Changing role of nearshore-marine foods in the subsistence economy of inland upland communities during the last millennium in the tropical Pacific Islands: insights from the Bā River Valley, northern Viti Levu Island, Fiji

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Abstract

Although the Fiji Islands have been settled for more than 3000 years, the prehistoric settlement history of the 750-km^2 Bā River Valley in northern Viti Levu Island is largely unknown. Investigations of two former upland settlement sites (Tubabaka and Vatusōsoso) in defensive locations, more than 10 km from the coast, and occupied perhaps AD 1250-1850, are reported here. At both sites, shellfish remains are abundant and dominated by nearshore-marine species that would have required round-trip journeys of at least 11.5 to 13 hours to obtain. Patterns of marine-shellfish consumption varied through time in a similar manner at both sites, increasing during their early occupation and declining later. This is likely to demonstrate the gradual adaptation of former coastal dwellers living at these sites to inland subsistence.

Key Words

Fiji, last millennium, shellfish, settlement, subsistence, Bā Valley

Introduction

Throughout most of the history of their human occupation, nearshore marine environments of the Pacific Islands have supplied much of the food for their human inhabitants (Szabó and Amesbury 2011). This is as true of the earliest period of occupation (Jones and Quinn 2009; Ono and Clark 2010) as of today, particularly on those (smaller) islands where people subsist mostly from locally-available foods (Bell et al. 2009).

Around the middle of the last millennium on many larger higher Pacific Islands, there was a sharp increase in the numbers of inland upland settlements (Field 2008; Pearl 2004). This change is plausibly linked to the outbreak of conflict and the start of a shift in subsistence regime from coastal-dominated to hinterland-dominated food acquisition (Field and Lape 2010; Nunn 2007; Nunn et al. 2007). There have been only a few attempts to quantify the nature of this shift and to use this information to discuss the evolution of subsistence economies in inland upland settlements in the Pacific Islands (Allen 1975; Davidson 1969; Green 2002). These are issues that have resonance for comparable coastal-hinterland transitions and interactions elsewhere in the world (Ardren and Lowry 2011; Creamer et al. 2011; Ulm 2011).

Study area

The Fiji Islands are a large archipelago in the southwest Pacific Ocean comprising some 90 inhabited islands (Figure 1). Viti Levu Island is the largest and includes around the Rove Peninsula the earliest-known archaeological sites in the group, dating from 3220-2970 calBP (Nunn et al. 2004). Research into the prehistory of Fiji has been carried out in various parts of the group, allowing a consensus on the chronology of its human occupation (Clark and Anderson 2009).

The current study focuses on the Bā (formerly Mbā) Valley in northwest Viti Levu Island, a 750-km^2 catchment whose prehistory is largely unknown. The catchment extends from a series of steep-sided forested ridges in its innermost parts through undulating grassland-covered lowlands, an intensively-farmed valley floor to a mangrove-forested delta (Figure 2). Today all these areas are occupied by people who participate in subsistence activities with commercial sugar-cane farming also being widespread in the lower and middle valley. Previous archaeological research in the Bā Valley was confined to air-photo surveys of lowland areas (Parry 1997) and a series of excavations at the adjoining Natunuku site where there was a colonizing-period (Lapita) settlement (Clark and Anderson 2009; Davidson 1990). The presence of inland settlements, fortified and/or in naturally-defensive locations, was noted by some of the early (19^{th}-century) European visitors; for example, "almost every important hilltop in Western Viti Levu [island] is crowned with an entrenchment of some kind" (Thomson 1908).

A comparable situation in the adjoining Sigatoka Valley (see Figure 1) stimulated a series of archaeological excavations (Field 2003) that spawned discussions about human-environment interactions (Field 2004; Field 2005; Kumar et al. 2006). The aim of the current research was to extend these discussions for the Bā Valley, initially by identifying and investigating former inland settlement sites with a view to illuminating its settlement history. Four months of fieldwork were carried out in 2009 and 2010. While aerial photographs and Google Earth were used to identify likely sites, particularly in upland areas, elderly long-resident informants proved more helpful in locating old village sites, fortifications, caves and rockshelters, particularly in the sparsely occupied upland hinterland.

Seventeen new sites were recorded (Figure 2) of which the two most thoroughly investigated are described in this paper. A preliminary chronology of the Bā Valley sites has been published (Nunn 2011) while a report describing all sites is with the Fiji Museum (Robb 2010). The radiocarbon ages reported in the present paper supersede, by virtue of their more up-to-date calibration, those reported in these studies.

The two sites (Tubabaka and Vatusōsoso) described below are both upland cave/rockshelter sites located in dissected terrain close to the valley's eastern divide. Unlike some other sites investigated in the Bā Valley, both showed signs of substantial prehistoric occupation, largely undisturbed by more recent (post-contact) settlement, that made use of marine-food resources despite being considerable distances from the coast. The following account focuses on the context of these sites and the shellfish remains recovered from them.

Tubabaka

Approximately 370 m above sea level, Tubabaka is a rockshelter used occasionally today for overnight stays during hunting trips. The rockshelter is elongate, open to the west for 30 m, and faces a small stream that flows into the Navisa Creek (see Figure 2). At its entrance, the rockshelter is 3.2 m high and extends inwards 5.5-9.5 m. Pottery sherds and shellfish remains are scattered across its floor and below its mouth.

Two test units were excavated towards the rear of the rockshelter. Sediments of mostly sandy clay texture were passed through a 5-mm sieve and archaeological specimens retained. The first unit (1 x 2 m) was excavated until bedrock was reached at 70 cm. The second (4 x 1 m) stretched from the rear wall of the rockshelter to its opening. The eastern (innermost) 2 m^2 consisted of two layers of cultural material that were excavated until sterile sediment was reached at 58 cm. Sediments in the western (entrance) 2 m^2 of the pit showed sign of having been removed by downslope erosion and contained comparatively little cultural material.

