

Mollusk Exploitation and Paleoenvironmental Change in the Koné Region: A Reanalysis of the Site 13 Mollusk Assemblages

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The issue of Lapita subsistence strategies has provoked several controversies and competing hypotheses, as summarized by Nagaoka (1988). Groube's (1971) "strandlooper" theory, which was based on his Tongan data, proposed that Lapita populations relied almost exclusively on the intensive exploitation of marine resources. In contrast, Green (1979), Kirch (1982), and others proposed that a reliance on crop plants and domestic animals, as well as marine resources, underlay Lapita subsistence. Nagaoka (1988:117) also asserts that many prior analyses of the Lapita faunal record were hindered by problems such as "the inconsistent and biased recovery techniques, incomplete taxonomic and quantitative analyses, and inadequate data reporting presentation." Such problems did indeed characterize the excavations and the monograph prepared by Gifford and Shutler (1956) for their 1952 excavations in New Caledonia, specifically at site 13 from which the Lapita cultural complex ultimately derived its name. Gifford and Shutler's reporting of the faunal data and the molluscan remains from their sites are especially cursory. Although they presented a mollusk species list for each site excavated in New Caledonia, their sampling methods were questionable. They only saved what they called "representative samples," literally a handful of each species, from all of the squares in the individual sites. However, for one square at site 13 they did save a complete sample of molluscan remains, this being square C1-2/D1-2, and from these specimens they prepared a basic NISP (Number of Individual Specimens Present) count for each species (Gifford and Shutler 1956, table 23).

Fortunately, the mollusk specimens from square C1-2/D1-2 at site 13 were cataloged by Gifford and Shutler, and have been curated in the P. A. Hearst Museum of Anthropology at Berkeley. My research was based on the premise that using methods developed since 1952, I might be able to extract more information concerning Lapita subsistence and possible paleoenvironmental changes in the Koné region, from the complete mollusk assemblage from square C1-2/D1-2. Particularly through the analysis of the mollusks in the eight consecutive excavation levels in square C1-2/D1-2, I hoped to reveal a relative chronology for molluscan subsistence at the site. Through an analysis of NISP, MNI (Minimum Number of Individuals), and weight data for these levels I will show how different species were exploited through time. Regarding the exploitation of mollusks by human populations, I also tested for the effect of long-term reduction in size of species caused by human predation. I also investigated the changing molluscan habitats that were exploited at different periods. In addition to these investigations of marine mollusk exploitation, I explored the possibility of extinctions of certain terrestrial mollusks (the *Placostylus* land snails) as a result of human occupation and environmental changes due to this occupation (specifically, deforestation and erosion caused by agricultural development). In this paper I also describe the cultural modifications to these mollusks relating to their subsistence uses or the meat extraction patterns in particular species.

Materials and Methods

In order to obtain NISP, MNI, and weight data for the mollusk shells from site 13, square C1-2/D1-2, each specimen was recorded, identified to species using standard taxonomic references, and then counted and weighed according to a protocol which I developed for this study (see Appendix). NISP was calculated and then checked against the figures published by Gifford and Shutler, while MNI was calculated for bivalves (presence of hinge = 1 specimen, and then total divided by two) and gastropods (presence of main body whorl and columella = 1 specimen). Weight was recorded in grams. Totals for NISP, MNI, and weight were then calculated for each species individually and then for all bivalves and gastropods in the square. Table 1 provides a list of species present in square C1-2/D1-2.

In order to analyze the possible effects of human predation on the size of individual species the five most common molluskan species in the square were chosen. These include two gastropod species, *Cerithium moniliferum* and *Potamides semitrisulcatus*, and three bivalve species, *Anadara scapha*, *Gafrarium tumidum*, and *Mesodesma glabratum*. Besides being the only species present in large enough numbers to reveal significant statistical results, these also come from various habitats which, according to Swadling (1977:298), are crucial for this type of size analysis since "any comparable changes found in the nature of their gathered populations over a period of time would more likely be due to human predation than environmental changes in food supply or substrate." Length measurements were made on all five species, while width measurements were only taken for gastropods. Malacologists have determined correlation coefficients between length and width for mollusks, thus making both measurements unnecessary, but in this case a measurement for width was required for the gastropods because of their extremely fragmented state of preservation. After the shells were measured, size frequency distributions were plotted for each species for each of the eight excavation levels.

