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A Bayesian AMS ^{14}C chronology for the colonisation and fortification of Rapa Island

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Introduction

One of our primary objectives on Rapa was to establish a settlement chronology. Although we encountered a range of archaeological sites and cultural features during our short time on the island, our chronological work was focused on determining the likely age of colonisation, with investigations of coastal rockshelters, and the age of hilltop fortifications and their proliferation (Figure 11.1). Heyerdahl's Norwegian expedition to Rapa occurred during the 1950s, shortly after Libby's breakthrough development of radiocarbon dating. Early applications of radiocarbon dating in archaeology were often limited, and in this tradition, Mulloy (1965:59) acquired two radiocarbon dates from the fortified site of Morongo Uta. One date of 310 ± 300 bp (bp = uncalibrated result) came from a hearth in the middle of a centrally located terrace (Enclosure 2) and a second date of 210 ± 200 bp was obtained from the 'floor level' of another terrace on the eastern side of the site (Enclosure 85). These dates were considered to be associated with the last phase of occupation of this fortification, rather than the age of first construction, but when the dates are calibrated they span AD 1260–1500 and AD 1400–1950, respectively. The results place the known age of fortification on the island in the later stages of East Polynesian prehistory, but they are of limited use due to the small sample size, lack of analytical detail and low precision.

Figure 11.1. Locations of archaeological sites with AMS radiocarbon dates mentioned in text. Drafted by R. Van Rossman. 1 = Ororangi (R-20); 2 = Ngapiri (R2002-50); 3 = Tevaitau (R-18); 4 = Morongo Uta (R-1); 5 = Puketaketake (R2002-42); 6 = Tangarutu; 7 = R2002-49; 8 = Noogurupe (R2002-43); 9 = Kapitanga (R-5); 10 = Ruatara (R-17); 11 = Vairu (R-3); 12 = Angairao, Shelter E; 13 = Taura (R2002-40); 14 = Pukumia (R2002-39); 15 = Akatanui, Shelter 3; 16 = Pukutai (R-19); 17 = Tapitanga (R-4); 18 = Taga Rockshelter; 19 = Potaketake (R-2); 20 = R2002-48; 21 = R2002-11; 22 = R2002-16; 23 = R2002-20.

The Norwegian expedition focused on the enigmatic fortifications on Rapa and not the age of colonisation. More recent work by Walczak (2001) identified the Tangarutu rockshelter as a possible early site. From deposits exposed in the cave he obtained two radiocarbon dates, of 330 ± 45 bp (Ly-8578) and 495 ± 40 bp (Ly-8577), which calibrate to AD 1460–1670 and AD 1400–1500, respectively. These dates overlap in age with Mulloy's dates from Morongo Uta and are quite late in the East Polynesian sequence.

In this chapter, we describe the results of our ¹⁴C dating program. We AMS ¹⁴C dated materials from stratigraphic excavations at various coastal rockshelters and fortifications; the contextual information for these dates is described elsewhere in this volume. In this chapter, we combine these data with additional AMS ¹⁴C dates on material collected opportunistically from exposed stratigraphic deposits and test probes (augers and 25 cm circular sample test pits) on fortifications, terraces and ovens. We use this AMS ¹⁴C survey technique in combination with Bayesian statistical analysis to establish a chronology for broader patterns of landscape use during the colonisation and fortification process. These observations will be valuable for defining future work on Rapa.

Sample selection and analytical methods

We analysed 25 samples from four rockshelters, 30 samples from 10 different fortifications and 10 additional samples from other types of contexts (e.g. ovens, domestic terraces). All of the radiocarbon samples from the four coastal rockshelters come from excavations detailed in Chapter 3. Datable materials were reasonably well preserved in these contexts and carbonised plant remains were recovered from most stratigraphic units of interest. This was particularly the case at Tangarutu rockshelter, where preservation was exceptional and artefacts made of perishable materials were recovered (e.g. fish hooks, cordage). Carbonised wood fragments were most commonly recovered, but we radiocarbon dated carbonised seeds and smaller twigs preferentially if they were available (see discussion below regarding the old wood problem).