Mollusc samples were obtained from both pits for dating. Results are shown in Table 1A and suggest that the stratigraphy of the cave fill is undisturbed, that it had begun accumulating by the 13th century, and may still have been accumulating shortly before the time of European settlement in the area (1870[1]) when indigenous settlement patterns throughout Fiji began to be reconfigured. Prior to European settlement of Fiji, there are likely to have been far fewer coastal settlements and many more in defensible and/or refuge upland locations like Tubabaka (Kumar et al. 2006; Routledge 1985; Ward 1969).

[1] Although bêche-de-mer traders were active along the Bā coast in the 1840s, this trade effectively ceased in 1850. The earliest European to settle in the Bā Valley was Charles Lindberg who arrived in June 1870.

Two marine species (*Anadara* sp. and *Gafrarium tumidum*) followed by the freshwater *Batissa* sp. form the majority (>98%) of the 4.2 kg of shellfish remains recovered during excavation (Table 2). Most other species identified in the assemblage come from similar nearshore-marine environments. Over three quarters of the assemblage originate from intertidal and shallow-water marine environments while the third highest ecological zone that was exploited was freshwater rivers (Figure 3).

Vatusōsoso

Vatusōsoso is a location (400 x 60 m) comprising caves and rockshelters cut in volcanic conglomerate interspersed with house mounds (*yavu*) along the sides of a deeply-incised valley approximately 270 m above sea level. Investigations focused on a large cave on the floor of which shellfish remains and potsherd scatters suggested a comparatively intense occupation history.

This cave has a narrow entrance, which bifurcates and provides access points to the main chamber. This is roughly circular, averaging 9 m in diameter with a maximum height of 1.6 m. Local people occasionally use the cave today as a refuge while hunting and identified several areas where there have been wall collapses.

Two test units (1 x 1 m) were excavated in the centre of the cave, both reaching bedrock at 80 cm. Sandy clay sediments were processed through a 5-mm sieve and archaeological material retained. Three samples were dated from close to the bottom of the cultural sequence. The results suggest that occupation of this cave was underway by persons consuming marine shellfish by the 16th century (see Table 1).

As at Tubabaka, two marine species (*Anadara* and *Gafrarium*) and one freshwater species (*Batissa*) form the bulk (>99%) of the shellfish assemblage (weighing 11.2 kg) (see Table 2). That the proportions of these are comparable to those from Tubabaka suggest that the people at both sites were exploiting similar coastal and riverine environments. What is different between the environments represented by the shellfish assemblage at Vatusōsoso compared to Tubabaka is that freshwater shellfish remains are more abundant at Vatusōsoso (see Figure 3). If the difference is significant, it could suggest either easier access to freshwater shellfish, generally confined to the larger rivers in this area (not those adjacent to the excavated sites), and/or more difficult access to marine-shellfish resources for the people living at Vatusōsoso, which is farther from the sea.

Data analyses

Two types of data analysis are reported below. The first discusses and attempts to quantify the effort involved by people living formerly in Tubabaka and Vatusōsoso in obtaining marine shellfish. The second discusses changes in marine-shellfish consumption at Tubabaka and Vatusōsoso through time.

Sources of marine shellfish and collection times

Owing to the distance from the coast, it would appear challenging for any community living at either Tubabaka or Vatusōsoso to obtain a regular supply of marine foods. Some calculations of the distances and times involved in acquiring such foods are given in Table 3 and refer to locations in Figure 4; locations A-D are the places considered likeliest for the collection of the marine shellfish species found at these inland sites. Travel times shown in Table 3 were calculated based on (PN) walking along the routes shown in Figure 4. These times are calculated on the assumption that the vegetation of the area was the same as today, which is unlikely but currently undemonstrable, and that (as today) paths existed along the easiest routes.

Table 3 shows the straight-line distances (shortest routes) from Tubabaka and Vatusōsoso to each of the likely marine shellfish-gathering locations. It can be seen that a round-trip journey, without allowing for rest stops or shellfish-collection time, would have taken between 11 and 16.6 hours to complete. More likely it is that the occupants of Tubabaka and Vatusōsoso would have taken the easiest (yet longer) routes to these resource locations. Details of these easier routes, as identified through discussion with the present inhabitants of nearby villages, are also shown in Table 3. The shortest round trip from Tubabaka to the coast (at C) takes 9.5 hours while that from Vatusōsoso to the coast (at C) takes 11 hours.

Allowing a total 1 hour rest and 1 hour for shellfish collection at the coast, return trips along the easiest routes would have taken at least 11.5 hours (from Tubabaka) and 13 hours (from Vatusōsoso) and could therefore have been made within daylight hours at most times of the year from both sites. The abundant freshwater shellfish that live in the larger rivers in the area, particularly the Bā and the Nasivi Rivers, could also have been targeted during these trips.

Today the villages closest to Tubabaka and Vatusōsoso are all connected by road (and often a regular bus service) to the coast, so it is impossible to gauge the enthusiasm of people in earlier times for journeys such as those envisaged. One man interviewed at Koroboya village north of Vatusōsoso ridiculed the idea of travelling on foot to the coast, saying that he would only attempt such a journey on horseback but even then it would take at least four hours each way.

It is possible that, even though people living at Tubabaka and Vatusōsoso were aware of food resources closer to home than those along the coast, they routinely gathered these because of their familiarity, abundance and ease of collection. This is illustrated by an account from the mid-19th century (post-European contact) that told of the "teeming fisheries" of the Bā River Delta, describing a visit in 1847 when

> "we went to the mouth of the [Bā] river where many canoes were engaged in fishing. There were also many people without canoes, wading to the middle in water on the reefs gathering shellfish" (Lawry 1850: 91).