Environmental habitats for all of the species present in square C1-2/D1-2 were determined by consulting the published literature for southwest Pacific mollusks, and then the total number and percentage of species and individuals from each habitat were tabulated. These habitats and numbers were then correlated according to the individual levels within the square to determine which habitats were exploited more or less heavily through time. The habitat results for site 13 were then compared with relevant data from site 26, a much later, historically occupied site, to establish any similarities or differences in habitat exploitation between the early Lapita culture at site 13 and the later settlements found at site 26.

The entire assemblage of shells from square C1-2/D1-2 was also examined to reveal breakage patterns and modifications made to the shells during the cultural process of meat extraction for subsistence (see Appendix A). Inter-site comparisons with shell artifacts from site 13A were also examined to reveal the general trends in meat extraction because of the relative paucity of large gastropod species in square C1-2/D1-2.

Finally, a preliminary analysis of the land snail genus *Placostylus* was also conducted for specimens from site 13, as well as from sites 13A, 14, and 26. The inclusion of these other sites was judged necessary to sample for possible longer-term paleoenvironmental trends post-dating the Lapita period. For the *Placostylus* shells, NISP, MNI, and size data (length, width, weight) were calculated and plotted as histograms and scattergrams in an attempt to re-identify the species present, and to investigate changing size relationships of these species over time.

Table 1
Molluskan Species Present, Site 13

Species	NISP	NISP (%)	MNI	Weight (g)	Weight (%)
Bivalves					
<i>Gafrarium tumidum</i>	664	32.80	279	3,271.2	30.00
<i>Anadara scapha</i>	647	31.90	277	4,972.0	46.00
<i>Mesodesma glabratum</i>	257	12.60	127	261.6	2.40
<i>Ostrea gradiva</i>	207	10.20	66	1,118.6	10.00
<i>Chama nivalis</i>	49	2.40	25	186.0	1.70
<i>Pinctada vulgaris</i>	49	2.40	16	304.0	2.80
<i>Asaphis dichotoma</i>	40	1.90	10	212.0	1.90
<i>Arca decusatta</i>	27	1.30	14	36.0	0.30
<i>Arca navicularis</i>	23	1.10	12	58.0	0.50
<i>Tridacna noae</i>	12	0.60	4	190.0	1.70
<i>Gafrarium pectinatum</i>	13	0.60	7	27.2	0.20
<i>Septifer bilocularis</i>	10	0.50	6	61.0	0.60
<i>Pecten senatorius</i>	9	0.40	3	22.0	0.20
<i>Arca nivea</i>	8	0.40	3	24.0	0.20
<i>Spondylus ducalis</i>	5	0.20	2	61.0	0.60
<i>Gafrarium protinatum</i>	2	0.10	1	2.0	0.02
<i>Periglypta puerpera</i>	1	.04	1	11.0	0.10
<i>Cardium dupuchense</i>	1	.04	1	3.0	0.02
Totals	2,024		854	10,820.0	
Gastropods					
<i>Potamides semitrisulcatus</i>	189	44.00	131	3,046.0	76.50
<i>Cerithium moniliferum</i>	113	26.00	107	148.8	3.70
<i>Planaxis sulcatus</i>	46	11.00	40	75.0	1.90
<i>Pterocera lambis</i>	11	2.60	1	54.0	1.400
<i>Nerita albicilla</i>	11	2.60	9	15.0	0.38
<i>Strombus luhuanus</i>	8	1.80	8	75.0	1.90
<i>Nerita plicata</i>	7	1.60	7	23.0	0.58
<i>Trochus niloticus</i>	6	1.40	6	73.0	1.80
<i>Nerita polita</i>	4	0.90	3	16.0	0.40
<i>Strombus canarium</i>	4	0.90	4	21.0	0.53
<i>Bulla ampulla</i>	9	2.10	5	41.0	1.00
<i>Conus</i> sp.	4	0.90	2	32.0	0.80
<i>Cypraea cylindrica</i>	4	0.90	4	11.0	0.28
<i>Placostylus</i> sp.	3	0.70	1	15.0	0.38
<i>Cypraea tigris</i>	2	0.50	2	11.0	0.28
<i>Cypraea annulus</i>	2	0.50	2	3.0	0.08
<i>Turbo cinerea</i>	2	0.50	2	5.0	0.13
<i>Columbela versicolor</i>	1	0.20	1	0.4	0.01
<i>Murex ramodus</i>	1	0.20	1	15.0	0.38
Totals	427		336	3,979.5	
Totals (Bivalves + Gastropods)	2,451		1,190	14,500.1	

