Adze Production in the Papeno‘o Valley, Tahiti, Society Islands:
Technological Analysis of the Putoura (TPP-035) Workshop Assemblage

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ABSTRACT

This study provides a technological and typological analysis of adzes, blanks, and preforms recovered from workshop site TPP-035 (Putoura), located in the Papeno‘o Valley, Tahiti, a major regional adze production centre in the Windward Society Islands. The Papeno‘o research provides a case study of adze manufacture in a resource-rich zone of high quality raw material. A range of raw material procurement practices was used to reduce both flake blanks and prismatic basalt cores. A variety of adze types was manufactured, with Type 3A adzes dominating. There is some evidence for reworking broken preforms and, in particular, broken and finished adzes. Adze manufacture at the Putoura workshops appears to have taken place within a ritualised context and, perhaps, in close association to rites carried out at a nearby marae and simple shrine. In this way, adze production within the Papeno‘o Valley may be similar to other major Eastern Polynesian production centres (e.g., Mauna Kea, Eiao) and smaller production locales (Kaho‘olawe), where adze manufacture was spatially associated with ceremonial shrines and is inferred to have taken place under ritual constraints.

Keywords: SOCIETY ISLANDS, TAHITI, PAPENO‘O VALLEY, QUARRY, ADZE TYPES, MANUFACTURING TECHNIQUES, REDUCTION MODELS, TOOL MAINTENANCE AND REWORKING, RITUAL ADZE PRODUCTION.

INTRODUCTION

The Papeno‘o Valley, situated along the north shore of Tahiti in the Society Island archipelago (Fig. 1), has numerous adze production workshops with voluminous adze, preform, blank, and debitage remains. It is considered a major zone of pre-contact adze quarrying and manufacture in the Society Islands (if not the largest in the archipelago). The extensive evidence for adze production within the Papeno‘o, including both the high volume of waste debris and the frequency of reduction locales, suggests that production output exceeded needs for local demand, as was the case at other well known major quarries in Polynesia including Mauna Kea (Hawai‘i), Eiao (Marquesas Islands), Tataga-matau (Samoa) and Tautama (Pitcairn Island) (after Leach 1993). Most of the archaeological work completed in the Papeno‘o Valley has been under salvage archaeology conditions. While

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numerous important adze manufacturing locales have been documented, few of the valley's archaeological assemblages have been properly studied or published in detail.

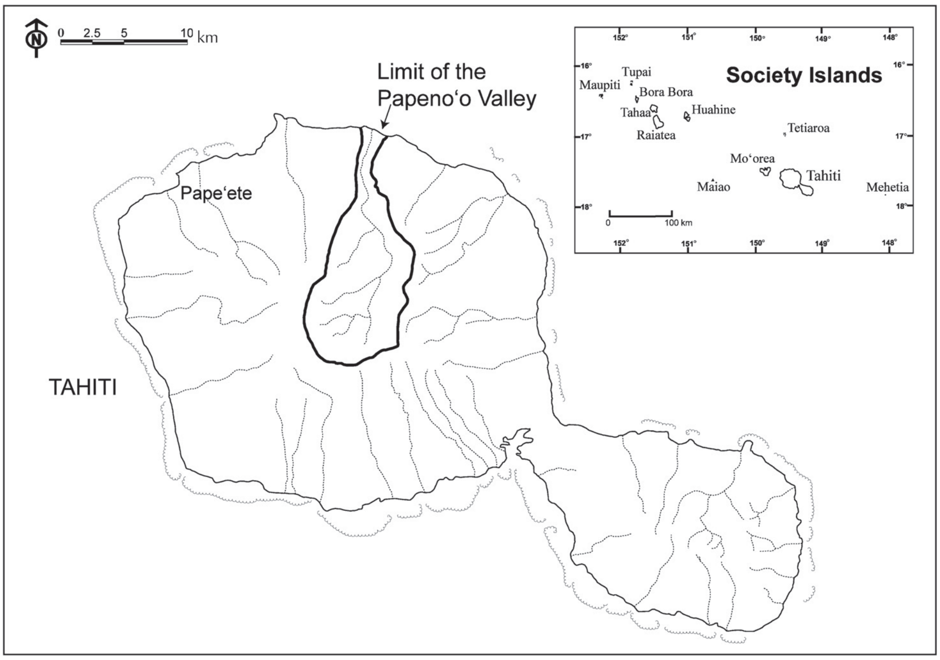

Figure 1: The extent of the Papeno'o Valley, Tahiti (Society Islands).

This paper aims to provide one of the first detailed descriptions of an adze production workshop situated in the Papeno'o Valley. The study describes technological and typological analysis of the finished adzes, blanks, and preforms from site TPP-035 (Putoura). These artefacts were found in association with by-products of adze manufacture (debitage), in addition to surface remains of a ceremonial temple (marae) with an attached shrine. A holistic model for the sequence of adze production at the workshop sites is proposed, describing evidence for initial raw material procurement, the sequence of adze manufacturing stages and reduction activities, and data on adze resharpening and reworking activities. The Papeno'o study reveals a range of raw material procurement practices, reduction of both flake and prismatic basalt cores, and production of varied adze types, with Type 3A adzes (Duff 1959) dominating. Extra-areal comparisons with the limited number of quarry sites and workshops studied elsewhere in the Society Islands are offered, in addition to technological comparisons with assemblages from other Polynesian adze quarries and workshop sites.

Finally, from a contextual point of view, I argue that Papeno'o adze production took place on some occasions within ritualised contexts, particularly in close association with both large and small ceremonial sites (marae and simple shrines). In this way, adze production at the Papeno'o Valley appears similar to that at other major production centres (e.g., Mauna Kea, Eiao) and smaller production locales (Kaho'olawe) in Eastern Polynesia, where adze production was spatially associated with ritual shrines and is inferred to have taken place under ritual constraints (McCoy 1986, 1990; McCoy *et al*. 1993). This Society Island case study provides support for the notion that at many major quarries in Eastern Polynesia, adze production was carried out under highly ritualised circumstances, and suggests that the very act of adze production at these centres was a significant social process in and of itself.

ADZE PRODUCTION IN EASTERN POLYNESIA

Archaeological debates concerning the organisation of craft production and economic specialisation in Polynesian chiefdoms often focus on adze manufacture (Bayman and Moniz-Nakamura 2001; Cleghorn 1982, 1986; Lass 1994, 1998; Leach 1993; McCoy 1986, 1990; Olszewski 2007; Withrow 1991). Most adze production research has stressed large scale manufacture at extensive quarry sites and associated workshops; perhaps the most famous of these is the Mauna Kea quarry in Hawai'i. Whether adze production at high-quality basalt quarries in Polynesia, such as Mauna Kea, was restricted and controlled by elites is an on-going, unresolved debate (Earle 1997; Lass 1994; McCoy 1990), as is the relationship between regional and local scale adze production. The issue is of central importance to understanding increasing social complexity in middle range societies, as changes in the structure of production, and mechanisms of elite control over production, will influence social relations at multiple scales (the household, community, and region) (Arnold 1992; Brumfield and Earle 1987; Earle 1978; Earle and D'Altroy 1989; Hagstrum 2001; Junker 1999; Mills 1995; Nichols *et al*. 2002).

The on-going debate concerning control of and access to high quality basalt sources and craft production of adzes in Eastern Polynesian has been notably Mauna Kea- and Hawai'i-centric, where several geochemical and technological studies are available (Bayman and Moniz-Nakamura 2001; Cleghorn 1982; Lass 1994; McCoy 1990; Mills *et al*. 2008; Lundblad *et al*. 2008; Williams 1989), while the large scale Eiao quarry in the Marquesas Islands has also been the target of recent research (Rolett 1998, 2001). In contrast, adze quarries in the Society Islands, including the Papeno'o Valley source(s) on Tahiti, the Vaiopatapata source and an unknown trachyphonolite source on Ra'iatea, are woefully under-studied, both with respect to their geochemical signatures and to the particular organisation of production at the quarry and workshop sites (Kahn 2005a; Sinton and Sinoto 1997; Weisler 1998). In order for the Society Islands to be integrated into adze production debates, high-quality data are needed from both small and large scale adze production centres in the archipelago. This article provides a case study from one of the many workshop sites situated in the Papeno'o Valley, thus offering an example of an adze manufacturing locale situated within a regional production centre.

