or coral
Tridacnidae	Giant clams	X	X	shallow waters of coral reefs; rest unattached to reef or lagoon bottoms; bore into coral pockets
Tellinidae	Tellins	X		burrow in sandy or muddy areas in intertidal regions
Veneridae	Venus clams	X	X	muddy sand or clean coral sand
Gastropods				
Architectonicidae	Sundial shells	X		sandy areas in shallow water
Buccinidae	Whelks	X		rocky shores of intertidal zones
Cerithiidae	Ceriths shells	X		clean coral or grassy sand in shallow waters of intertidal zones; also mud and grassy areas
Conidae	Cone shells	X	X	under coral or in crevices; coral sand or hard reef
Cypraeidae	Cowrie shells	X	X	coral reefs of shallow water
Littorinidae	Periwinkles	X		clings to rocks and grasses near tide line; also inhabits mangrove
Mitridae	Miter shells	X		clings to rocks and grasses or in sandy areas near tide line

TABLE 4.—Continued.

Taxon	Common name	Present		Habitat
		O.C.	M.B.	
Neritidae	Nerites	X	X	under rocks or in crevices at high tide levels of intertidal regions; clings to wave-washed rocks in great numbers
Strombidae	Conch shells	X	X	muddy, grassy, or clean coral sand in shallow waters of intertidal zones
Terebridae	Auger shells	X	X	sandy floors in shallow water
Turbinidae	Turban shells	X		intertidal reef zones; under coral rocks
Turridae	Turrid shells	X		attached to rocks in intertidal zones
Trochidae	Top shells	X	X	grassy areas; sometimes attached to rocks in intertidal zones

Despite the paucity of archaeological research dedicated to shellfish assemblages in Micronesia, it is clear that shellfish were an important component of the diet to people living in the limestone Rock Islands of Palau and probably the volcanic islands too, although preservation bias precludes a better assessment. One of the difficulties in evaluating the significance of shellfish in the Rock Islands is that some specimens could have been carried by natural phenomena (e.g., wind, tide, and storm activities). Likewise, it is often difficult, if not impossible, to discern which specimens, especially of the smaller taxa, were actually eaten by past inhabitants. And, all of these problems are exacerbated by the fact that different site inhabitants (e.g., Palauans, Yapese) during separate or even overlapping periods of time may have had similar (or dissimilar) cultural behaviors that influenced shellfish collection strategies and responses to environmental stimuli. These are issues that can be partially resolved, however, by careful examination of the faunal assemblages and other site constituents, extensive radiocarbon dating, and complementary lines of evidence such as ethnography and ethnohistoric accounts. So, what are the main factors influencing the quantity and quality of shellfish assemblages at Omis Cave and Metuker ra Bisech?

Despite both sites having both been used as stone money quarries, shellfish assemblages reveal some striking contrasts. In terms of taxonomic richness, Metuker ra Bisech has less than half the number of discrete shellfish taxa (48%) and families (47%) as those found at Omis Cave, despite the much larger sample from the former. As mentioned previously, one reason for this discrepancy is that Omis Cave is situated adjacent to the water and Metuker ra Bisech is far inland and at a much higher elevation. Wave and storm action could deposit smaller species in greater numbers and variety. Other predators such as birds may also contribute to this greater number of taxa. The gathering of larger shellfish (such as tridacnids) or other resources, including sea grasses, may also introduce smaller species into archaeological deposits as "piggy backers"; however, this is difficult, if not impossible, to quantify accurately. Several studies have addressed the sorting of