Obtaining datable materials from fortifications and other open-air sites was more challenging. The volcanic soils on the island are highly acidic and do not favour the preservation of organic materials. Hilltop fortifications are the most exposed site types and therefore highly susceptible to water erosion and wind deflation, both substantial in Rapa's subtropical location. Compared with rockshelters, fortifications are also larger and more difficult to assess with the limited excavations that our time allowed on Rapa. Regardless of these challenges, we encountered pockets of organic rich sediment containing artefacts, faunal materials and carbonised materials for radiocarbon dating on the terraces surrounding the central tower at each large fortification. Some of the deepest and richest midden soils were encountered on the flattened tops of the central towers themselves. We selected the richest areas for larger excavations and the details of this work are provided in Chapter 12. We also used smaller test units (augers and 25 cm circular sample test pits or STPs) to explore the distribution of midden soils across these terraces. Carbonised plant materials were usually encountered and samples were selected from the deepest intact deposits, which were often only 25 cm to 30 cm in depth. Analysis of these samples was limited by funding, but we tried to analyse at least two samples from each fortification. While visiting the hilltop fortifications, we encountered other domestic terraces on ridges and agricultural terraces in valley bottoms and surrounding hillslopes. Although these were not the focus of this project, we sampled them if exposures were present, in order to get an initial sense of their age.

Most of the AMS radiocarbon dates in this study were prepared chemically at the University of Oregon's Archaeometry Facility (now moved to The Pennsylvania State University) and analysed at the Keck Carbon Cycle Accelerator Mass Spectrometer at the University of California, Irvine (KCCAMS; methods below). Our study also includes seven radiocarbon dates run at The Australian National University and three run at the Waikato Radiocarbon Dating Laboratory (New Zealand). At the ANU facility, all charcoal samples were physically cleaned to remove adhering sediment, then washed in hot 10% Acid-Base-Acid (ABA), rinsed and dried. At Waikato, charcoal samples were washed in hot 10% HCl, rinsed and treated with hot 0.5%

NaOH. The NaOH insoluble fraction was treated with hot 10% HCl, filtered, rinsed and dried. The ANU radiocarbon determinations were made at a time when the laboratory was experiencing technical difficulties that resulted in several instances of demonstrable discrepancy in results. As the extent and nature of the problems remains unknown, it would be prudent to treat the ANU results cautiously. The results from Waikato and KCCAMS are considered reliable. We also include in our analysis two AMS radiocarbon dates collected during previous excavation at the Tangarutu rockshelter (Walczak 2001) and prepared at the radiocarbon laboratory in Lyon, France, using comparable preparation techniques. We exclude Mulloy's two radiocarbon dates from Morongo Uta due to a variety of analytical uncertainties (laboratory used, half-life used, etc) and the high error margins associated with each date.

Methods UO Archaeometry and UCI-AMS

The carbonised plant material analysed at KCCAMS was selected under a microscope to minimise errors associated with old wood (e.g. by selecting twigs or seeds; Kennett et al. 2002). The old-wood problem is thought to be minimal in this context, given the relative absence of long-lived tree species (no older than 20-year inbuilt age) on the island during the interval of interest (see Chapter 10). Sediments adhering to the samples were removed manually, then soaked in a series of acid/base/acid (ABA) baths (1 N HCL and NaOH for 30 minutes each). The HCL removes carbonate contamination and the NaOH extracts humic acid contamination signalled by discolouration of the solution. Base washes were continued until the solution was clear, indicating the near absence of contaminating humic acids.

A final acid wash removed secondary carbonates that could have formed during the base treatment. Samples were then returned to neutral pH with two 15 minute baths in Nanopure water at 70°C to remove chlorides, and dried on the heater block. Sample CO₂ was produced by combustion at 900°C for six hours in evacuated sealed quartz tubes using a CuO oxygen source and Ag wire to remove sulfur and chlorine compounds. Sample CO₂ was reduced to graphite at 550°C using H₂ and a Fe catalyst, with reaction water drawn off with Mg(ClO₄)₂. Solid graphite samples were pressed into AMS cathodes and loaded onto the target wheel with OX-1 (oxalic acid) and other known-age standards, together with calcite and Queets wood blanks for AMS analysis. Radiocarbon ages were $\delta^{13}\text{C}$ -corrected for mass dependent fractionation with measured values (Stuiver and Polach 1977).