PREVIOUS ARCHAEOLOGICAL STUDIES IN THE PAPENO'O VALLEY

Papeno'o Valley is the largest valley on Tahiti, reaching 23 km back into the island's interior (Fig. 1). Teuira Henry (1928) described the valley as a place of refuge (*te piha ia tete*). Eddowes' ethnohistoric and archaeological work (2001) has confirmed that at least the middle to upper sectors of the valley were used as a retreat or refuge area in the proto-historic period. However, the prehistoric occupation of the valley had a richer settlement history, as attested by the dense remains of agricultural features, ceremonial structures (marae and shrines), specialised use structures (e.g., archery platforms), habitations, and adze production workshops.

In 1925, Emory carried out the first archaeological survey of the Papeno‘o, describing approximately 40 sites. While his study focused on the largest complexes, mapping and recording 11 marae, smaller sites such as house terraces, archery platforms, and other structures were also recorded (Emory 1933: 82–95). A French team of CNRS researchers led by José Garanger instigated renewed survey of the valley in 1975–1979, in light of plans for the Territorial Government to build a large hydro-electric dam.[2] Survey and excavations focused on the middle to upper sectors, areas within the impact zone for the dam construction (Chazine n.d., 1977, 1978; M. Orliac 1977). The CNRS team uncovered approximately 20 previously unrecorded residential and ceremonial sites, in addition to the Putoa rockshelter (Chazine and M. Orliac 1986). In the 1980s, the Department of Archaeology, Territorial Government of French Polynesia (CPSH) completed an archaeological inventory of both the lower and upper sectors of the valley. The 1987–1988 surveys in the upper valley documented over 720 surface remains. CPSH, in collaboration with other researchers, completed salvage excavations at several sites within the impact zone, in addition to restoring a large ceremonial complex in the late 1980s and early 1990s (Navarro and Badalian 2000; C. Orliac 1984, 1985, 1987; M. Orliac 1989; M. Orliac *et al*. 1989).

Although synthesis of the survey and excavation results is lacking, the available data document dense zones of habitation in the Papeno‘o Valley, interspersed with ceremonial complexes, some of elaborate form. There is also extensive evidence for adze production. Primary quarrying areas have been identified (M. Orliac 1990: 10–11), in addition to numerous workshops and dense scatters of debitage and tools in both domestic and ceremonial contexts (Belçaguy 1990; Chazine 1978; Eddowes 1991, 1997; Navarro 1992; M. Orliac 1989). Many of the workshops are situated in the upper valley, which some have described as an intensive zone of lithic manufacture (Eddowes 1991: 182), while other adze production locales are situated in the middle sector, including the two workshops at TPP-035 that are the focus of the present analysis.

We lack a firm chronological sequence for the settlement and use of the Papeno‘o Valley, because few radiocarbon dates have been reported. Preliminary evidence suggests primary human occupation by the fourteenth century AD (M. Orliac 1997: 207). Many surface remains, including marae, appear to date to the late prehistoric period (mid-seventeenth to eighteenth centuries) and thus pre-date European contact (M. Orliac 1981). Habitation structures in the upper valley were reoccupied and used as a refuge by the Mamaia cult (traditionalists) into the early historic period (Eddowes 1991, 2001). However, by the start of the nineteenth century, the majority of sites in the valley had been abandoned for coastal areas, with perhaps only a few hundred inhabitants remaining (Eddowes 2001). Adze production sites in the Papeno‘o typically lack any evidence of European artefacts, suggesting that adze production dropped out quickly in the historic period. Tahitian ethnohistoric accounts do not document the valley’s importance as an adze production centre, lending support to the notion that Papeno‘o adze production ceased soon after European contact.

[2] Much of the Papeno‘o research carried out by CNRS and CPSH during the 1980s and 1990s remains unpublished. In this review, I refer to currently available published materials, as well as unpublished reports and notes archived in the Service de la Culture et du Patrimoine. My review is not exhaustive and it is likely that there are unpublished materials that I have missed.

PRELIMINARY THOUGHTS ON THE ORGANISATION OF LITHIC PRODUCTION

We lack a clear view of the organisation of lithic production in the Papeno'o Valley. My preliminary synthesis, largely limited to unpublished data available in site reports, suggests there were numerous production locales with dense lithic remains found both on the surface

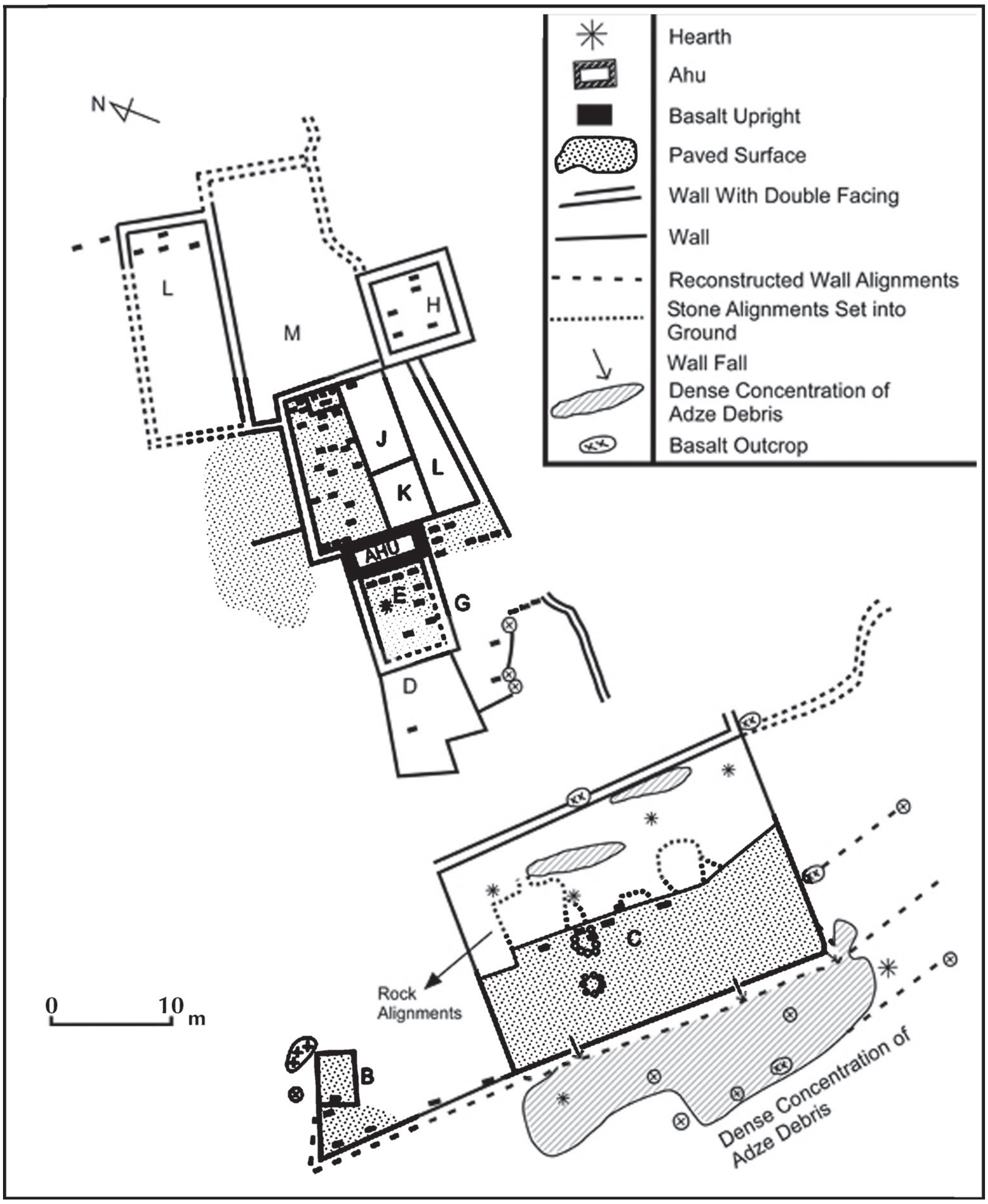

Figure 2: Plan of TPP-06, Papeno'o Valley (after Chazine 1977). Note adze manufacturing debris in close association with the marae complex.