Evidence for changes in shellfish consumption through time

Even allowing for the archaeological visibility of this dietary component, the data in Table 2 (shown in Figure 3) demonstrate the apparent dominance of marine shellfish in the diet of people at Tubabaka and Vatusōsoso. There is evidence that the ratio of marine to freshwater shellfish changed in a similar manner at both sites through the period they were occupied (Table 4, Figure 5). All three graphs shown in Figure 5 suggest a greater consumption of marine rather than freshwater shellfish during the initial occupation of these sites. The dominance of marine shellfish increases through time before a position of apparently higher consumption of freshwater molluscs is established during the later occupation of these sites.

Discussion

One simple explanation of the patterns shown in Figure 5 is that Tubabaka and Vatusōsoso were occupied initially by people accustomed to consuming mostly marine foods who continued to do so even though they lived a considerable distance from the sea. They also consumed freshwater molluscs from the larger rivers near the sites but maybe as these resources became locally depleted, perhaps as a consequence of their proximity and accessibility (compared to marine molluscs) to Tubabaka and Vatusōsoso, so the dependence on marine shellfish increased. As time went on, the occupants of these sites are likely to have become more familiar with their inland environments and began to develop subsistence lifestyles, perhaps more reliant on nearby agriculture, that were increasingly less dependent on nearshore marine subsistence.

The results obtained also pose several questions about the precise nature of the subsistence economy of the people who lived at Tubabaka and Vatusōsoso. One of the key questions is what other foods these people consumed and whether changes in the availability of these might help explain the changing shellfish consumption patterns shown in Figure 5.

The rivers that run past both Tubabaka and Vatusōsoso are both small in terms of discharge and are reported to dry up occasionally. These rivers are considered too small to have ever supported populations of *Batissa*, which are known to inhabit larger rivers in the area, something confirmed by local informants. Living individuals of the freshwater gastropod *Septaria suffreni*, the remains of which were recovered from excavations at both sites (see Table 2), are found in rivers adjoining both Tubabaka and Vatusōsoso. Yet these shellfish have a considerably lower food value than *Batissa* and may have been largely spurned by the earlier inhabitants of the area, as they mostly are today. Human predation pressures and increased levels of suspended sediment in rivers (a result of land clearance and deforestation) may account for a fall in the numbers and range of certain freshwater shellfish species in this area today (Haynes 1999). Freshwater fish are found in the larger rivers of the area, although not those adjoining Tubabaka and Vatusōsoso, and are also likely to have been more abundant in the past.

Despite the predominance of marine-tethered subsistence in the modern Pacific Islands, most larger islands have long-established inland settlements where mostly non-marine foods are consumed (Bonnemaison 1974; Thaman 2008). In Fiji, these include the ubiquitous coconut palm (*Cocos nucifera*), breadfruit (*Artocarpus altilis*), the Tahitian chestnut (*Inocarpus fagiferus*) and the canarium nut (*Canarium indicum*). All of these are found today growing in forests outside modern garden lands in the areas around Tubabaka and Vatusōsoso and probably represent now-abandoned areas of cultivation. Rats, feral pigs and chickens are also found in these areas today and are likely to have been consumed in prehistory together with a variety of native birds (Field et al. 2009; Jones and Quinn 2009). Yet the key reason why inland settlements on larger Pacific Islands are sustainable today is because of agriculture, which is also likely to have been practiced by the people at Tubabaka and Vatusōsoso, at least during their later occupation.

In the tropical Pacific Islands, there are some extant descriptions of agriculture being practiced by inland populations occupying inland sites around the time of European contact. In AD 1568, for example, on Guadalcanal Island, Solomon Islands, there were

> “so many villages on the hill-tops that it was marvellous, for more than 30 villages of 10 and 20 houses and more, could be counted within a league and a half of road. And all the slope

> around the hills was full of huts, clearings and plantations, kept in very good order" (Catoira quoted by Amherst and Thomson 1901).

In the Sigatoka Valley in Fiji during the early 1860s, a British Colonial official recorded that

> "Jealousy that made every village distrustful of its neighbours compelled the inhabitants to fortify themselves on the most inaccessible heights, and prevented them from cultivating any land beyond the few feet around each man's dwelling; if more were required, the cultivator, afraid to descend into the plain discovered some spot in the recesses of the mountains where he might plant his yams secure from molestation" (Anonymous 1864).

At the study sites, there are areas within 15-30 minutes walk that are suitable for taro (principally *Colocasia esculenta*) and yam (*Dioscorea* sp.) agriculture although no direct evidence for this could be found owing to the dense vegetation cover. The growing of taro and yam on steep dry hillsides in this part of Viti Levu Island was reported as well-established and ubiquitous by traveller Theodor Kleinschmidt in 1877 (Tischner 1984) so is likely to have been a mainstay of the subsistence economy at Tubabaka and Vatusōsoso during at least their later occupation.

Elsewhere in the Bā catchment, there is evidence for formerly extensive rainfed agricultural terraces, particularly around Bukuya Village at the head of the valley (Kuhlken 1999). Given that the terrain around the heads of some of the tributary valleys within an hour's walk of Tubabaka and Vatusōsoso is similar, it is possible that terraces for the intensive production of taro were also utilised. As elsewhere in Fiji, the physical evidence of ancient taro terraces here may have been obliterated by subsequent landscape change, particularly by grazing animals (Kuhlken 2002).

There are other issues that should be considered, principally whether or not the sites of Tubabaka and Vatusōsoso represent permanent or temporary settlement. It is possible that these sites were occupied permanently similar to the slightly inland rockshelter excavated at Navatu in northeast Viti Levu Island (Gifford 1951). Alternatively, Tubabaka and Vatusōsoso may have been occupied by coastal or lowland communities only at times when they felt in danger. Work on Lakeba Island in eastern Fiji concluded that that fortified inland sites in the period ca AD 1020-1490 were probably established as precisely such temporary refuges (Best 1984). Later though on Lakeba (ca AD 1490-1770) in response to sustained threat levels, inland upland settlements were permanently occupied.   A third possibility is that Tubabaka and Vatusōsoso were occupied simultaneously with coastal communities and interacted with them; a comparable situation was described for the Nebira site (ca AD 1230-1650) in Papua New Guinea (Shaw et al. 2011). During the 19th century following European contact, which may therefore not be a useful guide to understanding pre-contact interaction, there are records of trade between coastal and inland communities in this part of Fiji involving fish and yams (Lawry 1850) and salt and tapa[2] (Boyd 1986).