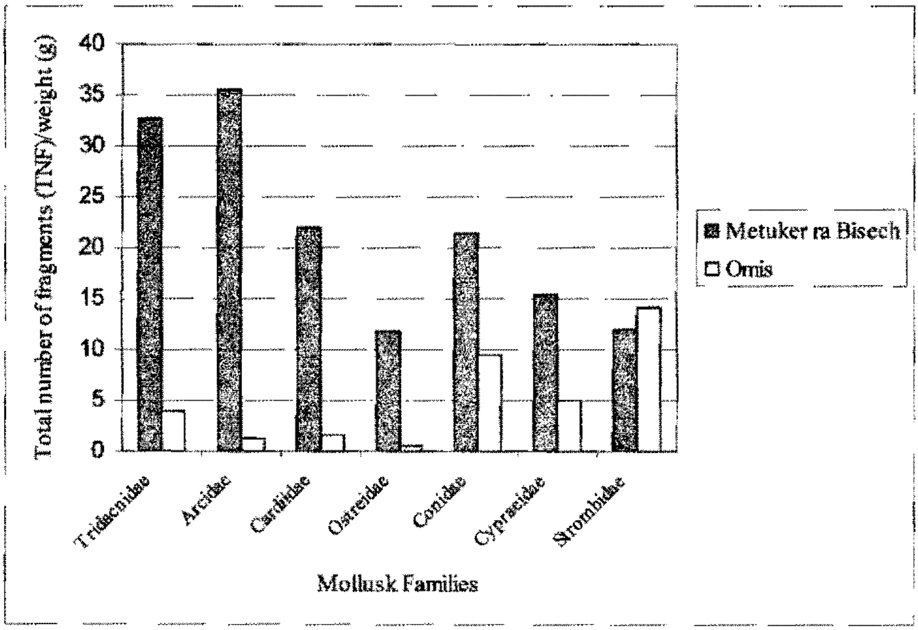

FIGURE 6.—Total number of fragments (TNF)/fragment weight (g). Higher numbers indicate larger size fragments; lower numbers indicate smaller size fragments.

faunal and artifactual material by weather-related phenomena or "piggy-backing" on other shells or objects (Bird 1992; Carucci 1992; Hughes and Sullivan 1974; Lever et al. 1964). These hypotheses, however, have not yet been tested at quarry sites in Palau.

To better compare assemblages from both sites, quantitative measures of the total number of fragments (TNF) for each taxa, minimum number of individuals (or MNI, based on the unique identifiable elements for each taxa that is representative of a single individual), and weight (g) were standardized (see Claassen 1998:117; Grayson 1984). Because the types and quantity of shellfish remains were different between sites, I used the seven most common families that included both bivalves (Tridacnidae, Arcidae, Cardiidae, Ostreidae) and gastropods (Conidae, Cypraeidae, and Strombidae) to standardize the data and give a measure of relative abundance. The TNF were divided by total specimen weight for each site to illustrate differences in fragment size (Figure 6). The MNI were divided by soil volume to establish a comparison of shell quantity between sites (Figure 7). Total shellfish weight (g) for each site was divided by the weights for each family to give a comparative indication of their overall prevalence (Figure 8).

The average weights for individual fragments indicate that shellfish are more highly fragmented at Omis Cave. Taphonomic studies of various mollusks demonstrate that under many conditions, bivalves are more likely than gastropods to become fragmented. The morphology and crystalline composition of bivalves makes them susceptible to breaking along structurally weaker points (Claassen 1998:56). This trend holds true for Omis Cave, where there is an increase in average weight per fragment from bivalves to gastropods. At Metuker ra Bisech the