Results

Species Quantification and Size Reduction

I began by rechecking the NISP data on mollusks from site 13, square C1-2/D1-2 (Table 1). Gifford and Shutler had identified 56 species in this square, yet when I examined the Hearst Museum collection and catalogue, 12 species of bivalves and 7 species of gastropods were missing. It is possible that these specimens were not saved, were left in New Caledonia, or were lost in transit but there is no record of them in the museum catalog. Fortunately, most of these species were reported as having been present only in trace quantities so that their absence does not significantly alter my results. The species that are present in significant numbers, *Donax tinctus* and *Ostrea commercialis*, are both bivalves.

Gifford reported that the species present in the greatest numbers from this square were *Gafrarium tumidum* and *Anadara scapha*, whose raw NISP counts were 664 and 647, respectively. Also present in large enough quantities to have been used as a food source are *Mesodesma glabratum*, *Ostrea gradiva*, *Potamides semitrisulcatus*, and *Cerithium moniliferum*. NISP, MNI, and weights for the entire list of species are found in Table 1 which is arranged in rank order by species. A total of 2,451 specimens were recorded from this square, with a calculated MNI of 1,190 individuals. Total weight was 14,500.1 grams. There were 18 different bivalve species (NISP = 2,024, MNI = 854, total weight = 10,820 g) and 19 gastropod species (NISP = 427, MNI = 336, total weight = 3,979.5 g).

The NISP values for each species were also calculated for each of the eight 6-inch arbitrary excavation levels in the square. This raw count by levels was compiled into Tables 2 and 3, listing bivalves and gastropods respectively. From these tables it is evident that the largest concentrations of shell came from levels 3 and 4 (or 18-24" and 24-30") which held 851 and 865 specimens for a combined total of 70% of all the shells from this square. Gifford and Shutler maintained, and my figures support, the hypothesis that the site was most intensively occupied during this period (Gifford and Shutler 1956:30) The levels above and below these have significantly fewer specimens (levels 1-3: 247, 10%; levels 6-8: 488, 20%).

The weight of the individual specimens was recorded and then a total calculated for each species (Table 1). The greatest total weight recorded was that of *Anadara scapha* at 4,972 g comprising 46% of the bivalves. It is followed by *Gafrarium tumidum* at 3,271.2 g (30% bivalve total) and *Potamides semitrisulcatus* at 3,046 g (82% gastropod total). Other species with significant weights are *Ostrea gradiva*, *Mesodesma glabratum*, and *Cerithium moniliferum*. These substantial weights are recorded because of the high numbers of these species at the site. However, a rank order of species according to weight would be different from that constructed using NISP or MNI because of the individual size variation between species. Weight and size of individual species are important tools for determining the average body mass of certain species, from which a hypothetical nutritional value or percentage of diet might be calculated, but this manipulation is beyond the scope of this paper. Such analyses are conducted and discussed in works by Meehan (1982), Wing and Brown (1979), and Kirch and Yen (1982).

Size measurements were taken on the five most common species at the site (*Cerithium moniliferum*, *Potamides semitrisulcatus*, *Anadara scapha*, *Gafrarium tumidum*, and *Mesodesma*

Table 2
Bivalves, NISP by Level, Site 13

Genus	0-6"	6-12"	12-18"	18-24"	24-30"	30-36"	36-42"	42-48"	Total
<i>Anadara</i>		14	54	303	197	51	14	14	647
<i>Arca</i>				9	28	8		13	58
<i>Asaphis</i>				3	18	14	2	3	40
<i>Cardium</i>						1			1
<i>Chama</i>			1	6	5	11	14	12	49
<i>Gafrarium</i>	2	17	38	253	279	63	15	12	679
<i>Mesodesma</i>	1	1	15	26	90	38	37	49	257
<i>Ostrea</i>		7	13	73	73	20	4	17	207
<i>Pecten</i>				2	1	3	1	2	9
<i>Periglypta</i>					1				1
<i>Pinctada</i>				22	21	6			49
<i>Septifer</i>					3	3	3	1	10
<i>Spondylus</i>					4	1			5
<i>Tridacna</i>			3	9					12
Total	3	39	124	706	720	219	90	123	2,024