and in excavated contexts. Based on the volume of lithic debris, adze manufacture appears to have exceeded local need and there is complex spatial patterning in lithic reduction and use locales, probably related to both site function and site status. The full range of adze manufacture appears to have been carried out at many sites. These include large ceremonial sites with evidence of adze manufacture (Chazine 1977; M. Orliac *et al*. 1989), such as marae complex TPP-06 (Fig. 2), in addition to domestic contexts with associated workshops (Chazine 1978; Eddowes 1997; Navarro 1992; M. Orliac *et al*. 1989). At the Toki platform (habitation site), dense quantities of lithic debitage were associated with refuse pits and a polishing stone (M. Orliac *et al*. 1989: 113). Lithic reduction was limited to certain areas; it was not found in the house proper, nor on the terrace below, but was situated in and around a cooking area. The Rapiti site has evidence of a cooking area where debitage was found only in moderate quantities (M. Orliac *et al*. 1989: 136), while other Papeno'o habitation sites, such as Toere, lack strong evidence of adze manufacture or frequent adze use (M. Orliac *et al*. 1989).

Yet other sites appear to be finishing areas for adze preforms fashioned elsewhere. An example is Marae Tauro-iti, a simple shrine or family marae with two polishing stones incorporated into the surface architecture. Here, dense concentrations of debitage were recovered in addition to hammerstones and cores. The debitage size distribution suggests an emphasis on late stage preform trimming or adze reworking activities (M. Orliac *et al*. 1989: 69), probably associated with wood sculpting (Belçaguy 1990: 39). Other sites, such as marae TPP-84, lack strong evidence of adze manufacture but do have evidence for specialised activities associated with numerous flake tools of differing shapes and sizes (C. Orliac 1984).

Much of the island of Tahiti remains a 'terra incognita' with respect to archaeological site inventory. Few sites other than monumental temples have been studied, and results from archaeological projects have rarely been published in full and remain in the difficult to access 'grey literature'. Based on currently available data, Papeno'o Valley sites stand out from other locales on the island of Tahiti. At present, there are no other Tahitian valleys with extensive evidence of adze manufacture or with a well documented presence of high quality raw materials suitable for adze production. Likewise, no other valleys have evidence for marae or shrine sites in association with voluminous adze manufacturing debris.

THE PUTOURA (TPP-035) WORKSHOPS

In 1925, Kenneth Emory first mapped and described a portion of the TPP-035 complex as Site 75 (1933: 90, 92, Figure 53, Plate 1B). Emory recorded the site's Tahitian place name as Putoura and described a large main terrace (A in Emory's Figure 53) with an attached small marae (B). Emory's site map records a single upright on the main terrace A and two rows of uprights along the attached small marae B, which is also referred to as a shrine in the text for the plate. A series of terraces, delineated by stone alignments, was also recorded (C, E, F, D).

In November 1987, Jean-Luc Rieu, then with CPSH, revisited the site for a salvage archaeology programme, as a new road cut had uncovered dense lithic remains at the complex. Rieu remapped the site, discovering previously unrecorded stone alignments and terraces (Fig. 3, G–M), and a set of previously unrecorded uprights (Fig. 3, 9–12) in the southeastern end of Emory's main terrace A. Although cooking features such as earth ovens or hearths were not recovered in the road cut, Rieu did record dense concentrations of adze debitage, blanks, and preforms in two separate locations, designated as Workshop 1 and Workshop 2. Figure 3 provides a map of the site, incorporating details from both Emory's and Rieu's earlier maps. Based on current data, Structure A is an 'inland' marae lacking an ahu but having an enclosing wall and uprights, and thus would be classified as Green's Type IIIi (Green 1961: 171; Green and Descantes 1989). Structure B is an attached shrine, and would be classified as structure Type IXa (Descantes 1990, 1993; Green and Descantes 1989).

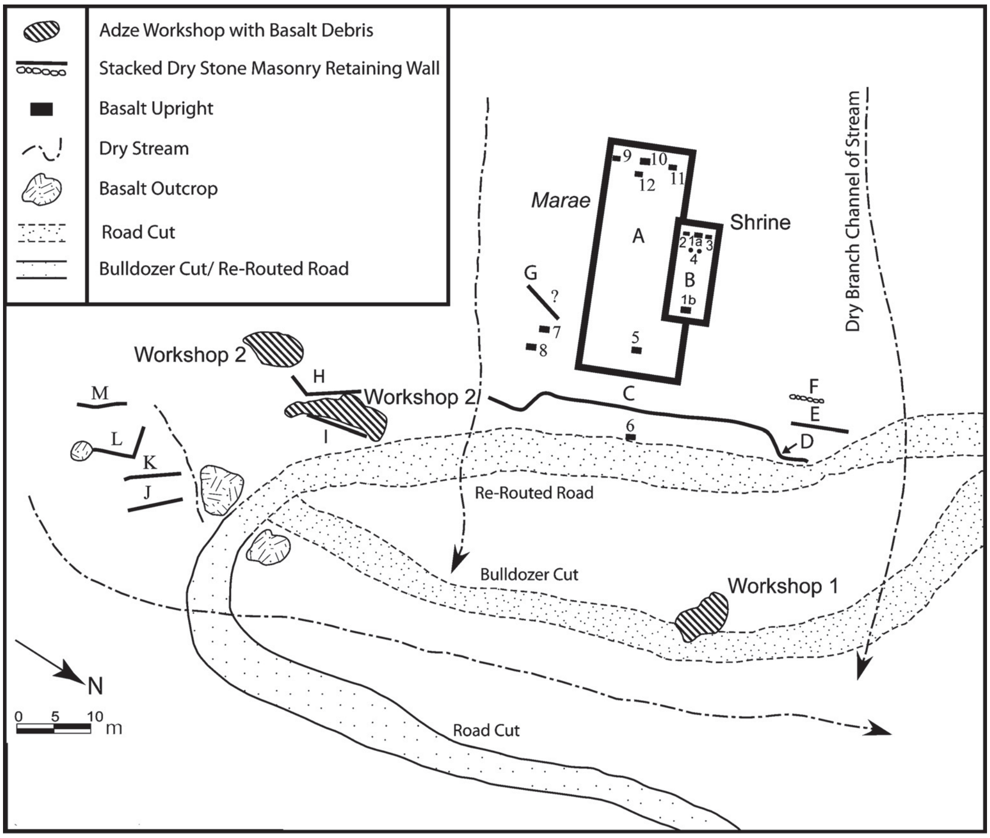

Figure 3: Site TPP-035, Putoura, Papeno'o Valley (after Rieu 1987 and Emory 1933: 92).