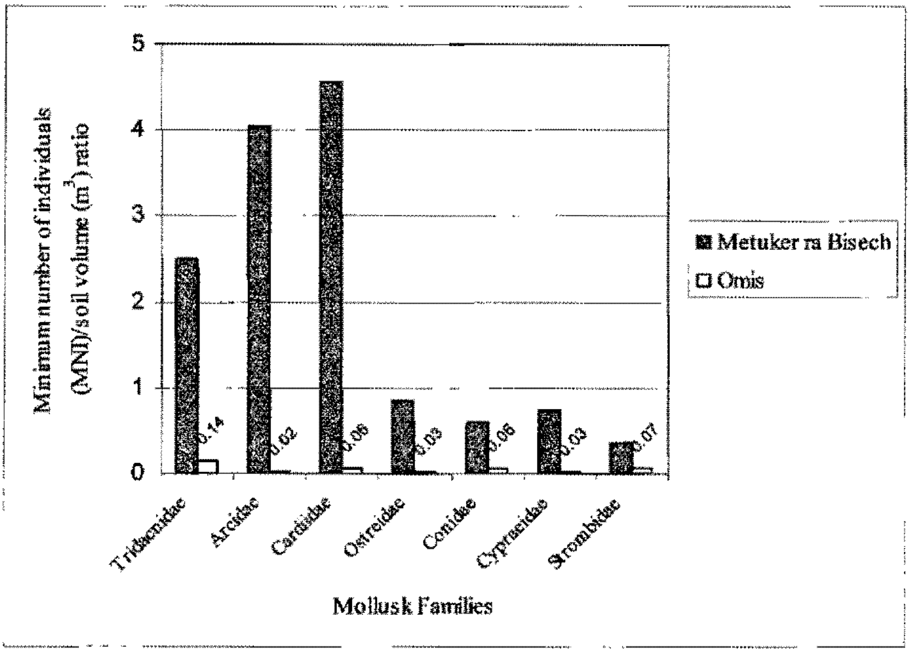

FIGURE 7.—Shellfish density measure for each site using minimum number of individuals (MNI)/soil volume (m^3).

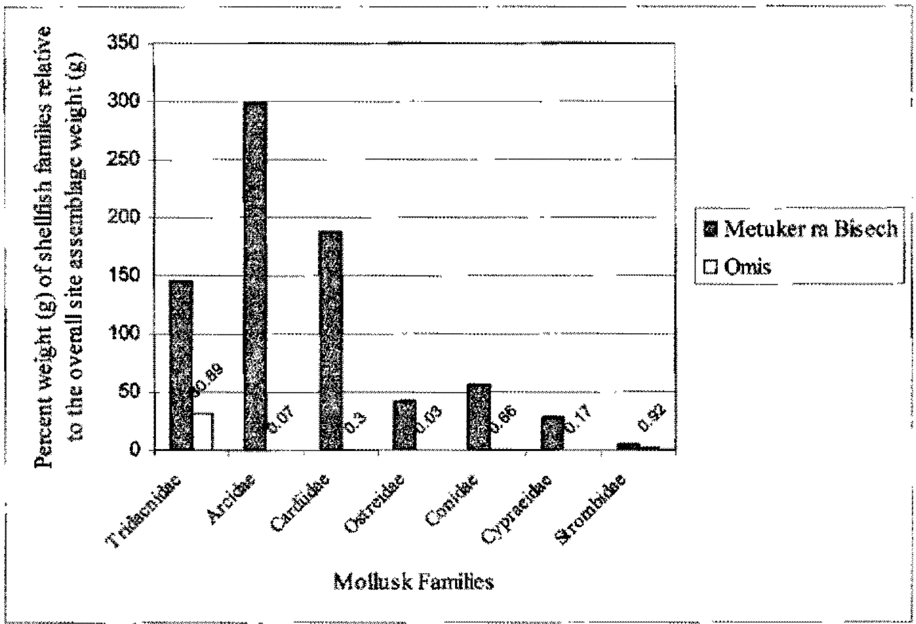

FIGURE 8.—Percentage by weight of major shellfish families relative to the overall site assemblage weight (g). Higher numbers indicate the relative abundance of each family within their respective site.