A plausible scenario for the settlement history of Tubabaka and Vatusōsoso based on the shellfish and radiocarbon data (in Figure 5) and acknowledging other analyses of last-millennium settlement pattern changes in Fiji and nearby island groups is as follows.

- Stage 1: AD 1250-1350, inland settlements established by coastal and/or near-coastal (valley-floor) communities as refuges in times of danger, occupied only sporadically.
- Stage 2: AD 1350-1750, inland settlements occupied permanently, an important component of subsistence in the early part of this period being nearshore-marine shellfish, but supplemented increasingly during the later part by inland-derived foods, particularly from proximal agriculture.
- Stage 3: AD 1750-1850, inland settlements occupied permanently, with consumption of nearshore-marine shellfish decreasing as non-marine foods became increasingly dominant, and as (near-) coastal communities became re-established and inland-coastal trade began. The apparent

[2] Tapa is a fabric made from the bark of the paper mulberry (*Broussonetia papyrifera*) that was used as cloth in prehistoric times in many Pacific Island groups.

rise in marine shellfish consumption in the youngest part of Vatusōsoso Pit 2 (see Figure 5) may indicate increased supply from such trading with coastal communities.

Conclusion

The investigations of Tubabaka and Vatusōsoso reported here represent the first in this part of Vitu Levu Island. They also represent the first studies from inland (excluding near-coastal) settlements in the tropical Pacific Islands to demonstrate apparently parallel changes in marine-shellfish consumption through time. The suggested three-stage settlement history is consistent with evidence from elsewhere in Fiji and surrounding island groups (Best 1984; Davidson 1969; Green 2002; Nunn 2007; Pearl 2004).

Similar changes in settlement pattern throughout the tropical Pacific have been explained by the impacts of climate-forced (through sea-level fall) marine resource depletion on dependent coastal communities (Nunn 2007; Nunn et al. 2007). Comparable studies from elsewhere in the world can also be plausibly linked to non-local climate-forced resource depletion. Examples come from the Pacific Rim in both Australia and South America where drought associated with increased climate variability (proxied by ENSO) appears to have been a major driver of changes in prehistoric settlement pattern (Williams et al. 2010; Williams et al. 2008).

The effects of falling sea level around the same time, across the transition between the Medieval Warm Period and the Little Ice Age that affected most parts of the world (Mann et al. 2009), also caused changes to nearshore marine subsistence strategies that have been claimed as having influenced changes in settlement pattern. Examples come from coastal eastern Australia and New Zealand where major changes in nearshore shellfish ecology are likely to have driven changes in human subsistence (Rowland 1976, 1999; Ulm 2006) and the Pacific coast of Mexico where climatic impacts on shellfish subsistence led to the abandonment of coastal settlements (McGoodwin 1992).

These examples underline the importance of factoring external environmental changes into any discussions about the reasons for changes in prehistoric human societies (deMenocal 2011; Haberle and Lusty 2000; Nunn 2007).

Acknowledgements

This research was generously funded by the G. Unger Vetlesen Foundation. Our thanks to Fiona Petchey for re-calibrating the radiocarbon ages. Comments from William Boyd and an anonymous reviewer considerably improved the manuscript. Thanks also to Mereoni Camailakeba, Reemal Chandra, Sepeti Matararaba, Shalni Sanjana and Sainimere Veitata for field assistance. *Mari vāvinavinā ivamū na lewenivanua vāmōmō o Bā qania na kea yasayasa, vinā dū riki na vīvuke*.

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people at Tubabaka and Vatusōsoso. Raw data are in Table 4; note that data from Pit 2 at Tubabaka are not included because molluscs were found in only two spits. Median ages for dated samples in these pits are shown for reference (see Table 1).

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Table 1. All radiocarbon dates from the Tubabaka and Vatusōsoso sites. All dates from the University of Waikato Radiocarbon Dating Laboratory corrected using marine correction factor (ΔR) of 11±26 years (Petchey et al. 2008) and calibrated using the IntCal09 and Marine09 curves in OxCal v4.1.7(Bronk-Ramsey 2010; Reimer et al. 2009).

Table 2. Mollusc species found during excavations at Tubabaka and Vatusōsoso. Data are Minimum Numbers of Individuals (MNI).

Table 3. Distance and walking hours (excluding rest stops and shellfish-collecting time) of various routes from Tubabaka and Vatusōsoso to likely coastal resource supplies. For calculation of walking hours, it is assumed that the vegetation is the same as it is today and that paths existed through the most densely-forested areas.

Table 4. Minimum Numbers of Individuals (MNI) and percentages of marine and freshwater molluscs found in excavations (by 10-m spit) at Tubabaka and Vatusōsoso.