Calibration and phase modelling

All AMS ¹⁴C dates were calibrated with OxCal 3.10 (Bronk Ramsey 1995, 2001, 2005), using the Southern Hemisphere atmospheric curve for terrestrial samples (McCormac et al. 2004). We assumed, based on ethnohistoric records, that each date preceded the Mission Period, so each probability distribution was truncated using AD 1825 as a *terminus ante quem* model in OxCal. The resulting 1- σ (68.2%) and 2- σ (95.4%) calibrated ranges are reported with probability distributions given for discontinuous distributions. In a few cases, discontinuous ranges containing small gaps (e.g. five to 10 years) were collapsed into a single interval for clarity.

The chronology of Rapa's colonisation and settlement expansion underpins the studies of resource use, landscape transformation and social change presented in this volume. This complex settlement history unfolded within a relatively short period (ca. 800 years), during a time of pronounced fluctuations in atmospheric ¹⁴C production, which leads to broad and discontinuous calibrated age ranges (Blackwell et al. 2006). The timing and pace of key events on Rapa (e.g. the initial establishment and subsequent proliferation of fortifications) are therefore difficult to know precisely. To constrain these possible dates, we used Bayesian models provided

by OxCal to estimate the beginning and end of five overlapping phases in the settlement history: Initial Colonisation; Expansion of Rockshelter Use; Initial Fortification; First Expansion of Fortifications; and Final Expansion of Fortifications. The *Boundary* command essentially proposes an event that has not been directly dated – the first fire built in a rockshelter, for example – and estimates a probability distribution for its occurrence based on the known dates included in the phase (Bronk Ramsey 2000, 2005). The resulting start and end dates for each phase are presented with 1- σ and 2- σ ranges, similar to calibrated ¹⁴C dates.

Table 11.1. Radiocarbon dates from Rapa Island.

Lab #	Provenience	Site type	Material	¹⁴ C	Error
UCIAMS-2197	Tangarutu, E2, 123 cm	rockshelter	charcoal	465	25
ANU-11849	Tangarutu, NS1, base layer	rockshelter	charcoal	570	70
UCIAMS-14771	Tangarutu S3, 112 cmbs	rockshelter	charcoal	600	15
ANU-11847	Tangarutu, base	rockshelter	charcoal	650	100
ANU-11848	Tangarutu, E2, Spit 23–25	rockshelter	charcoal	710	70
UCIAMS-14769	Tangarutu T1, 150 cm	rockshelter	charcoal	905	20
ANU-11850	Tangarutu, Quarry Pit Core 1, 158–178	rockshelter	charcoal	1020	180
UCIAMS-2325	Tangarutu, E2, 10 cm	rockshelter	charcoal	380	25
ANU-11924	Tangarutu, E2, Spit 2	rockshelter	charcoal	440	60
UCIAMS-14726	Tangarutu, E1, Spit 4	rockshelter	gourd	320	15
UCIAMS-14768	Tangarutu E2, 23–25 cm	rockshelter	charcoal	475	20
UCIAMS-14772	Tangarutu, E1, Spit 11	rockshelter	Aleurites sp.	345	20
ANU-12100	Tangarutu, E2, Spit 18 (Lower Part of E2)	rockshelter	Aleurites moluccana endocarp.	380	60
ANU-12102	Tangarutu, E2, Spit 19 (Lower Part of E2)	rockshelter	Pandanus, cf tectorius key	660	150
UCIAMS-14770	Tangarutu V1, 90 cmbs	rockshelter	charcoal	350	15
ANU-12101	Tangarutu, E1, Spit 4 (upper part of E1)	rockshelter	Aleurites moluccana endocarp.	410	60
Ly-8577	Tangarutu, Unit 1, Walczak 2001	rockshelter	charcoal	495	40
Ly-8578	Tangarutu, Unit 2, Walczak 2001	rockshelter	charcoal	330	45
UCIAMS-14765	Akatanui, Shelter 3, C1, A1, Spit 2	rockshelter	Aleurites sp.	385	15
ANU-11925	Akatanui, base level, 30–40 cm	rockshelter	charcoal	480	70
UCIAMS-14763	Akatanui, C1, Spit 4, 30–40 cm	rockshelter	charcoal	610	15
ANU-11851	Angairao E, 2nd Oven, Spit 10, 140–150 cm	rockshelter	charcoal	500	50
UCIAMS-14767	Angairao, Shelter E, 2nd oven, Spit 11, 150–160 cm	rockshelter	charcoal	375	15
UCIAMS-14766	Angairao, Shelter E, 2nd oven, Spit 11, 150–160 cm	rockshelter	charcoal	220	20
ANU-11923	Taga, Test pit A, Spit 2, 20 cm (base of deposit)	rockshelter	charcoal	370	150
UCIAMS-14755	Morongo Uta (R-1), Exposure 4, 18 cm	fortification	charcoal	380	20
UCIAMS-2178	Morongo Uta (R-1), Exposure 2, 10 cm (Tower)	fortification	charcoal	350	20
UCIAMS-2177	Morongo Uta (R-1), Exposure 1, 20 cm	fortification	charcoal	145	20
UCIAMS-14773	Morongo Uta (R-1), Exposure 3, 10 cm	fortification	charcoal	130	20
UCIAMS-47240	Morongo Uta (R-1), 8 cmbs, Exposure 4	fortification	charcoal	210	15