Workshop 1 is located about 30 m to the northeast of Marae A, while Workshop 2 is located about 30 m to the southeast of Marae A. Both consist of dense concentrations of adze manufacturing debris (flakes, flake fragments, shatter) and broken and unfinished adze preforms and blanks. Workshop 1 is located on a flat plain; whether or not this adze production area was associated with surface architecture (e.g., stone alignments or a terrace) is impossible to say, because the area had already been impacted by a bulldozer cut by the time Rieu mapped this feature. Workshop 2 is associated with two stacked stone walls, H and I. The majority of lithic debitage from Workshop 2 is concentrated on the terrace formed by alignment I and its flat interior surface, which backs up against stacked wall alignment H.

Rieu's fieldnotes indicate that all tools[3] were collected from the surface of Workshops 1 and 2 in the area of the bulldozer road cut and adjacent locales. The greater part of Workshop 1 (45 m^2) was excavated and selected artefacts were mapped on an excavation plan. Workshop 2 was first apparent in the road cut. Here, surface artefacts were relatively infrequent and artefact density increased about 1–2 cm below the surface, where most artefacts were recovered in a 10-cm-thick cultural deposit. A portion of Workshop 2 was excavated and surface artefacts were collected across this feature over a 64 m^2 grid. Thus, the principal zone of either workshop was not excavated; rather, flakes and tools visible along the surface of the impacted and non-impacted zones were collected and mapped, and only those portions impacted by the road cut were excavated. This paper provides an analysis of the 54 adzes, blanks, preforms, and other tools from Rieu's excavation and surface collection. The analysis of the extensive debitage collection (n=3895) is on-going and will be forthcoming in another publication.

THE PUTOURA ARTEFACT ASSEMBLAGE

METHODS AND TERMINOLOGY

Each artefact was first classified according to a broad morphological class (adze blank, adze preform, complete adze, repaired adze; see Table 1). The classification of adze blanks and preforms is somewhat subjective, and not wholly agreed upon by Polynesian archaeologists, who currently use varying classificatory schemes (Bayman and Moniz-Nakamura 2001; Cleghorn 1982; McCoy 1986, 1990; Weisler 1990). Following Weisler (1990) and Dye and colleagues (1985), I define adze blanks as worked cores or flakes where it is impossible to determine exactly the probable finished cross-section form; these items are sometimes discarded at a stage where they can be further modified into more than one cross-section form.[4] Preforms have taken on a more finished form, where inferences about the shape of the finished tool can be made with a high degree of confidence. They typically have determinable cross-sections and lack surface grinding. Taken as a whole, the broken and discarded blanks and preforms recorded in the present study correspond to adze rejects, as defined by McCoy (1990) and Bayman and Moniz-Nakamura (2001).

[3] Rieu's 'tools' category subsumes any lithic artefact exhibiting signs of human reduction and use. It includes cores, adzes, preforms blanks, retouched flakes, and utilised flakes, in addition to non-utilised waste debitage.

[4] Thus, in Table 5, blank cross-section is reported as indeterminable if the artefact could be further reduced into more than one cross-section (similar to the blank category of Dye *et al*. 1985: 11); these are referred to in the text as early stage blanks. If the blank had taken on a shape where the final probable cross-section could be inferred with some degree of confidence, the cross-section was noted accordingly; these are referred to in the text as late stage blanks.

TABLE 1
Metric and non-metric attributes recorded in the TPP-035 analysis

Attribute	**Descriptive comments**
Raw material	Basalt, unknown
Morphological class	Adze, preform, blank, etc.(see Table 2)
Length	Maximum (total) length, to nearest mm
Maximum thickness	Maximum (total) thickness, to nearest mm
Minimum thickness	Minimum (total) thickness, to nearest mm
Mid-point thickness	At mid-point of length, use to distinguish cross-section
Maximum width	Maximum (total) width, to nearest mm
Minimum width	Minimum (total) width, to nearest mm
Mid-point width	At same mid-point as mid-point thickness
Poll width	To nearest mm
Cutting edge width	To nearest mm
Cutting edge angle	Angle between bevel and blade, measure with goniometer
Weight	To nearest g
Cross-section type	Describe at shoulder, if shoulder is not well defined, describe at mid-point. Describe more than once if it appears to vary across the adze body. *Trapezoidal* (front wider or narrower than back, or back narrower than front); *square* (width at mid-section equals thickness); *rectangular* (thickness is *c*. half width at mid-section); *triangular*; *sub-triangular*; *reverse triangular*; *reverse sub-triangular*; *oval-lenticular*; *circular*
Longitudinal profile	Tang undeterminable, pronounced, incipient, untanged
Butt reduction	Present or absent. Describe placement (front, back, sides, combination) and whether minor or major. Note off-setting at an angle rather than reduction, hammer dressing, or lugs
Bevel formation	Yes, no, undeterminable
Bevel flakes	0, 1, 2, 3, 4, 5 or more
Hammer dressing	None, minor, moderate, extensive, butt only
Cutting edge form	Straight, slight curvature (concave or convex), marked curvature, blade corners rounded (can relate to use/reworking)
Polished surfaces	0, 1, 2, 3, 4
Polish position	Front, back, sides, blade/bevel, only at cutting edge
Percentage polished	Estimate percent of total adze that is polished
Adze portion/condition	Complete, broken (describe which section is intact, i.e., broken-butt half, broken-cutting edge/body fragment but no intact shoulder, etc.)
Series	Core or flake series
Bi-directional flaked edges	0, 1, 2, 3, 4, not applicable
Cortex coverage (%)	0, 1–24, 25–49, 50–74, 75–99, 100
Cortex type	Absent, waterworn, prismatic/dyke stone
Flake scars	0, 1, 2, 3, 4, 4 or more
Comments	Shape of blade. Describe chin, butt reduction, cross-section (is base narrower than face), shape of poll, are front, back, sides flat, type of tang. Degree of reduction: uni-directional or bi-directional flaking, number of edges bi-directionally flaked. If broken, where and type of break. If visible repair and reworking, where and how pronounced, nature of flaking, hammer dressing, grinding. Reason for rejection (breakage, lump that could not be removed, etc.)

The worked basalt category refers to varying classes of cores (tabular prismatic slabs, waterworn cobbles, or vesicular cobbles) which have been only minimally reduced before they were discarded. Objects in the worked basalt class are similar to McCoy's Stage 1 Adze Blank (McCoy 1986: 11) or Techno-Morphological Type 1 Adze Reject (McCoy *et al*. 1993: 123). As McCoy (1999) notes, in most other contexts these objects would be classified as modified flakes. I argue that many of the TPP-035 objects in the worked basalt category correspond to the testing of raw material and/or to the initial stage of blank reduction.

Thirty attributes were recorded, measured, and described for each artefact (Table 1). To build a multi-scalar picture of variation in adze manufacture and adze use, the study used a mixture of typological and technological attributes. I recorded class-specific attributes with the highest utility for documenting assemblage variation, as outlined in various studies (Cleghorn 1982; Davidson 1961; Garanger 1972; Kahn 1996; Leach and Leach 1980; Turner 2005; Weisler 1990; Withrow 1991).

Artefact description follows Weisler (1990) for blanks and preforms. Size and weight are measured, as well as condition (whole or fragmentary), series (undeterminable, flake, core), cortex coverage, and the number and location of edges with bi-directional flaking, to gather data relevant to modelling local adze production (see Table 1). I make a distinction between uni-lateral flaking (an edge with flaking across one face only, see Cleghorn 1982: 193) and bi-directional flaking (an edge with both faces flaked, see Leach and Leach 1980). The number of edges with bi-directional flaking should increase the further along the object is in the reduction sequence (Cleghorn 1982: 196; Weisler 1990: 38) and certain patterns of preform shaping (whether bilateral, trilateral, or quadrilateral) can vary with the type of parent material reduced (Leach and Leach 1980).