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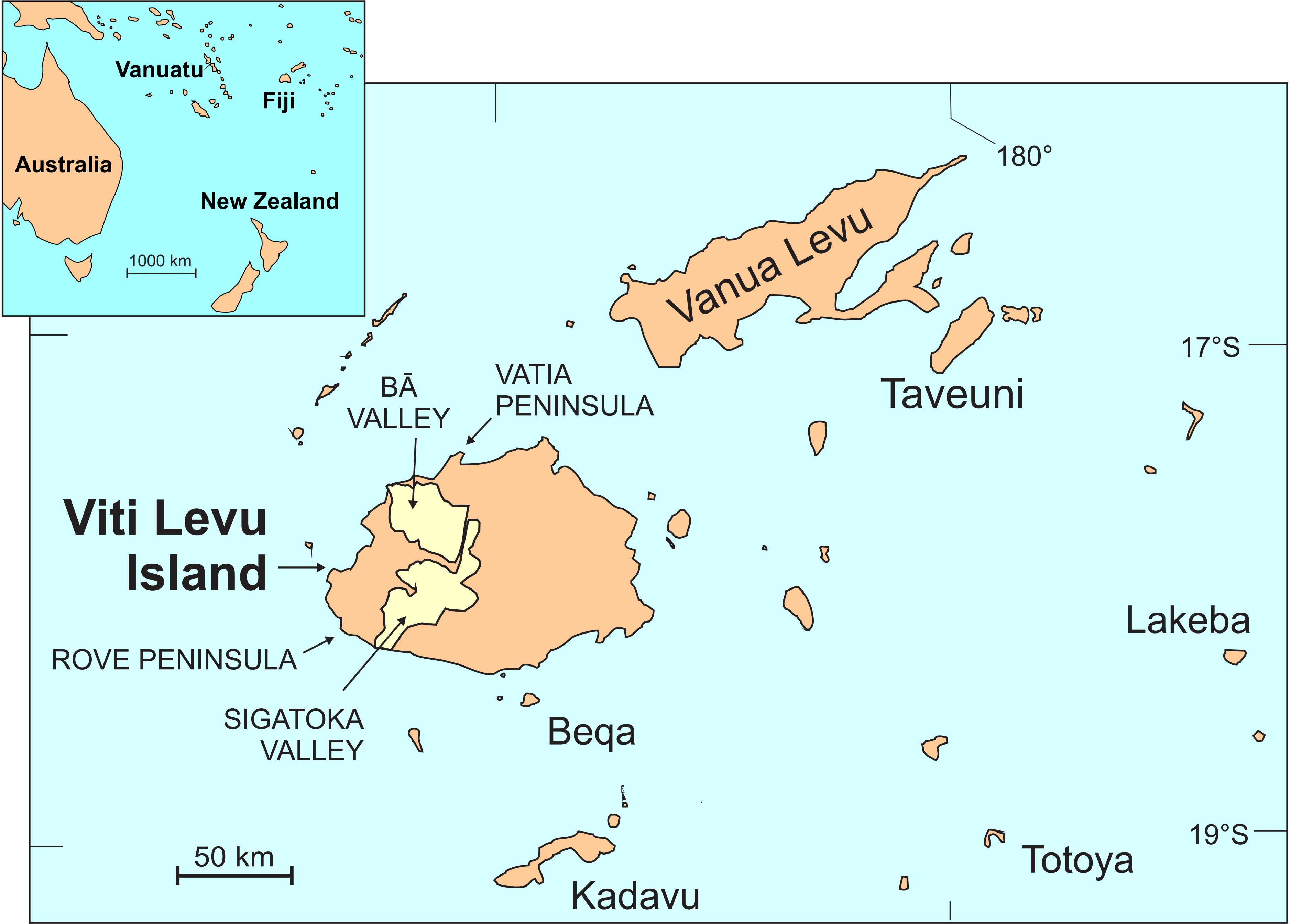
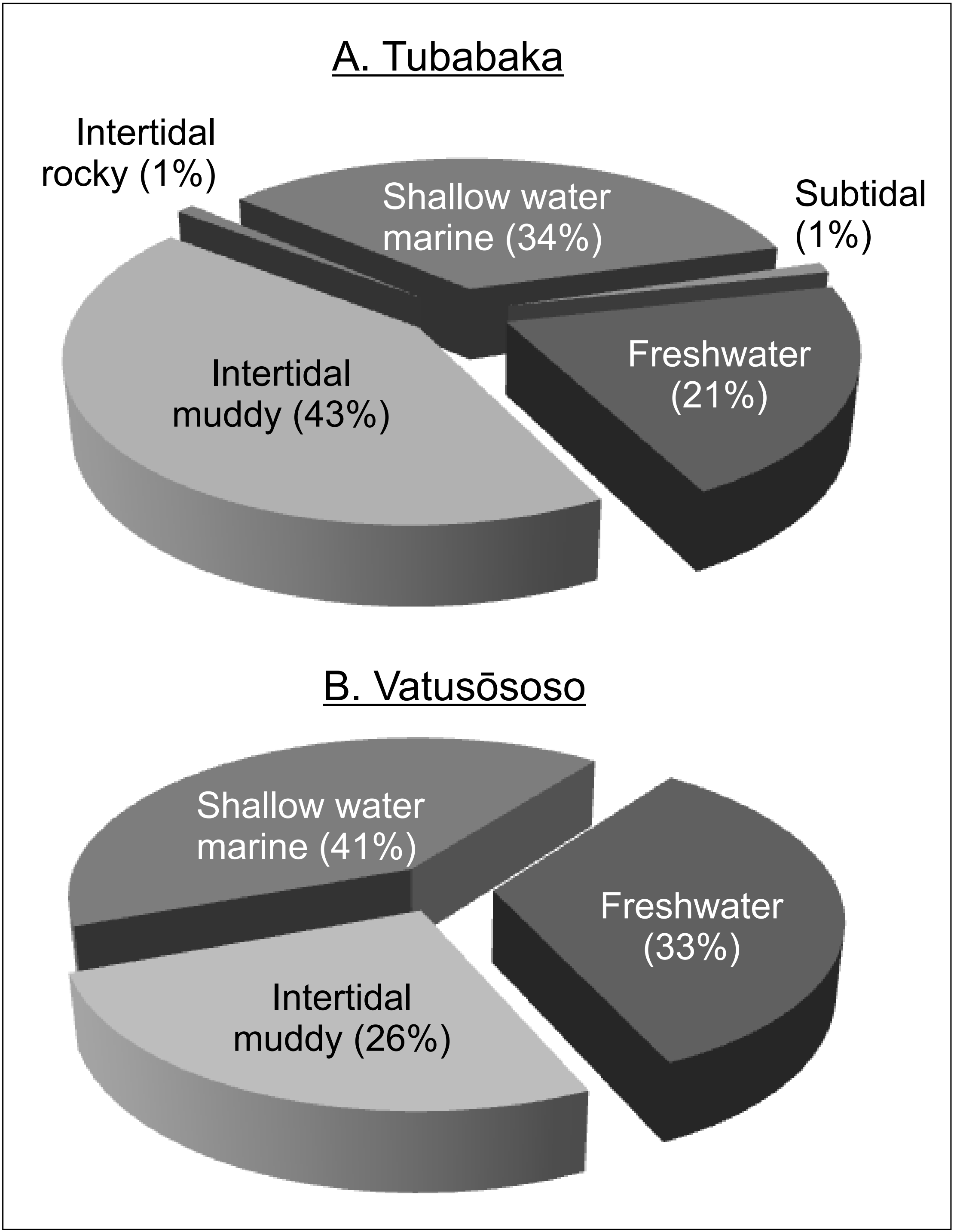