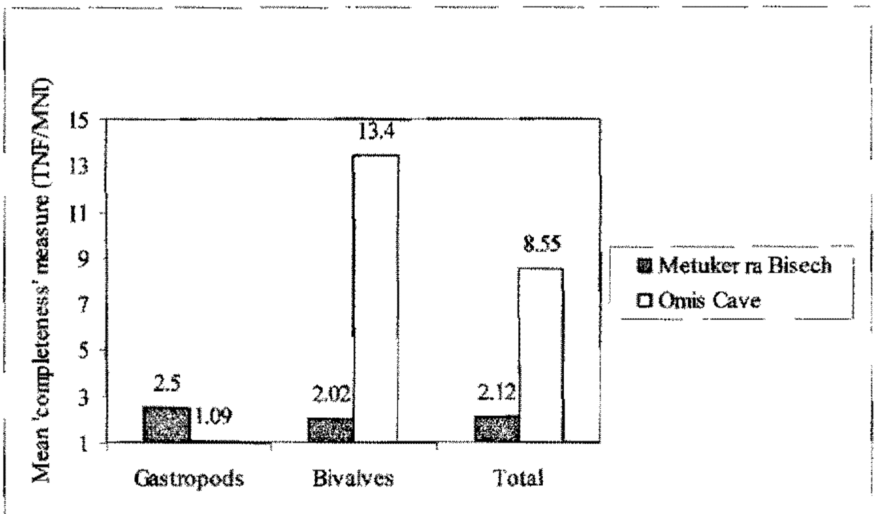

FIGURE 9.—'Mean completeness' of shellfish (TNF/MNI). Values approaching 1.0 are more complete, whereas numbers above 1.0 show increasing rates of fragmentation.

reverse is true, except for Ostreidae. This is not surprising given how oyster shells, having a foliated structure, tend to fracture more easily than other types of bivalves (Claassen 1998:56–57). The ratio of MNI divided by soil volume (Figure 7) follows a similar trend to that of total shellfish weights with a higher density of taxa from Metuker ra Bisech than Omis Cave. More whole bivalve halves were also recovered from Metuker ra Bisech, mirroring what both quantitative standardizations show. Figure 8 simply illustrates the relative abundance of families between each site in terms of weight, but also gives an indication of how weight measures affect the samples. The seven shellfish families from Omis Cave comprise less of the overall site assemblage weight compared to Metuker ra Bisech, with the exception of Strombidae and Tridacnidae. The data presented in these figures suggest that 1) shellfish are more highly fragmented at Omis Cave; 2) Omis Cave is taxonomically richer; 3) the overall assemblage weight is dominated by tridacnids at Omis Cave (not necessarily reflecting a higher percentage of use as seen by MNI counts); and 4) peoples living at Metuker ra Bisech had a preference for bivalves, especially Tridacnidae, Arcidae, and Cardiidae with gastropods being far less important—the similarity in environment between the two sites makes it unlikely that these differences can be attributed to habitat.

The 'mean completeness' of shellfish assemblages was also determined by dividing TNF (minus the indeterminate fragments) by MNI to give another estimation of fragmentation (with values approaching one being more complete; see Grayson 1984 for a review of sample size effects; Figure 9). The completeness measure for Omis Cave gastropods was 1.09, bivalves 13.4, and total assemblage 8.55. Metuker ra Bisech gastropods were 2.5, bivalves 2.02, and total assemblage 2.12. Using this measure of completeness, the Omis Cave assemblage shows an overall fragmentation rate that is over four times that of Metuker ra Bisech. Although gastropod fragmentation is higher at Metuker ra Bisech than Omis Cave and would appear to conflict with the overall trend, this can be attributed to the size of the gastropods found at each site. By dividing gastropod TNF with total weight, individual fragments at Omis Cave weigh 1.7 g, while Metuker ra Bisech weighs 19.0 g. These numbers reflect some of the smaller species or specimens (< 2 cm) in various gastropod families such as Architectonicidae, Cerithiidae, Neritidae, Patellidae, Terebridae, Turbinidae, and Trochidae; although they have a high MNI, they easily could have been washed or brought into the site by non-cultural processes.