Continued on next page

Table 11.1. *continued*

Lab #	Provenience	Site type	Material	¹⁴ C	Error
UCIAMS-14762	Ruatara (R-17), Exposure 1, 14 cmbs	fortification	charcoal	345	15
UCIAMS-14774	Ruatara (R-17), STP#2, 15 cm, terrace below tower	fortification	charcoal	210	15
UCIAMS-47243	Ruatara (R-17) Exposure 3, 8 cmbs	fortification	charcoal	630	15
UCIAMS-47244	Ruatara (R-17), Exposure 2, 11 cmbs	fortification	charcoal	170	15
UCIAMS-2181	Potaketake (R-2), Unit 1, Feature 2, 10 cm	fortification	charcoal	210	25
UCIAMS-2188	Potaketake (R-2), Unit 1, Feature 3, 30 cm	fortification	charcoal	240	25
UCIAMS-2184	Potaketake (R-2), Unit 1, Feature 4, 51 cm	fortification	charcoal	240	20
UCIAMS-14757	Kapitanga (R-5), below tower, Exp. 3, 33 cmbs	fortification	charcoal	240	15
UCIAMS-14758	Kapitanga (R-5), upper terrace, Exp. 4, 35 cmbs	fortification	charcoal	195	15
UCIAMS-14760	Pukutaketake (R2002-42), STP#2, 19 cm	fortification	charcoal	145	15
UCIAMS-14759	Pukutaketake (R2002-42), STP#2, 35 cm	fortification	charcoal	235	15
UCIAMS-2190	Ororangi (R-20), Unit 1, Feature 1, RC-3, 12 cm	fortification	charcoal	200	25
UCIAMS-2182	Ororangi (R-20), Unit 1, RC-2, 60 cm	fortification	charcoal	185	20
UCIAMS-80840	Tevaitau (R-18), Unit 1, west side, 8 cmbs	fortification	single nut	240	20
UCIAMS-2186	Tevaitau (R-18), Unit 1, Feature 1, 20–30 cm	fortification	charcoal	195	20
UCIAMS-80841	Tevaitau (R-18), Unit 2, Feature 2, 20 cmbs	fortification	single charcoal	185	20
UCIAMS-2187	Tevaitau (R-18), Terrace E, Exp. 2, 22 cm	fortification	charcoal	140	30
UCIAMS-14725	Vairu (R-3), tower, Auger 7, 5–10 cm	fortification	charcoal	190	20
UCIAMS-14761	Vairu (R-3), Exp 1, 25 cm	fortification	charcoal	180	15
UCIAMS-2180	Tapitanga (R-4), Unit 1, Stratum I/II, S1, 20 cm	fortification	charcoal	145	25
UCIAMS-2179	Tapitanga (R-4), Unit 1, Feature 2, 35 cm	fortification	charcoal	140	20
UCIAMS-14756	Noogurupe (R2002-43), Exposure 1, 20 cm	fortification	charcoal	120	15
UCIAMS-47241	Noogurupe (R2002-43), STP#2, 25 cmbs	fortification	charcoal	615	15
UCIAMS-60739	Noogurupe (R2002-43), STP# 3, 15–25 cmbs	fortification	single charcoal	230	25
UCIAMS-60740	Noogurupe (R2002-43), STP#1, 10–19cmbs	fortification	single charcoal	140	25
UCIAMS-36955	Ngapiri (R2002-50), STP #1, 15cmbs, Rapa	small fortification	charcoal	205	25
UCIAMS-36951	Pukumia (R2002-39), STP 3, 11cmbs, Rapa	small fortification	charcoal	185	25
UCIAMS-36952	Pukutai (R-19), Auger 3, 18 cmbs, Rapa	small fortification	charcoal	195	25
UCIAMS-46300	Taua (R2002-40), FS 114, Exposure 1, 25 cmbs	small fortification	charcoal	250	25
UCIAMS-47242	R2002-49, STP#1, 18 cmbs	domestic terrace	charcoal	380	20
UCIAMS-36954	R2002-49, Exp. 1, E. End, 37 cmbs	domestic terrace	charcoal	485	25
Wk-14889	Ha'urei, R2002-20, Aitoke oven, road cut	oven	charcoal	673	41
Wk-14887	Ha'urei, R2002-11, Tukou oven, road cut	oven	charcoal	677	41
Wk-14888	Ha'urei, R2002-16, Tukou terrace, fill	agricultural terrace fill	charcoal	338	61
UCIAMS-36953	Ha'urei, R2002-48, Exp 1, 50 cmbs, base	domestic terrace	charcoal	200	25