Table 3
Gastropods, NISP by Level, Site 13

Genus	0-6"	6-12"	12-18"	18-24"	24-30"	30-36"	36-42"	42-48"	Total
<i>Bulla</i>				1	6	1		1	9
<i>Cerithium</i>	4	11	15	31	35	12	4	1	113
<i>Columbella</i>		1							1
<i>Conus</i>			1		3				4
<i>Cypraea</i>				2	5		1		8
<i>Murex</i>			1						1
<i>Nerita</i>				2	13	3	4		22
<i>Placostylus</i>			1				2		3
<i>Planaxis</i>		4	5	12	22	2	1		46
<i>Potamides</i>	1	21	12	83	52	17	2	1	189
<i>Pterocera</i>			2	7	2				11
<i>Strombus</i>				5	3			4	12
<i>Trochus</i>			2	1	3				6
<i>Turbo</i>				1	1				2
Total	5	37	39	145	145	35	14	7	427

glabratum) for a rather different purpose, specifically to determine if there was any evidence of size reduction in certain species as they were exploited by humans over time. Similar studies of molluskan size reduction had been conducted by Swadling (1976, 1986), Catterall and Poiner (1987), Spennemann (1987), and Ford (1989). Length, width, and height for each individual specimen of these five species were recorded and then an average for each separate level was calculated. Individual histograms of length (and width for gastropods) were plotted for each species at each level. The plots of size by level revealed both unimodal and bimodal patterns, but really no obvious reductions in size for any one species. Furthermore, for all five species, the average sizes for levels 6-8 were generally smaller than those in later levels. Size increased in levels 3-5 and then usually decreased again in the latest levels (1-2). However, the samples in levels 6-8 contained many more juvenile specimens than those in the upper levels, which caused the mean to drop somewhat. Small sample size further affected the means from lower levels. The shells in the lowest levels also appeared very broken and waterworn, as though they were part of a natural beach deposit. This makes me hesitant to compare what are probably naturally occurring shells with the samples from the higher levels which have direct cultural associations (pottery, stone tools, etc.).

If one discounts these three lower levels from the size comparison, then one discovers that for all species (except *M. glabratum*) there was a general reduction in size over time, although it is not a large reduction. One must also remember that the levels dug by Gifford and Shutler were completely arbitrary and may not reflect actual cultural occupations and stratigraphy. Considering this with the similarity of mean size in all species from levels 3, 4, and 5, one might propose that these shells were deposited over a period of continuous occupation when people were culling these molluskan populations for certain sizes of shells. This continuous predation might have caused the local molluskan populations to become smaller, as observed from means in levels 1 and 2. However, these conclusions about size reduction must remain tentative.

Habitat

Habitats for all 37 species of mollusks in square C1-2/D1-2 were determined using reference works by Cernohorsky (1971), Rippingdale (1961), Roberts et al. (1982), Salvat (1970), and Swadling (1986). From these guides, I determined that 10 major habitats are represented by mollusk species at the site, the most highly exploited ones containing the most specimens being Muddy Shores and Muddy Sand/Reef. A list of species that inhabit each of the environments and the number of specimens from each of the eight levels in the square is given in Table 4, and a summary by habitat in Table 5. From this I observe that 56% of all the shells in this square were collected from these first two habitats. Other important habitats include the Intertidal with 13.7% of the total specimens and Beach Sand to Reef areas with 10.8%.

Interestingly, the two most important habitats, Muddy Sand/Reef and Muddy Shores, support only six represented species at the site, while the Intertidal areas combined contain 16 species but include only 21% of the total number of specimens. Furthermore, there is a definite change in the dominant habitats through time. There is a basic division between sandy environments (including Beach Sand to Reef, Sand on Reef, Intertidal, Algal/Reef) which dominate the earlier, lower levels of the square and muddy environments (Muddy Sand/Reef, Muddy Shores,