Two of the other major shellfish assemblages reported from Palau are from Peleliu (Osborne 1979) and sites in the southern Rock Islands such as Ngemelis (Carucci 1992). In general, the most common bivalves found in these studies were *Atactodea* and *Fragum,* occurring in about the same relative abundance (MNI) in both collections. *Strombus gibberulus* was the most common taxon (95% in Osborne's and 89% in Carucci's collection). Except for *Fragum,* which comprises 15% of the total weight and 20% of the MNI at Metuker ra Bisech, these data are quite different from what is found at the two Yapese stone money quarries.

My analysis reveals a disparity in the shellfish taxa identified as well as preservation between the two quarry sites. I suggest that the high shellfish fragmentation at Omis Cave is primarily due to the intensive engineering tasks associated with limestone carving in a smaller, more restricted area, whereas remains from the site of Metuker ra Bisech (most of which were almost completely intact), reflect the separation of habitation and quarrying areas at a much larger inland site. Widely separated radiocarbon dates and evidence of stone money quarrying at Omis Cave suggest substantial disturbance of the soil. I would not discount the possibility that the Yapese collected only certain taxa or restricted their collecting to certain locations, but this hypothesis is difficult to test given differences in location and preservation. Despite these questions, shellfish remains provide important evidence about habitation, subsistence, quarrying, and other daily activities of the Yapese quarry workers who lived at the two sites while they carved stone money disks.

The diversity and abundance of shellfish demonstrates the importance these resources had for people living at the sites. We still do not know, however, the role shellfish actually played. Were they eaten, used for making tools and ornaments, or did they serve some other purpose? In their analysis of *Strombus gigas* in the West Indies, Jones O'Day and Keegan (2001) suggest that "most gastropod and bivalve shells are so durable that they are unlikely to break into fragments without human intervention," and that "there is no reason for large and heavy shells (e.g., *S. gigas*) to be brought to a settlement unless some further use was intended. Thus, we should assume that large shells and their fragments found in archaeological sites were the product of tool manufacture." This may be true of West Indian sites, but not necessarily for others along the North American Pacific coast (see Erlandson et al. 1999 and Sharp 2000 for some California examples), the Mississippi Valley (Peacock 2000), or stone money quarries. Osborne (1979:88) also suggested a similar arrangement, noting that when tridacnid shells were not needed for tools, their meat was collected and the massive shells were left on the reef. However, some shellfish will remain fresh for days if left in shells and then transported over long distances.

There are several possible explanations for the relatively high presence of tridacnid shells (TNF, MNI, and weight) at Omis Cave and Metuker ra Bisech that may also address Jones O'Day and Keegan's (2001) and Osborne's (1979) hypotheses. The first is that radiocarbon dates and metal tools place quarrying activity at Metuker ra Bisech just prior to and after European contact. *Tridacna crocea*, the only species of tridacnid found at the site, was rarely, if ever, used for producing tools in prehistory and was probably only a food item. Because of its smaller size (< 15 cm in length), there would have been little effort expended to bring both the meat and shell up to the main site. The shell then could have served as a container or other unmodified utilitarian instrument. In addition, Yapese quarry workers were generally low caste, often providing corvée labor to Palauan clans or villages in exchange for quarrying rights (de Beauclair 1971; Einzig 1966; Gillilland 1975). It is unlikely that they would have had unrestricted access to any and all food items. Oral traditions describe Palauans bringing food to quarry workers (e.g., Holyoak and Miko 2000), but whether this was done on a regular basis is unknown. The Rock Islands have shallow, poor soils for cultivating crops like taro. Thus, shellfish could have been a nearby, easily captured, and important food source.

The high fragmentation rate of tridacnids and other shells at Omis Cave is probably not explained by tool production either. No shell tools have been found at the site and only two small fragments of a *Trochus* shell ring were recovered during excavation (Fitzpatrick 2001). Shell midden deposits are quite common in other caves and rockshelters in Palau (Carucci 1992; Masse 1989), and it is likely that people living there brought larger shells into the site. The cave's proximity to reef and lagoon habitats would have made this quite easy. Radiocarbon dates at Omis Cave also span more than 2,000 years from 300 cal. B.C. to the modern era. The slightly sloping stratigraphic profiles, radiocarbon dates, and lack of shell artifacts all point to shellfish assemblages having been affected by engineering activities.