Vanuatu
Fiji
Australia
New Zealand
1000 km
180°
Vanua Levu
17°S
Taveuni
BĀ
VALLEY
VATIA
PENINSULA
Viti Levu
Island
ROVE PENINSULA
SIGATOKA
VALLEY
Beqa
Lakeba
19°S
Totoya
50 km
Kadavu

Figure 1

Figure 2


UPLAND INLAND
SETTLEMENT
SITES IDENTIFIED
DURING THIS PROJECT
177°45´E
Natunuku
(Lapita-era)
site
Vatia
Peninsula
Bā Delta
mangrove
swamp
NAYAVUTŪ
NAILILI
TUBABAKA
VATUSŌSOSO
Navisa Creek
Namosau
Creek
NAQARA
1060 m
KĀMALU
VATULŌLŌ
QELEIYAMACOKO
DRIKUSI
SARAVI
Nadrau
Creek
Bā
River
NAQATA
NAVINOTI
NAVEIBULI
1160 m
Waisali
Creek
Savatu
Creek
KOROIKEWA
Nakara
River
NACULE
TAVICO
17°45´S
Talawase
Creek
0
5
km
ULUIMAGODRO
Bukuya
Village
(modern)

Figure 3


A. Tubabaka
Intertidal rocky (1%)
Shallow water marine (34%)
Subtidal (1%)
Intertidal muddy (43%)
Freshwater (21%)
B. Vatusōsoso
Shallow water marine (41%)
Freshwater (33%)
Intertidal muddy (26%)