Uncalibrated AMS radiocarbon results

Four coastal rockshelters produced cultural materials that were AMS radiocarbon dated between 1020 ± 180 and 220 ± 20 bp (Table 11.1). Tangarutu is located on the western side of the island at Anarua Bay, and Akatanui and Angairao are positioned on the northern and eastern side of the island, respectively, with Taga on the eastern slope of Ha'urei Bay just below the Tapitanga fortification. Tangarutu was the largest rockshelter and was the most promising as an early colonisation site given its size and stratigraphic complexity (see Chapter 3). Large sections of the remaining deposits at the site were exposed by the more recent mining of sand from this locality to produce concrete for roads, and Walczak (2001) reported two ages from these exposures at the site; 330 ± 45 and 495 ± 40 bp.

Multiple test pits at Tangarutu were excavated and the stratigraphic sequence is complex, with mixing occurring in some parts of the cave. Basal deposits date to between 1020 ± 180 and 465 ± 25 bp. The upper part of the sequence at Tangarutu produced ages between 320 ± 20 and 475 ± 20 bp and other 'mid-sequence' AMS radiocarbon ages range between 330 ± 40 and 660 ± 40 bp. A majority of ages at Tangarutu falls between 300 and 500 bp.

The deposits at the remaining rockshelters were more ephemeral, indicating less extensive use or a single occupation. Three dates from the Akatanui shelters range between 610 ± 15 and 385 ± 15 bp, and a similar range (500 ± 50 and 220 ± 20 bp) was identified in the Angairao shelter. The thin deposits in the Taga shelter produced an age of 370 ± 150 bp.

We also obtained radiocarbon dates on 10 of the primary fortifications surrounding Ha'urei Bay. These dates range between 630 ± 15 and 120 ± 15 bp. Based on these data, the two earliest fortifications occupied were Ruatara and Noogurupe. Ruatara has a commanding view over the rich agricultural lands at the head of Ha'urei Bay and three (Piriati, Akatamiro, Tupuaki) of the five smaller bays along the north coast of the island. Noogurupe was identified by John Stokes (Stokes n.d.) as on the western side of the island overlooking Ha'urei Bay to the east and Anarua Bay to the west, the latter containing Tangarutu Cave. The earliest date at Ruatara is 630 ± 15 bp, and additional dates from domestic terraces at the site suggest habitation until 170 ± 15 bp. The earliest date at Noogurupe is 615 ± 15 bp, essentially equivalent to the earliest date at Ruatara. Additional dates at Noogurupe similarly suggest persistent settlement through to 120 ± 15 bp. Relatively early and persistent settlement is evident at the Morongo Uta (350 ± 20 to 130 ± 15 bp) fortification that overlooks Iri Bay to the west and Ha'urei Bay to the east. This is one of the largest fortifications on the island and was the focus of the Norwegian expedition (Mulloy 1965). The remaining seven fortifications surrounding Ha'urei Bay date to between 250 and 150 bp. In fact, all 10 of the fortifications have ^{14}C dates in this range and present challenges with respect to calibration and chronology building on the island (see below).