It should be noted too, that a fundamental difference between *Strombus gigas* and tridacnids lies in their size and morphology. The most common tridacnids used for tools in the Pacific, *Tridacna maxima* and *Tridacna gigas* (Moir 1986–87), are much larger than *S. gigas*, attaining lengths of 35 cm and 100 cm respectively (Rosewater 1965), whereas *S. gigas* rarely exceeds 30 cm in length (Dance 1974: 83). Tridacnids also have two halves and are often used as containers for water. *S. gigas* is a gastropod and its use as a vessel is not well documented, nor would it be as convenient to use as half of a larger bivalve shell. With such a complex mixing of cave deposits, it is difficult to assign specific faunal remains to a particular cultural period. Nonetheless, it is reasonable to conclude, given the available evidence, that engineering tasks associated with stone money quarrying introduced a variable that broke shell into fragments as a result of human intervention on a massive scale.

CONCLUSIONS

The analysis of shellfish remains from Omis Cave and Metuker ra Bisech suggests the following:

1) Radiocarbon dates and artifact assemblages indicate that Palauans used Omis Cave over a long period of time, perhaps intermittently as a temporary campsite, and by the Yapese for stone money manufacture. Metal tools and a lack of pottery at Metuker ra Bisech suggest that only the Yapese used this site within the last few hundred years for quarrying stone money.

2) The greater varieties of shellfish found at Omis Cave are likely a result of the site's close proximity to the sea. Storms, tidal action, predators, and indirect transport of smaller taxa all likely influenced the kinds and size of shellfish found at the sites.

3) Nearly all shellfish taxa, including those shared by the two sites, are found in intertidal zones or shallow reef areas. This is not unexpected given that Rock Island ecological zones are within a barrier reef with numerous complex coral reef systems.

4) Shellfish remains are highly fragmented at Omis Cave and much less so at Metuker ra Bisech. In the case of stone money quarries, this is probably a result of multiple factors including site dimensions, quarrying activities in a restricted area, and engineering tasks associated with the carving or breaking of limestone, movement of debitage, and transport of stone money disks away from flowstone deposits. We should expect to find similar fragmentation rates in future investigations at quarry sites.

5) People living and working at stone money quarry sites showed a preference for bivalves, particularly tridacnids, although a wide variety of shellfish were exploited. Previously I thought giant clam shells found at quarry sites may have been used for producing tools or as utilitarian objects (e.g., water or food containers) (Fitzpatrick 2001). Very few shell tools have been found at stone money quarry sites and none in direct association with quarry refuse (i.e., limestone debitage). This suggests that tridacnids were predominantly gathered for food, although their use as containers cannot be ruled out. The small number of shell artifacts in general suggests that shellfish at these sites are primarily food remains or incidental site constituents.

6) Shellfish varieties recorded at stone money quarries are dissimilar to those found at other sites in Palau (Carucci 1992; Masse 1989; Osborne 1979), suggesting that even though people took advantage of the rich diversity of faunal material in these environments, they were probably doing so with different dietary or technological preferences. Further research will help determine what these preferences were and if they represent cultural differences (Yapese vs. Palauan). In any case, this research reinforces the idea that shellfish were an important resource for those living in the Rock Islands over a long period of time, as Masse (1989), Osborne (1979), and Carucci (1992) have suggested.

This study provides the first description of faunal remains recovered from Yapese stone money quarries. The data allow for a better understanding of how Yapese Islanders made use of these sites and provide a framework for developing hypotheses about settlement patterns, engineering tasks, and modes of activity at quarry sites. The evidence, especially in the case of the Omis Cave assemblage, suggests that proper sampling techniques using ⅛-inch screen can help in recovering smaller taxa present, some of which may result from non-cultural processes.

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