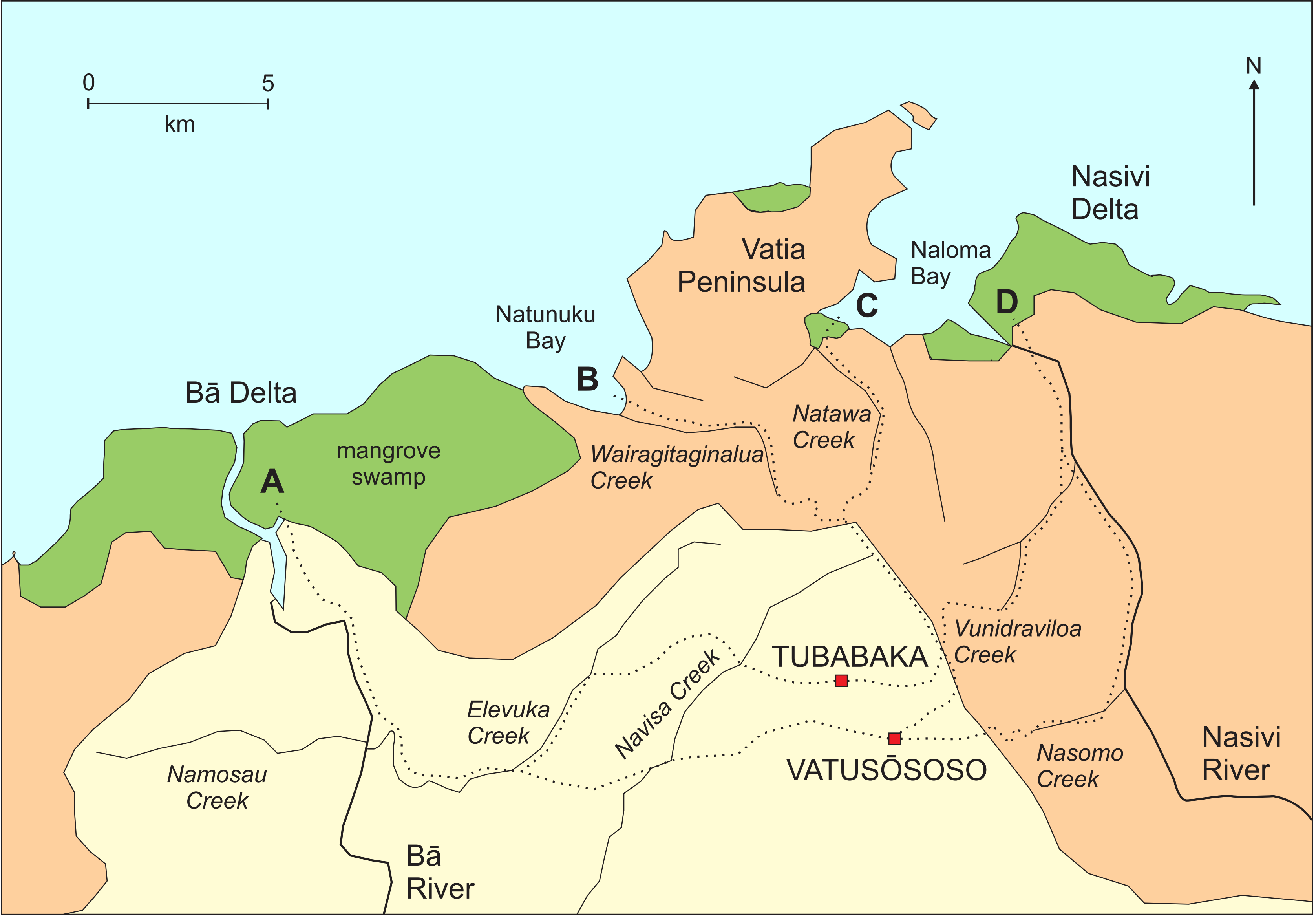
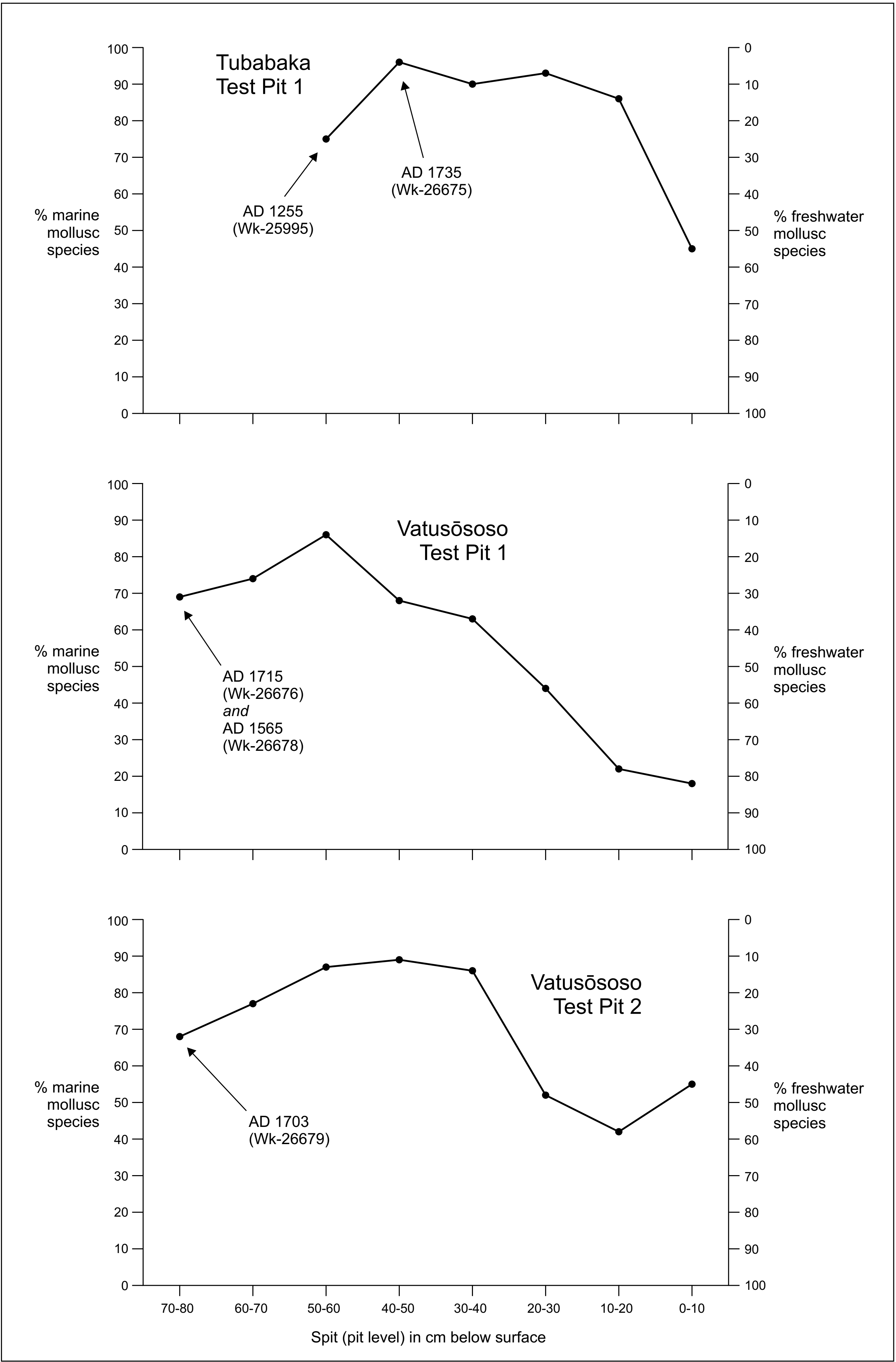

0
5
km
N
Bā Delta
mangrove
swamp
A
Natunuku
Bay
B
Vatia
Peninsula
C
Naloma
Bay
D
Nasivi
Delta
Wairagitaginalua
Creek
Natawa
Creek
Vunidraviloa
Creek
TUBABAKA
Navisa Creek
Elevuka
Creek
VATUSŌSOSO
Nasomo
Creek
Nasivi
River
Namosau
Creek
Bā
River

Figure 4

Figure 5



Tubabaka
Test Pit 1
AD 1255
(Wk-25995)
AD 1735
(Wk-26675)
Vatusōsoso
Test Pit 1
AD 1715
(Wk-26676)
and
AD 1565
(Wk-26678)
Vatusōsoso
Test Pit 2
AD 1703
(Wk-26679)
% marine mollusc species
% freshwater mollusc species
0
10
20
30
40
50
60
70
80
90
100
70-80
60-70
50-60
40-50
30-40
20-30
10-20
0-10
Spit (pit level) in cm below surface

Table 1. All radiocarbon dates from the Tubabaka and Vatusōsoso sites. All dates from the University of Waikato Radiocarbon Dating Laboratory corrected using marine correction factor (ΔR) of 11±26 years (Petchey *et al*. 2008) and calibrated using the IntCal09 and Marine09 curves (Reimer *et al*. 2009) in OxCal v4.1.7 (Bronk Ramsey 2010).