Bayesian chronology

A total of 65 AMS ^{14}C dates form the foundation of our provisional chronology for the colonisation and fortification of Rapa. Much more archaeological work in the future will be required to test and improve this chronology. We take a Bayesian statistical approach to chronology building that takes into account knowledge about the context of AMS radiocarbon dates (e.g. stratigraphic sequencing) and other *a priori* knowledge to establish the likely ages (represented by probability distributions) of a series of developments on the island that include: (1) initial colonisation, (2) coastal expansion, (3) initial fortification, (4) first expansion of fortification, and (5) final expansion of fortification (Figure 11.2). These changes in the distribution and character of settlement are modelled in a series of overlapping phases using the program OxCal (see methods).

Figure 11.2. Results of Bayesian analysis of radiocarbon dates from Rapa, showing the beginning and end of five phases, starting with initial colonisation and ending with the final phase of fortification before the Mission Period at AD 1825.

The dates within phases were not ordered stratigraphically because these samples often come from different archaeological sites or widely separated test units that do not allow correlation. Stratigraphic relationships between dates are explored in the chapters focused on the excavation of fortifications and coastal rockshelters. We used the historically recorded abandonment of fortified settlements during the Mission Period (AD 1825) to constrain the distribution of the final two fortification phases. We return to this complex question below, but adding this *a priori* knowledge to the model helps resolve several issues related to the poorly behaved calibration curve between AD 1600 and the present.

The initial colonisation phase is represented by a set of dates from Tangarutu rockshelter. All of these dates come from the basal deposits at this site and these levels represent the earliest known cultural materials on the island. The earliest of these dates comes from a small test probe below the base of a modern sand mining pit in the middle of the cave. The large error margins associated with this date from the ANU facility span 800 years between AD 600 and AD 1400 (Figure 11.3, unfilled outline). This is constrained by the other available dates for this phase, between AD 1000 and AD 1400, with peak probability at ca. AD 1000 and AD 1400. It is consistent with the earliest precise AMS ^{14}C date (UCIAMS-14769) on comparable deposits, of AD 1100 to AD 1200. That is consistent, in turn, with the palaeoecological study in which erosion of likely anthropogenic origin has a similar age (Chapter 10; Kennett et al. 2006). The phase boundary for initial colonisation is modelled between ca. AD 800 and AD 1300, with peak probability between AD 1100 and AD 1200. The phase boundary ends between AD 1300 and AD 1600, and peaks between AD 1400 and AD 1500. The fairly wide age distributions for these phase boundaries, compared with later phases, is related to the smaller number of dates used to define the phase.

Figure 11.3. Phase modelling results showing probability distributions of radiocarbon dates constraining the early colonisation phase. Prior distributions (routine calibration) are shown in outline, and posterior distributions (modelled in a phase) are solid.

The number of coastal rockshelters with evidence of human use increases between AD 1400 and AD 1600 (Figure 11.4). A majority of the dated components at the Tangarutu rockshelter comes from this interval, indicating more intensive use of this location in conjunction with expanded use of rockshelters elsewhere on the island. Three other rockshelters (Akatanui, Angairao and Taga) show clear signs of human use during this interval and Akatanui was used into the 1700s (UCIAMS-14766), and also later than that, as indicated by the incorporation of European material in the upper stratigraphy of the site (Chapter 3). Taga is one of the few small rockshelters positioned along the mid-slopes of Ha'urei Bay. The deposits were ephemeral and we ran only one exploratory date. It has a high error margin (ANU-11923), but this has been constrained in our model, based on the other dates from the rockshelters in this phase, to between ca. AD 1400 and AD 1600. This is consistent with a handful of AMS dates on other site types (e.g. ovens, terraces) dating to between AD 1200 and AD 1800 along the edge of Ha'urei Bay (Figure 11.5).