Table 4
Molluskan Habitats by Level, Site 13

Habitat & Genus	0-6"	6-12"	12-18"	18-24"	24-30"	30-36"	36-42"	42-48"	Total
Beach Sand to Reef									266
<i>Bulla</i>				1	6	1		1	
<i>Mesodesma</i>	1	1	15	26	90	38	37	49	
Muddy Sand or Reef									721
<i>Columbella</i>		1							
<i>Asaphis</i>				3	18	14	2	3	
<i>Gafrarium</i>	2	17	38	253	279	63	15	12	
<i>Periglypta</i>					1				
Sand on Reef									23
<i>Pterocera</i>			2	7	2				
<i>Strombus</i>				5	3			4	
Intertidal (rock/coral/ trees)									338
<i>Arca</i>				9	28	8		13	
<i>Chama</i>			1	6	5	11	14	12	
<i>Ostrea</i>		7	13	73	73	20	4	17	
<i>Pecten</i>				2	1	3	1	2	
<i>Septifer</i>					3	3	3	1	
<i>Spondylus</i>					4	1			
Intertidal (sand/reef)									183
<i>Cerithium</i>	4	11	15	31	35	12	4	1	
<i>Conus</i>			1		3				
<i>Cyraea</i>				2	5		1		
<i>Murex</i>			1						
<i>Trochus</i>			2	1	3				
<i>Turbo</i>				1	1				
<i>Pinctada</i>				22	21	6			
Intertidal (seaweed/ weed)									22
<i>Nerita</i>				2	13	3	4		
Land									3
<i>Placostylus</i>			1				2		
Muddy Shores									647
<i>Anadara</i>		14	54	303	197	51	14	14	
Mangrove Mud									235
<i>Planaxis</i>		4	5	12	22	2	1		
<i>Potamides</i>	1	21	12	83	52	17	2	1	
Algal/Reef									12
<i>Tridacna</i>			3	9					

Mangrove Mud, Land) which dominate the later, upper levels. This division is shown numerically in Table 5. In it we see that early levels (6-8) contain 214 or 44% mud dwelling mollusks and 274 or 56% sand dwelling mollusks. However, the dominance of sand dwelling mollusks changes in the later levels (1-5) where we find 1,392 or 71% mud dwelling specimens and only 570 or 29% sand dwelling specimens.

Breakage Patterns

The examination of both bivalves and gastropods from square C1-2/D1-2 revealed several general trends in breakage patterns. Upon initial analysis, the most striking feature of these shells was the complete and unbroken nature of the bivalves. Only approximately 15% of all bivalve specimens from this square exhibited breakage, usually minor damage to the outer edges of the shell; the umbo and hinge areas were rarely damaged. This pattern can be attributed to the relative ease of meat extraction from bivalves which can be pried open uncooked or will open readily once they have been cooked. Furthermore, the slight amount of damage that is present on the bivalves exhibits those breakage patterns frequently found in midden shells (Meehan 1982), particularly from post-depositional breakage due to scavenging animals, trampling, and weight displacement from other shells in the site.

In contrast with the absence of breakage in bivalves was the extremely fragmentary nature of most of the gastropods. Some species of gastropods such as *Cerithium moniliferum* and *Planaxis sulcatus* were on the whole, complete, but these species are so small in size that their nutritional value would be far less than the energy needed to extract meat from them. Breakage does occur in these small species, usually in the lip or main body whorl, but it is relatively inconsequential to this analysis because only *C. moniliferum* appears in large enough numbers to be of statistical value.

Of more importance are the larger species of gastropods such as *Potamides semitrisulcatus*, *Trochus niloticus*, *Turbo setosus*, *Cypraea tigris*, and *Pterocera lambis*. Although these species are all represented at site 13, they occur in trace numbers, indicative of a reliance on bivalves for subsistence at this site. They are, however, more common at the nearby site 13A, and hence, these shells were used first to describe the breakage patterns, and then the site 13 shells were compared to them.

Potamides semitrisulcatus, which does occur in great number at 13, seems to have been broken in the least discriminating manner. Upper spire, apex, and lip were removed from 80% of the specimens. Body whorls and columellae were also commonly removed and most specimens were broken into several pieces as if they were simply smashed with a rock. In approximately half of these specimens, 60% or less of the original shell remains.