Wherever possible I record the reduction series used: whether the blank was produced from a flake (flake series), a blocky fragment of prismatic volcanic rock (core series), or a waterworn cobble (core series). Complete and fragmentary adzes are classified following Duff (1959) and Emory and Sinoto (1964). These classification systems focus on morphological shape, cross-section, and the presence or absence of a tang. I also draw from Turner's recent work on New Zealand adze assemblages (2000: 231–303, 2005) by measuring and comparing attributes which can successfully pinpoint adze repair, modification, and reworking. For example, comparing the width at the shoulder to the width of the cutting edge can be instructive, because greater width at the shoulder than the cutting edge can correspond to bevel and blade repair. I define repaired and modified adzes as those artefacts with evidence for polishing (i.e., at least some portion of the adze retains polish), but which exhibit clear signs of rejuvenation, such as major bevel and blade repair, and/or reduction of the sides, front, back, or poll to reduce adze breadth and length.

ARTEFACT DESCRIPTIONS AND REDUCTION SERIES

Fifty-four artefacts from the TPP-035 workshops were analysed, including a hammerstone, a pick, and an adze, 5 worked basalt pieces, 5 repaired/modified adzes, and 41 blanks and preforms (Table 2). Only a single complete adze was recovered. It is rather atypical of the assemblage as a whole (Tables 2, 3, 4, 5). It appears to be an expedient, quickly made adze, fashioned from a flake blank that had close to the already desired cross-section. The adze has a 'stumpy' short appearance and is 86 mm long. It is clearly derived from a flake blank where the ventral surface was oriented to the front. The front is not 100 percent flat and appears to have been only minimally worked, while the back and one side have been reduced with uni-lateral flaking. A long flat ridge has been created on the back through removal of a long 'channel-like' flake. This ridge preparation was the result of flaking the water-worn cobble core before the removal of the flake blank from which this adze was made, a procedure described by Leach and Leach for the Riverton adze quarries (Leach and Leach 1980: 128). The poll is heavily reduced along the sides and has an incipient tang. The blade is roughly rectangular and the cutting edge is straight, with curved in corners. The adze has a trapezoidal cross-section, with the front wider than the back. The front is only minimally polished (*c*. 15%); the back and sides remain unpolished and the adze lacks hammer dressing. The high incidence of small uni-directional flakes found along the edges is similar to patterns found on resharpened or repaired adzes, as is the curvature of the cutting edge corners. This adze cannot be typed using the Duff typology (see Other column, Table 3). It appears to represent a form of expedient adze manufacture, similar to the "scrappy flake adzes" described by Turner for Norfolk Island (Turner *et al*. 2001: 58).

TABLE 2
Morphological class counts for the TPP-035 artefacts

Hammerstone	1
Worked basalt	5
Pick	1
Adze	1
Adze blank	24
Adze preform	17
Repaired/modified adze	5
Total	**54**

TABLE 3
Duff (1959) adze and chisel types represented in the Putoura assemblage*

Artefact class	**Type 1A**	**Type 3A**	**Type 3D**	**Type 4A**	**Other**
Complete adze	-	-	-	-	1
Blanks	-	11	-	1	-
Preforms	-	5	2	-	-
Reworked adzes	1	4	-	-	-
Total	**1**	**20**	**2**	**1**	**1**

* Frequency counts are presented only for artefacts where cross-section as well as presence/absence of a tang could be identified with a high degree of confidence. The preform assemblage had more artefacts with classifiable cross-sections retaining the butt/poll, which hinders their classification using the Duff typology.

Adze blanks and preforms were the dominant products at the TPP-035 workshops (Table 2). Of the 41 blanks and preforms, 12 are whole (29%) and 29 (71%) are broken fragments (Table 4). The majority of TPP-035 blanks and preforms were discarded because of end shock fracture, as has been found at Polynesian quarries (Cleghorn 1982; Weisler 1990). Other reasons for artefact discard include lumps surrounded by step fractures that could not be removed, removal of thick flakes from the bevel or shoulder which removed too much mass, and breakage because of internal raw material defects, as has been documented in other quarry contexts (Cleghorn 1982: 176; Lass 1994: 40–41; Leach and Leach 1980: 116).

Most of the blanks derive from flake blanks, but other reduction series were used (Table 4). Where flake or core series could be determined (n=11), 46 percent of blanks were reduced on flake blanks, while 54 percent of blanks resulted from the reduction of waterworn cobbles and prismatic basalt slab cores. Where flake or core series could be determined for preforms (n=4), three (75%) were reduced on flake blanks and one (25%) was reduced from a core. All flake series artefacts were oriented with ventral surface to the front, dorsal surface to the back, and striking platform to the poll. As discussed below in the reduction model, knappers used the lateral margins of the ventral surface of flake blanks for flake removal to shape the back and sides of the adze and to begin to refine the transverse section.

TABLE 4
Metric and non-metric data, TPP-035 adzes, preforms, blanks

	Adzes	**Blanks**	**Preforms**
Sample size	1	24	17
Mean metric attributes*			
Max. length (mm) [1/9/3]	86.2	112.3 ± 45.0	126.8 ± 66.1
Max. width (mm) [1/9/3]	42.2	62.5 ± 32.1	49.1 ± 15.3
Mid pt width [1/9/3]	25.6	57.0 ± 35.1	25.6 ± 32.1
Max. thickness (mm) [1/9/3]	26.6	43.7 ± 26.0	51.0 ± 23.3
Mid pt thickness [1/9/3]	23.4	42.0 ± 30.6	51.4 ± 35.5
Weight (g) [1/9/3]	104.0	651.7 ± 969.0	563.3 ± 709.4
Discrete attributes			
Condition			
Whole	1	9	3
Fragment	-	15	14
Series			
Indeterminate	-	13	13
Flake series	1	5	3
Core series	-	6	1
Cortex			
Yes	-	5	1
No	1	19	16

* Metric attributes were measured for complete specimens only. Sample size is noted in brackets for adzes, then for blanks, then for preforms. For example, 1/9/3 = 1 adze, 9 preforms, and 3 blanks (after Weisler 1990).

The majority of blanks (79%) lack cortex cover, but five (21%) retain cortex, ranging from 25 to 75 percent of their total surface. In contrast, only a single preform (6%) retains cortex, in this case 1 to 25 percent of the total surface. These data indicate that one aspect of the transition from late stage blank reduction to preform reduction involved removal of the remaining cortex. The location of cortex largely depended on the original parent material. At least one flake blank retained cortex on the striking platform, while waterworn cobble cores and prismatic basalt cores discarded in the early stages of reduction had cortex on either the front or back surface or on both surfaces.

Early stage blanks (13 of 24, or 54% of the blank assemblage) have evidence for uni-lateral flaking along the front or the back, but lack bi-directionally flaked edges (Table 5).

In these early 'roughouts', the front was minimally worked to produce a flat surface. Flakes were then struck from the lateral margins of the front (using this surface as a platform for flake detachment) to straighten the lateral margins of the blank, and in doing so, create the sides of the adze and an apex or ridge on the back which could be further reduced. Early blanks commonly lack well-defined cross-sections and typically lack evidence for poll reduction, tang formation, or bevel reduction.

TABLE 5
Non-metric data, TPP-035 adzes, preforms, blanks

	Adzes	**Blanks**	**Preforms**
Sample size	1	24	17
Surfaces bi-directionally flaked per specimen			
Missing data (patina)	-	1	-
None (uni-directional)	-	13	3
One	-	3	1
Two	1	4	2
Three	-	2	11
Four	-	1	-
Longitudinal profile			
Indeterminate	-	4	1
Tanged	1 incipient	4 incipient	3 incipient
	-	4 pronounced	8 pronounced
Untanged	-	12	5
Bevel formation			
Undeterminable	-	11	9
Yes	1	6	7
No	-	7	1
Cross-section			
Indeterminate	-	5	-
Trapezoidal	1	3	1
Rectangular	-	1	-
Sub-rectangular	-	1	-
Reverse triangular	-	11	16
Reverse sub-triangular	-	2	-
Circular	-	1	-

In contrast, 42 percent of the blank assemblage represents more advanced blanks with bi-directional flaking on one to four edges. After reduction of the front, the back was typically reduced to a flat surface and then the sides were flaked. Some late stage blanks had evidence for poll reduction, tang reduction, and/or bevel formation before completion of the final shaping of the sides, front and back. Eight out of 20 complete blanks or poll/butt fragments had either minor or extensive evidence for butt reduction (reduction of the front, back, and/or sides).[5] Of the 13 blank fragments with intact bevels, 46 percent had some degree of bevel reduction. Overall, 21 percent of the blanks had indeterminate cross-sections that could be further reduced into more than one cross-section type.