Within the context of expanding coastal settlement, we see evidence for elevated settlements (domestic terraces) on ridgelines and the first establishment of fortifications at Noogurupe and Ruatara between ca. AD 1300 and AD 1400 (Figure 11.6), approximately 200 years after the first evidence for island settlement. We suspect there is a historical connection between the people who first occupied Tangarutu rockshelter, those who settled on the ridgeline overlooking the pondfields of Anarua Valley, and those who later established the Noogurupe fortification overlooking Anarua and Ha'urei bays. The contemporary establishment of Ruatara is likely to have resulted from the fissioning of the founding community at Anarua. Our limited stay on the island did not allow for a comprehensive inventory or examination of elevated domestic terraces on ridgelines, although they appear to be fairly common, as noted by Walczak (2001). More work is required to sort out the chronology of these types of sites, but the R2002-20 site suggests their use at the same time as fortifications were first established.

At least two phases of expanded fortification occurred on the island before the Mission Period. Persistent settlement is evident at Ruatara between AD 1400 and AD 1800, and this also appears to be the case at Noogurupe, with a possible hiatus between AD 1400 and AD 1650. Morongo Uta, which developed into the largest fortification on the island, was also established

Figure 11.4. (Left) Phase modelling results showing probability distributions of radiocarbon dates constraining the coastal expansion phase. See Figure 11.3 for details about how the figure is organised.

Figure 11.5. (Below) Calibrated AMS radiocarbon dates for miscellaneous archaeological sites and features on Rapa that were not included in the five modelled settlement phases. The posterior distributions (solid) are constrained by the *terminus ante quem* of AD 1825, based on ethnohistoric records indicating the loss of upland settlement by this time.

Figure 11.6. Phase modelling results showing the probability distributions of radiocarbon dates forming the basis of the first and final fortification phases on Rapa. See Figure 11.3 for details about how the figure is organised.

during the first fortification expansion phase between AD 1400 and AD 1650. Settlement at Morongo Uta persisted until the early 1800s.

Details of the final fortification phase are marred by major fluctuations in the calibration curve after about AD 1700 (Figure 11.7). All radiocarbon ages starting at about 240 $\pm$ 15 bp are impacted by these fluctuations and cannot be distinguished from those on modern materials. However, we know, based on mission records, that fortified villages were abandoned by AD 1825 when the modern communities of Area and Ha'urei were established. This *a priori* knowledge was built into our Bayesian model and it serves as an important calibration datum (*terminus ante quem*) to help clean up the probability distributions. It truncates the probability distributions at this date and shows a cluster of seven fortifications dating to the early 1700s and at least 10 fortifications in the late 1700s, when Vancouver observed at least six forts in use on the western side of the island (Chapter 2). Smaller satellite fortifications (e.g. refuges) that were probably connected in some way with the larger fortifications nearby also date to the late 1700s (see Figure 11.5, Tauo, Ngapiri, Pukutai and Pukumia). These sites are discussed more fully in Chapter 12.

Figure 11.7. Southern Hemisphere atmospheric curve for terrestrial samples (McCormac et al. 2004) between AD 1400 and AD 2000, showing a major plateau and fluctuations between AD 1650 and AD 200 that make calibration challenging.

Conclusions

The systematic use of radiocarbon dating as a survey technique provides a framework for reconstructing a broad pattern of landscape use and how this changed through time. The approach is becoming more commonly used in a variety of coastal and island contexts where erosional processes expose deposits (Erlandson and Moss 1999; Kennett 2005) and it may be particularly useful in East Polynesian contexts where ceramics are absent, along with other temporally diagnostic artefacts used elsewhere to establish preliminary settlement chronologies.

This approach does not serve as a replacement for more intensive stratified excavations, and intensive archaeological work is clearly required to establish more definitive site chronologies. On Rapa, we used the survey technique to establish a broad chronology that can guide future work on the island. Our data suggests that the island was most likely colonised between AD 1100 and AD 1200. This was followed by expanded use of coastal zones and construction of the first elevated domestic terraces between AD 1200 and AD 1600. It is within this context that the first two fortified hilltop settlements (Noogurupe and Ruatara) appear on the island between AD 1300 and AD 1400. The number of fortifications expanded, slowly between AD 1400 and AD 1650 and then more rapidly during the 1700s just before historic contact.

The need for further research, and quite soon, is underlined by the evidence that many of the sites on Rapa are endangered by destructive processes. Hilltop fortifications are heavily wind deflated, and animal grazing has removed much of the vegetation stabilising these sites, leading to erosion, which is also destroying the rock terrace walls. In addition, the mining of sand for road construction from the Tangarutu rockshelter presents a serious threat to these deposits.

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