Both *Trochus niloticus* and *Turbo setosus* were broken in similar ways although there is slight variation with the *Trochus* shells. In both of these species the main body whorl and lip were removed. Also in 75% of the *Trochus* shells the apex and apical whorls were removed; the apex of 90% of the *Turbo* shells was left intact. The damage done to the *Trochus* shells was limited to the removal of whorls along the sutures, perhaps reflecting the extraction of the whorl for the manufacture of armbands. This suggests that meat extraction was not the only process that influenced breakage patterns of these shells. Bivalves were also commonly reused as net sinkers.

Table 5
Molluskan Habitat Summary, Site 13

Habitat	Number of Species	NISP count	NISP (%)	Levels 1-5	Levels 6-8
Mud	9	1,606	66.0		
Muddy Sand	5	721	29.4		
Muddy Shores	1	647	26.4		
Mangrove Mud	2	235	9.6		
Land	1	3	0.1		
Total Mud Dwelling				1,392 (71%)	214 (44%)
Sand	26	844	34.0		
Beach Sand to Reef	2	266	10.8		
Sand on Reef	3	23	0.9		
Intertidal (rock/coral)	8	338	13.7		
Intertidal (sand/reef)	9	183	7.5		
Intertidal (seaweed/weed)	3	22	0.9		
Algal/Reef	1	12	0.5		
Total Sand Dwelling				570 (29%)	274(56%)

Finally, both *Cypraea tigris* and *Pterocera lambis* were systematically broken. In these species the dorsal outer whorl was sheered off along the long axis of the shell, leaving the hollow body and the modified lip and aperture complete. This large opening allowed for the easy removal of the body mass of the mollusk.

Placostylus Shells

The initial examination of all *Placostylus* spp. (a terrestrial pulmonate) shells from sites 13, 13A, 14, and 26 revealed that the species identifications made by Emerson, Hanna, and Hertlein for Gifford and Shutler had been incorrect. They had identified three species, *Placostylus duplex*, *P. questieri*, and *P. porphyrostomus*. But close examination of the shells by malacologist C. C. Christensen (Bishop Museum, Honolulu), and my own comparison with species descriptions and illustrations in Franc (1957), Solem (1961), and Pilsbry (1900) has allowed these shells to be re-identified. Those shells listed in Gifford and Shutler's report as *Placostylus questieri* should be correctly identified as *P. alexander*. Only one of these specimens was found at site 26. The shells that had been identified as *P. porphyrostomus*, and which occurred at both sites 13A and 26 though morphologically very different, are two distinct species. The specimens from site 26 are *P. mariae*. The one *P. duplex* shell at site 26 was also *P. mariae* but had been misshapen due to a juvenile trauma to the mantle, and was also misidentified. Finally, the shells at site 13A are definitely not *P. porphyrostomus*, nor are they *P. mariae*. These specimens have not been conclusively re-identified, although tentatively they resemble *P. senilis minor*, but this has yet to be verified. There is a possibility that these shells may be an extinct and as yet unidentified species.

The quantitative data for these three *Placostylus* species are presented in Table 6. The unidentified species at site 13A is definitely the most numerous as well as the most massive in thickness. Although *P. alexander* is larger in length and width, the average specimen at site 13A weighs more than *P. alexander*. Weight, length, and width for each specimen were plotted on separate histograms according to species and site. A plot of length vs. width was also made for the specimens that had previously all been identified as *P. porphyrostomus*. These data show a clear division between those specimens at site 13A and those at 26, thus indicating that two separate species are found at the different sites. Furthermore, both adult and juvenile samples of both species were found, discounting any theory that the specimens at site 26 might be the juvenile form of the species at site 13A.

Table 6
***Placostylus* Shell Measurements**

Species (site)	MNI	NISP	Total Weight (g)	Mean Length (mm)	Mean Width (mm)	Mean Weight (g)
<i>P. alexander</i> (26)	1	1	39	91.0 ± 0.00	57.0 ± 0.0	39.0 ± 0.00
<i>P. mariae</i> (26)	20	20	272	53.9 ± 12.9	31.3 ± 4.9	13.6 ± 7.40
<i>P. senilis minor</i> (13A)	44	44	1,782	70.2 ± 10.5	40.2 ± 4.6	40.5 ± 16.7

Discussion

Species Quantification and Size Reduction

With regard to the site 13 mollusks, Gifford and Shutler commented that "there is nothing noteworthy about the assemblage of molluskan species" (1956:30). From this statement one might propose that patterns found at site 13 were similar to other sites that Gifford and Shutler excavated. But since they did not save or record any molluskan data other than presence/absence of species at these other sites, whether their claim is true cannot be tested. However, much can be said that is "noteworthy" about the mollusks from site 13, square C1-2/D1-2.