The preform assemblage had a markedly higher incidence of bi-directional flaked edges than the blank assemblage (Table 5), indicating that this reduction strategy was used to thin late stage blanks, but more commonly preforms. Overall, 14 preforms (82%) exhibited one or more surfaces with bi-directional flaking. Of these, a single preform (6%) had bi-directional flaking on one edge, two (12%) were bi-directionally shaped along two edges (typically the back/sides), and eleven (64%) were bi-directionally flaked along all three edges (front, back, sides). Knappers at this workshop used tri-lateral shaping to reduce preforms and to refine the cross-section for the majority of late stage preforms with reverse triangular cross-sections. At Putoura, bi-directional flaking of the back/side edges is not found in early blank reduction but is a technique associated with later preform refinement.

A higher frequency of tang formation is found in the preform assemblage (65%) compared with the blank assemblage (33%), indicating that tang reduction sometimes commenced at the late blank stage, but more frequently began at the preform stage. Of the preforms retaining the butt/poll, 50 percent had pronounced tang formation, 19 percent had incipient tang formation or were in the process of tang formation when they broke, and 31 percent were discarded before tang formation commenced. The same pattern holds true for bevel reduction: 86 percent of the preforms retaining cutting edges exhibited evidence for bevel formation, compared with 46 percent of the blanks retaining cutting edges. Eleven of the 16 complete blanks and blank fragments retaining the poll/butt had evidence for butt reduction; of these, 73 percent had extensive butt reduction along the sides, front, and back of the poll. The preform assemblages document how poll reduction often commenced with the thinning of the front to establish the shoulder/butt juncture and a concave poll; once this was accomplished the sides and back of the poll/butt were reduced. Three preforms had extensive reduction shaping the butt into a flare at each corner, characteristic of the Duff Type 3A type where "… a top view of the grip [poll] reveals the outwards and upward projection of the corners of the poll as incipient lugs" (Duff 1959: 135).

Extra Areal Comparisons

Both flake blanks and prismatic basalt cores were fashioned into adzes at Putoura workshops, unlike at some other quarries in Polynesia, such as Kapōhaku, Hawai'i Islands (Weisler 1990), where the reduction of flake blanks was strongly emphasised. The TPP-035 results are similar to those of Leach's study of the Hane collections from the Marquesas Islands, where dyke stone with naturally trapezoidal shapes was reduced, in addition to flake blanks (Anderson *et al*. 1994; see also Rolett 1998: 184 and Suggs 1961: 112–113). A small degree of 'opportunistic use' of prismatic basalt cores with close to the desired cross-section is found in Samoa as well (Leach and Witter 1987). Diverse reduction strategies were probably carried out in areas such as the Papeno'o Valley, with abundant prismatic basalt slabs and water-worn cobbles of good flaking quality.

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[5] Blank fragments representing pieces of the cutting edge half or mid-section were excluded in this count.

ADZE TYPES, SIZES, AND CROSS-SECTIONS

Thirty-six of the 41 blanks and preforms could be typed according to cross-section. Ma'ohi knappers at Putoura predominantly produced blanks and preforms of reverse triangular cross-section[6] (75%), while 11 percent were trapezoidal (front wider than back); however, further side reduction would probably have resulted in the latter being reduced into reverse triangular forms. Data for the complete adze and the reworked adzes are broadly in agreement with the blank/preform assemblages. A single adze and a reworked adze had trapezoidal cross-sections, while the rest of the reworked adzes (n=4) had reverse triangular cross-sections. There was, however, some diversity in cross-sections recovered within the blank assemblage. A single blank with rectangular cross-section was found, in addition to a single blank with a roughly circular cross-section, and two blanks with reverse sub-triangular cross-sections.

TABLE 6
Range values for length and weight, adze blanks and preforms

Range (min-max)	**Blanks (N=9)**	**Preforms (N=3)**
Length (mm)	66.8–192.4	75.9–201.5
Weight (g)	100–1380	30–3040

Although sample sizes are small, the metric attributes of complete adzes, blanks, and preforms document substantial diversity in size in the TPP-035 assemblages, particularly for length and weight (Tables 4, 6). The large spread in standard deviation values for blank and preform length and weight (Table 4), the substantial range in minimum and maximum length and weight values (Table 6), and the overall large distribution of adze size when length is plotted against weight (Fig. 4) indicate that preforms and blanks of varying size were produced at the Putoura workshops. When the metric data are integrated with the cross-section and typological data, it is apparent that Ma'ohi knappers manufactured more than one type of blank and preform at this workshop. These include small reverse triangular Duff Type 3 adze blanks and preforms between 66 and 100 mm long and 30 and 100 g in weight, large Duff Type 3 adze blanks and preforms between 100 and 192 mm long and over 250 g in weight, and large Duff Type 4A blanks, *c.* 201 mm long and 1380 g in weight.[7]

Most of the TPP-035 adze blanks, preforms, and adzes could be confidently assigned to Duff Type 3A (Table 3); however, other adze types were produced, including Duff Type 3D chisels or gouges (Fig. 7C), a Duff Type 4A adze with a large and heavy body (Fig. 8A), and a reworked Duff Type 1A.

[6] Reverse triangular adzes have triangular shaped cross-sections with the apex down when hafted (Duff 1959).

[7] The large range in weight is skewed by one 'outlier', an extremely heavy preform. However, the overall pattern that emerges when weight is plotted against length is that both large and small adzes were the intended output of knappers at the Putoura workshops.

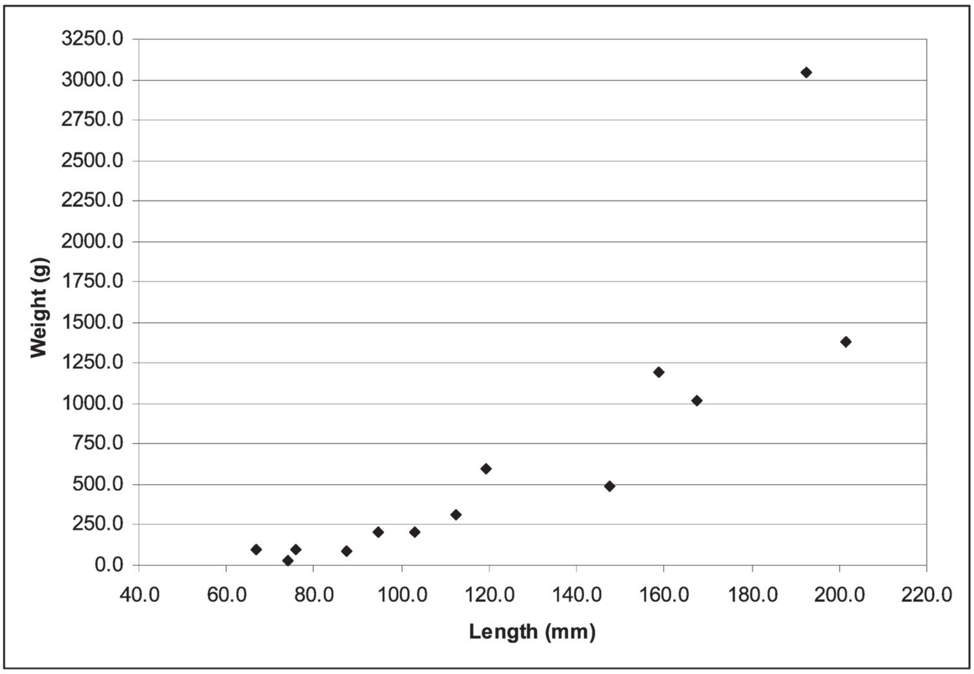

Figure 4: Plot of length against weight for complete adze blanks and preforms from TPP-035.