Pit	***Laboratory number***	***Sample material***	***Depth (cm)***	$\delta^{13}C$	***Conventional radiocarbon age (BP)***	***Calibrated radiocarbon age BP at 95.4% probability***	***Calibrated radiocarbon age AD at 95.4% probability***
Tubabaka							
TP2	Wk-28292	Marine shell (*Anadara* sp.)	43	-0.9+/-0.2	635±33	390-135	AD 1560-1815
TP1	Wk-26675	Marine shell (*Anadara* sp.)	45	-1.3+/-0.2	609±30	325-105	AD 1625-1845
TP1	Wk-25995	Freshwater shell (*Batissa* sp.)	55	-8.5+/-0.2	747±34	735-655	AD 1215-1295
Vatusōsoso							
TP1	Wk-26676	Marine shell (*Anadara* sp.)	75	-1.2+/-0.2	616±30	355-115	AD 1595-1835
TP1	Wk-26678	Charcoal	75	-26.6+/-0.2	320±30	470-300	AD 1480-1650
TP2	Wk-26679	Marine shell (*Anadara* sp.)	75	-0.5+/-0.2	624±31	370-125	AD 1580-1825

Table 2. Mollusc species found during excavations at Tubabaka and Vatusōsoso. Data are Minimum Numbers of Individuals present (MNI).

1. Marine mollusc species

Test Pit	*Anadara* sp.	*Asaphis violascens*	*Atactodea striata*	*Codakia tigerina*	*Fimbria soverbii*	*Gafrarium tumidum*	*Hyotissa hyotis*	*Morula funiculus*	*Nerita albicilla*	*Nerita polita*	*Nerita undata*	*Phasianella variegata*	*Placuna sella*	*Saccostrea cucullata*	*Tapes dorsatus*	*Oxymeris maculata*
Tubabaka																
TP1	225	0	0	6	0	176	0	0	1	4	0	0	0	0	1	2
TP2	152	15	0	0	0	146	0	0	0	0	6	1	1	0	0	0
Vatusōsoso																
TP1	308	0	4	5	1	454	0	0	0	1	0	0	0	1	0	0
TP2	363	0	5	7	0	590	1	1	0	1	0	0	0	0	2	0

2. Freshwater mollusc species

Test Pit	*Batissa* sp.	*Septaria suffreni*
Tubabaka		
TP1	117	1
TP2	70	0
Vatusōsoso		
TP1	512	1
TP2	325	0

3. Totals

Test Pit	*Total all shells*	*Total marine*	*Total freshwater*	*% marine*	*% freshwater*
Tubabaka					
TP1	533	415	118	77.9	22.1
TP2	391	321	70	82.1	17.9
Vatusōsoso					
TP1	1287	774	513	60.1	39.9
TP2	1295	970	325	74.9	25.1
All pits	3506	2480	1026		

Table 3. Distance and walking hours (excluding rest stops and shellfish-collecting time) of various routes from Tubabaka and Vatusōsoso to likely coastal resource supplies. For calculation of walking hours, it is assumed that the vegetation is the same as it is today and that paths existed through the most densely-forested areas. Straight-line distances represent the shortest routes for which travel times are estimated based on local knowledge. Easiest routes were all walked.

	Straight-line distance to coast (one-way km)	**Straight-line travel time (round-trip hours to walk)**	**Easiest-route distance (one-way km)**	**Easiest-route travel time (round-trip hours to walk)**	**Details of easiest route**
Tubabaka					
Tubabaka to Point A	16.8	15.5	22.5	11.5	Across Navisa, down Elevuka, along Bā floodplain
Tubabaka to Point B	10.5	11.5	14.7	10.5	Along ridgeline to NE, down Wairagitaginalua
Tubabaka to Point C	10.1	11	12.3	9.5	Along ridgeline to NE, down Natawa
Tubabaka to Point D	11.2	12	13.8	10.5	Across ridgeline to NE, down Vunidraviloa, along Nasivi floodplain
Vatusōsoso					
Vatusōsoso to Point A	18.7	16.6	26	12.5	Across Navisa, down Elevuka, along Bā floodplain
Vatusōsoso to Point B	12.7	15.5	17.2	14	Along ridgeline to NE, down Wairagitaginalua
Vatusōsoso to Point C	12.1	11.5	13.7	11	Along ridgeline to NE, down Natawa
Vatusōsoso to Point D	12.5	13.5	17.7	12.5	Across ridgeline to NE, down Nasomo, along Nasivi floodplain

Table 4. Minimum Numbers of Individuals (MNI) and percentages of marine and freshwater molluscs found in excavations (by 10-cm spit) at Tubabaka and Vatusōsoso.

Site	Test Pit	Spit (cm range)	Marine shells present	Freshwater shells present	% Marine	% Freshwater
Tubabaka	TP1	0-10	59	73	44.7	55.3
		10-20	177	30	85.5	14.5
		20-30	107	8	93.0	7.0
		30-40	44	5	89.8	10.2
		40-50	22	1	95.7	4.3
		50-60	3	1	75.0	25.0
Tubabaka	TP2	0-10	0	0	-	-
		10-20	295	67	81.5	18.5
		20-30	29	4	87.9	12.1
		30-40	0	0	-	-
		40-50	0	0	-	-
		50-60	0	0	-	-
Vatusōsoso	TP1	0-10	6	27	18.2	81.8
		10-20	28	100	21.9	78.1
		20-30	106	136	43.8	56.2
		30-40	143	83	63.3	36.7
		40-50	253	117	68.4	31.6
		50-60	190	32	85.6	14.4
		60-70	37	13	74.0	26.0
		70-80	11	5	68.8	31.3
Vatusōsoso	TP1	0-10	22	18	55.0	45.0
		10-20	38	52	42.2	57.8
		20-30	129	117	52.4	47.6
		30-40	381	63	85.8	14.2
		40-50	177	21	89.4	10.6
		50-60	104	16	86.7	13.3
		60-70	104	31	77.0	23.0
		70-80	15	7	68.2	31.8
Total shells			**2480**	**1027**	**70.7**	**29.3**