The most apparent observation to be made from the quantitative data for these identified species is the overwhelming dominance of bivalves in number and weight (Bivalve MNI = 854, weight = 10,820 g; Gastropod MNI = 336, weight = 3,979 g). Bivalves make up 72% of the shell assemblage in this square, indicating that bivalves were a much more important food source than gastropods. This dominance of bivalves most likely is a reflection of the local marine environment around the site and the availability of these mollusks, rather than any cultural preference. The summary of species presented in Nagaoka's (1988) article on Lapita subsistence shows that both gastropods and bivalves were dominant in Lapita sites. More excavation in New Caledonia is necessary to determine if this is a regional pattern exhibited at site 13.

Furthermore, those species present in site 13 are also found in other sites such as site 26. Although no quantitative data are available for site 26, the main species found at site 13 are also those at site 26. Their extensive geographic presence in site 26 might also indicate a quanti-

tative dominance. These sites are relatively close to each other, and their occupants should have been able to exploit similar molluskan resources. Whether these resources changed drastically through time can not be determined from the available data.

The results of the size frequency analysis of five species from square C1-2/D1-2 for the effects of human predation on molluskan populations are somewhat inconclusive. Although further statistical analysis of these data may reveal a small size reduction through time at the site, there is not an obvious reduction that can be attributed to their use as subsistence resources. In her article on the analysis of molluskan archaeological assemblages, Ford (1989:170) casts aspersions on the results of other size reduction hypotheses (e.g., Swadling 1976; Catterall and Poiner 1987). She points out many processes that affect shell size such as variation in the source population of mollusks, molluskan transport activities from the natural to cultural environment, the depositional environment, and post-depositional processes, few of which can be controlled for in an archaeological faunal analysis. These important considerations make it difficult to attach much significance to the small changes observed in the five species analyzed. One can certainly not ascribe these changes to human predation alone.

Habitat

The shift observed in the dominant species habitat at site 13 from sand to mud is much more significant than any size changes in individual species. This trend might possibly reflect a change in the cultural preferences for food species. But more likely, this shift reflects environmental impacts from the prehistoric human occupation of New Caledonia. As humans began to clear forests and expand their agricultural activities, erosion rates would have increased, resulting in increased sediment loads in the streams that drain into the bays and estuaries surrounding the Foué Peninsula, in turn changing the marine environment. Sandy beaches became infused with more sediments, producing mud flats. Fewer sand dwelling species such as *Mesodesma*, *Trochus*, or *Strombus* could survive in their reduced habitats while mud dwellers such as *Gafrarium*, *Potamides*, and *Anadara* thrived and increased in numbers. This sediment change was observed by Gifford and Shutler who described the soil matrix in levels 6-8 as "brown, coarse, beach sand and coral" which was very different from the "black adobe soil" in levels 1-5 (Gifford and Shutler MS [1952]:58).

The species present at site 26 were also identified in an attempt to determine if this site might also display the late pattern at site 13, that is, the dominance of mud species. Although only "representative samples" of mollusks were saved from this site, preventing an exact comparison of the sites, Gifford and Shutler did note the presence/absence of the species for the individual squares in the three locations in this site. Of the 65 species present at this site, only 13 of them were mud dwellers. The geographical dominance of the mud dwellers might also indicate a numerical dominance, possibly mirroring the late habitat exploitation pattern at site 13. This conclusion is, however, speculative.

Breakage Patterns

The described breakage patterns of these molluskan species indicate that techniques used at site 13 allowed for the easiest extraction of meat. Bivalves were rarely broken because

meat was easily extracted without breakage, whereas gastropods such as *Potamides semitrisulcatus* and *Turbo setosus* were greatly fragmented to allow the removal of meat from their tightly wound coils. However, from the example of one species, it is evident that meat extraction was just one cultural process that influenced these breakage patterns. Patterns were also affected by the secondary cultural uses of these mollusks (e.g., for armbands, beads, fishing gear). Also, these breakage patterns are only prevalent in species present in great numbers at the site, the numbers indicating that these specimens were probably used as a food source. Patterns appeared most clearly on the largest species of gastropods, species whose body weight and nutritional value was high enough to merit the effort required to extract their meat. Unfortunately, few of these specimens were present at site 13.