Extra-areal comparisons

The Duff 3A type, or reverse triangular cross-section adze (Duff 1959), has been considered a dominant form in late prehistoric Society Islands contexts (Emory 1979; Emory and Sinoto 1964: 156; Green 1967: 220; Sinoto 1976), in addition to the Duff 4A adze with an intermediate triangular/quadrangular cross-section (Gerard 1978; Kahn 2005a). However, few Society Island studies have delineated what other adze cross-section types were produced in the late prehistoric period and whether the domination of Duff 3A and 4A forms represents a standardisation of adze production linked to the rise of adze-making craft specialists, as has been advanced for rectangular adzes in Hawai‘i (Kirch 1985, 1990a, 1990b; but see critique by Cleghorn 1992). The TPP-035 assemblages highlight that while Duff Type 3A adzes dominate, Duff Types 1 and 4 were also manufactured. Reverse triangular forms are numerically dominant in other excavated assemblages from the Papeno‘o Valley, but trapezoidal or reverse trapezoidal cross-sections are also represented (Belçaguy 1990), in addition to plano-convex forms (Orliac *et al*. 1989: 74). Given that most sites in the Papeno‘o appear to post-date AD 1650, the data suggest that a number of adze cross-sections continued to be produced in late prehistoric Society Island contexts.

Looking to other late prehistoric period sites in the Windward Society Islands, some diversity in adzes forms is found, but Duff 4A adzes appear to dominate.[8] In Mo'orea, adze and preform collections from late prehistoric house sites in the 'Opunohu Valley, dating between the mid-fifteenth and seventeenth centuries, are predominantly Type 4A, but tanged adzes of Type 3, with intermediate triangular-quadrangular cross-sections, are also found (Kahn 2005a: 388–390, Table 6.9); the latter are also considered a late prehistoric type commonly found in the Society Islands (Gerard 1978: 174, 178). Adzes excavated from a later proto-historic house site in the 'Opunohu Valley were mainly Type 4A, but included a sub-triangular cross-sectioned adze probably representing a chisel (Oakes 1994: 90). Tanged quadrangular adzes of Type 1A have been recovered from adze caches in the 'Opunohu Valley (Green 1967: 220), while early quadrangular types lacking tangs have been documented in private collections from the 'Opunohu Valley and Niuroa Valley, Mo'orea (Lepofsky 1994: 156–157, 219–221).

Gerard's (1978) study of museum collections from surface contexts and excavations throughout the Society Island archipelago illustrates that reverse triangular forms dominate, but triangular, oval-lenticular, quadrilateral, and trapezoidal cross-sections are also found, as well as other forms similar in appearance to chisels. These findings support earlier contentions by Emory and Sinoto about adzes found in private collections and archaeological caches throughout the archipelago (Emory and Sinoto 1965: 84–85). Although the oval-lenticular and quadrilateral forms lacking tangs probably date to the early settlement period when such adze forms were more common (Emory and Sinoto 1964: 156), Gerard (1978: 178) discusses unpublished excavations in workshops on Ra'iatea which suggest that Types 3A and 4A were not supplanted in the Leeward Society Islands by other styles that existed into the late prehistoric period; further publication of these workshops on Ra'iatea is required before this can be confirmed.

Thus, the TPP-035 collections provide support for the inference that Duff Type 3A and 4A adzes were not the only types manufactured in later prehistory in the Windward Society Islands. Late prehistoric Society Island adze manufacture appears to be similar to the Hawaiian adze sequence (Cleghorn 1992) where one form predominates throughout (in Hawai'i, rectangular adzes), yet various forms (reverse trapezoidal, reverse triangular) are found through time and are not abandoned in the late prehistoric period as was once thought. Recent experimental manufacture of a New Zealand canoe with adzes replicated according to traditional techniques (reported in Turner 2005), demonstrates how a diversity of adze forms and sizes was used for major woodworking activities such as canoe manufacture. It is therefore likely that functional requirements necessitated that several adze forms be made through time.

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[8] On the basis of analysis of mainly surface collected adzes in museum collections, Gerard (1978: 178) has argued that the 3A type dominates in later prehistory in the Windward Society Islands, while the 4A type dominates in later prehistory in the Leeward Society Islands. However, my analysis of Mo'orea adzes, based mainly on dated archaeological contexts, suggests that the 4A type supplanted the 3A type as most dominant in later prehistory in the Windward Society Islands.

PROCUREMENT

Because of their advanced stage of reduction, many preforms and some blanks lacked evidence for reduction series or type of parent material; these are classified as 'indeterminate' (Table 4, Fig. 5). Of the artefacts retaining reduction series data, flake blanks struck from water-worn cobbles and prismatic basalt slab cores are found with equal frequency, while the reduction of water-worn cores is less frequent (Fig. 5). There was some diversity in the raw material selected by knappers for adze reduction at the Putoura workshops; this was probably a response to the diversity of original parent materials locally available.

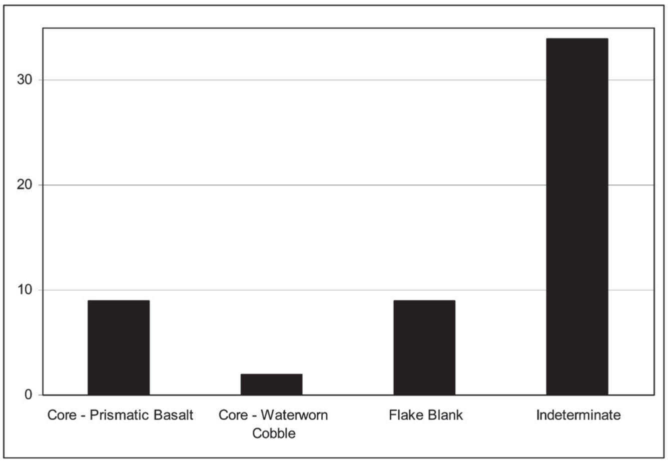

Figure 5: Raw material procurement at TPP-035 (includes the worked basalt category, and all adzes, preforms and blanks; i.e., complete, fragmentary and reworked).

A diversity of procurement sources is likewise suggested in the macroscopic identification of raw material type. Most TPP-035 artefacts had a fine-grained texture, blue-grey in colour with small black phenocrysts. Others had a fine-grained texture, grey in colour with larger brown or black phenocrysts. While geological samples must be submitted for geochemical sourcing for definitive results, preliminary data indicate either that raw materials from more than one volcanic flow were used in adze production or that there is significant variation within the flow from which raw materials were procured. The diverse range of quality in the raw materials reduced suggests that cobbles were collected from river beds cross-cutting multiple geological flows or from boulder fields/outcrops with more than one source represented; the reduction stage data suggest that some material may have been quarried.

The worked basalt category provides additional data on procurement practices and initial blank production. All worked basalt specimens are fashioned from prismatic basalt cores. They exhibit an opportunistic use of natural dyke stone slabs with flat surfaces or sloping surfaces suitable for a bevel, and have cross-sections close to the desired final cross-section (either reverse triangular or trapezoidal). Two were discarded because of mid-body breaks; the other three were complete, but were discarded after initial testing or preliminary flaking, perhaps because of an inferred inferior flaking quality. Most have a series of preliminary uni-directional flakes or testing flakes removed from either the front or back surfaces (or both), but none have true bi-directional flaking. All of the worked basalt artefacts retain cortex cover, ranging from *c*. 25 to 75 percent of the artefact surface. This, along with the evidence for preliminary reduction, supports the notion that these artefacts represent minimally worked prismatic basalt cores, probably collected from nearby dyke flows, which were discarded after preliminary raw material testing. They probably represent one facet of initial blank production.