Placostylus Shells

In the introduction to his section on the *Placostylus fibratus* species in the *Manual of Conchology*, Henry Pilsbry prefaced his discussion by quoting the famous line from Dante's *Inferno* (although he assigned it to Milton): "All hope abandon, ye who enter here," as advice to "those entering upon the study of these Placostyles" (Pilsbry 1900:35). Indeed, the study of this genus in New Caledonia is characterized by "almost inextricable confusion" caused by seemingly endless variety of species and much individual and environmental divergence. Yet one thing is clear, there are definitely three different species at sites 13A and 26. No specimens were found at site 14, while at site 13 their presence is negligible and unsuited to a detailed analysis. These species are *P. mariae* and *P. alexander* at site 26 and an unidentified species at site 13A. Furthermore, since the occupation at site 13 was much earlier than 26, one might propose that the species at 13A had become extinct by the time site 26 was occupied. Other extinct *Placostylus* species have been identified in archaeological contexts such as *P. senilis* at the Vatcha Lapita site (Green and Mitchell 1983). The causes of such extinction are speculative, but might be due to a change in environment (e.g., forest clearance and spread of anthropogenic grasslands) caused by human occupation of the island. Alternatively, these snails may have been over-exploited by humans. Gifford and Shutler did report the ethnographic use of *Placostylus* snails as a food source by the residents of the island.

Conclusions

Ideally, the results discovered in this analysis would be stronger if they could be compared with other data from New Caledonia sites. However, Gifford and Shutler did not save this material so inter-site comparisons are impossible except at the most basic levels. However, my results can be placed in the larger context of the Lapita cultural complex in Oceania.

The species that were most likely exploited for subsistence at site 13 (*G. tumidum*, *A. scapha*, *M. glabratum*, *P. semitrisulcatus*, and *C. moniliferum*) are not extremely common at other Lapita sites (Nagaoka 1988), but the predominance of these species might be due to regional environmental variation in New Caledonia. Another difference in this site's mollusks from other Lapita assemblages is the absence of a significant size reduction from human predation in the most highly exploited species. Swadling (1977, 1986), Kirch and Yen (1982), and Spennemann (1987) reported size reductions for some other Lapita sites, and these results seem reliable. However, the absence of this trend at site 13 does not mean that this process did not affect the

mollusks found here because most likely it did. This human cultural process, however, cannot be distinguished from other natural processes, working with this limited set of data.

One of the more important results of this study is the observation of the shift of exploited molluskan habitats from the dominance of sand habitats during the early levels of the site to mud habitats in later levels. This shift seems most likely to have been a result of environmental changes in the Koné region caused by human occupation. This pattern could be crucial to the determination of initial settlement and colonization in the Lapita culture and Oceania in general.

The observations about breakage indicate that specific cultural patterns and guidelines were followed by the Lapita population to extract meat from molluskan shells. Naturally these patterns are influenced by the morphology of individual species but they are also affected by the other cultural uses of the shells. More research needs to be done on these breakage patterns throughout Oceania to determine specific cultural variations.

The evidence from the *Placostylus* snails is important because the revision and correction of the species identifications may aid further research on these snails. They are interesting in Lapita archaeological assemblages because the extinction of certain species has been connected to the original occupation of these islands by humans. They have also been used for dating cultural occupations. With more investigation these snails may prove to be just as important in site 13.

Ultimately, the molluskan faunal analysis at site 13 raises more questions about subsistence strategies than it answers. Unfortunately many of these questions cannot be answered for New Caledonia without further excavations. Certainly all conclusions about subsistence are tentative until the vertebrate fauna from the site are reanalyzed. A preliminary comparison does little to resolve the conflict between the strandlooper and horticultural hypotheses. Although the strandlooper theory seems more limited in scope, the evidence from site 13 seems to indicate this type of pattern. There are surprisingly few vertebrate remains at the site and of course no floral remains were preserved to indicate any agricultural activities. Whether these Lapita populations were strandloopers or horticulturalists remains to be proven. Yet the fact remains evident that marine mollusks were an important component of Lapita subsistence.

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