Table 7 provides the metric attributes for the complete worked basalt artefacts. The greatest variation is found in length and weight, similar to data presented for blanks and preforms, and thus provides secondary confirmation that both small and large bodied adzes were among those manufactured at the Putoura workshops. These minimally worked prismatic basalt cores were most often reduced on either the front or back surfaces before the sides were worked, similar to results found for the blank and preform analysis.

TABLE 7
Metric attributes for worked basalt artefacts*

	Average	**Range**	**Standard deviation**
Length (mm)	157.0	120.3–225.0	59.0
Width (mm)	74.7	57.1–104.2	25.7
Thickness (mm)	88.9	75.9–99.0	11.8
Weight (g)	1000	710–1290	410.1

* All values are based on a sample size of five (see Table 1), other than for weight, which was based on a sample size of four (weight of one sample was mistakenly left unrecorded).

Extra-areal comparisons

Other Papeno'o Valley lithic assemblages, like the materials recovered from TPP-035, demonstrate a great diversity in raw material types, with materials ranging from very fine-grained dark blue/grey with small phenocrysts, to medium-grained with larger inclusions (for example, see M. Orliac *et al*. 1989: 66; M. Orliac and Ottino 1983: 10). Some of this diversity probably reflects the range of procurement practices for raw materials used in adze manufacture in the Papeno'o, notably quarrying or mining of prismatic basalt slabs from dyke features and reduction of water-worn cobbles collected from stream beds (Belçaguy 1990: 27; M. Orliac 1990, 1989). Other researchers have argued that prismatic basalt slabs were minimally worked, used, and perhaps minimally 'tested' before their reduction into adzes and/or eventual discard (Orliac *et al*. 1989: 73), but more explicit technological studies of other Papeno'o Valley assemblages are needed before this can be confirmed. Current evidence about the range of raw materials reduced in the Papeno'o Valley is consistent with other Society Island studies. Because of the complex geological environment of this archipelago, the reduction of river cobbles or basalt outcrops leads to a diverse range of raw materials in the resulting waste debitage and tool assemblages (see Kahn 2005a).

ADZE MAINTENANCE: REPAIR AND REWORKING

A broken preform was extensively modified after breakage in an effort to refashion the bevel. Five broken adzes had considerable evidence of repair and modification and evidence of having at one time been in a finished form, with patches of polish or hammer dressing, or a combination of the two. Although not in a complete condition, these resharpened adzes retain their original cross-sections, showing them to comprise one Duff 1A and four Duff 3A (see Table 3). Repair resulted in extensive flaking of the cutting edge and bevel, with varying degrees of reshaping of the rest of the blade, body, or poll in order to reduce the width of the adze so it was in line with the reworked cutting edge. In all cases, resharpening and repair of Duff Type 3A adzes produced characteristic concave cutting edges and resulted in the width at the shoulder being greater than the width of the newly reduced cutting edge (for descriptions of reworked New Zealand adzes see Turner 2000: 231–304, 2005). One of the reworked adzes appeared to be the blade section of a large Duff 3A adze, while two other repaired Duff 3A adzes were of a smaller, thinner variety. At least one repaired adze appears to have been knapped by someone lacking great skill, as most of the reshaping flakes terminated in deep step fractures.

These repaired adzes also provide data on the frequency and location of hammer dressing and adze polish, which can vary both between adzes types and between adzes of the same type. The modified Duff 1A had a quadrilateral to sub-rounded cross-section; the latter was the result of extensive hammer dressing. This adze was not extensively polished; only the front bevel was lightly polished, while the other surfaces had hammer dressing.

One of the repaired Duff 3A adzes lacked hammer dressing but retained polish on the blade, while another had evidence for extensive hammer dressing on all surfaces other than the blade (Fig. 6). Two modified adzes retained little remnant polish or hammer-dressing because extensive flaking had removed nearly all traces of these activities. One specimen retained about 10 percent coverage of hammer dressing along the back, while another had a small portion of remnant polish along the blade.

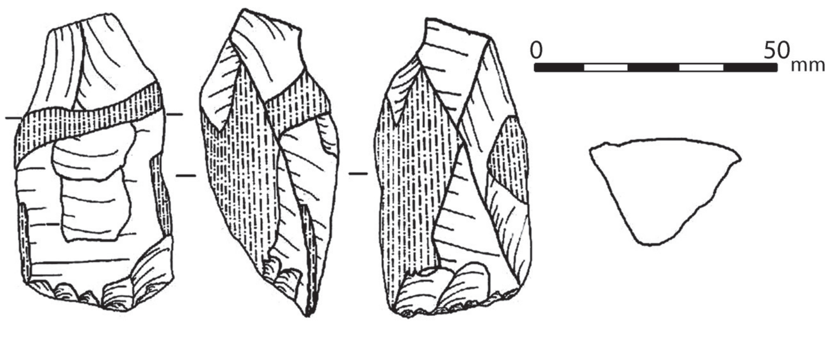

Figure 6: Object 36 from TPP-035, a reworked adze retaining hammer dressing (represented by dashed/dotted lines). The bevel has been extensively reworked (note flakes used to thin the bevel).

That five of the six complete adzes were repaired suggests that even in areas with easily accessible raw material of a fine quality, such as the Papeno‘o Valley, time was still taken to curate and rejuvenate adzes after breakage. Data from adze replication experiments (Turner *et al*. 2001: 56; Turner and Bonica 1994) demonstrate that it was less time consuming to curate and rework broken preforms or adzes than to replace them with newly made specimens, which was probably a significant factor in decisions to rejuvenate. The presence of repaired adzes also has implications for the types of activities found at or around this workshop and their organisation. One scenario is that adzes were used in the immediate vicinity near the workshop for varied tasks and that through time these adzes were repaired, either by the persons using the adzes or by knappers at the workshop (these individuals may be one in the same). A second scenario is that adzes requiring repair after being used at other areas within the valley were brought to the knappers at this workshop specifically for repair. The latter would suggest that the Putoura knappers were considered specialists within the local community.

Extra-areal comparisons

Adze maintenance and retooling has not been a focus of previous Society Island adze studies. Nonetheless, Society Island adze collections studied by Gerard show extensive resharpening and reworking, as I have reconstructed from Gerard's drawings (1978: Plates 29, 33–48, 50–53, 58–60). Repair and reworking of a broken preform and used (complete) adze have also been documented at ScMo-171C, a residential site (rectangular house) dating to the late prehistoric period in the 'Opunohu Valley, Mo'orea (Kahn 2005a: 387) and undoubtedly other assemblages display similar patterns.

Turner's work on Polynesian adze assemblages has most strongly emphasised reworking or maximisation of tool-use life (2000: 231, Turner *et al*. 2001), documenting the practice in both New Zealand and Norfolk Island assemblages. Her New Zealand research illustrates how broken preforms and finished adzes were extensively repaired and reworked at a range of site types, both near and far from the production quarries (1992: 261–262). Turner and Bonica (1994) relate tool reworking to economising behaviours, notably conservation of raw materials as well as effort.

It is also possible that some repair and reworking activities were related to particular social contexts found at Polynesian adze quarries. Ethnographic research on adze production, such as Stout's (2002) Irian Jaya case study, describes a community of adze makers including both experts and apprentice individuals lacking high proficiency.[9] Archaeological evidence (Cleghorn 1982) along with spatial analyses of site types and site locations (McCoy 1999) at the Mauna Kea quarry suggests an adze production community of members with mixed skill levels. It is likely that apprentices took part in all stages of stone tool production as part of the learning process and they may have practised on broken tools to a greater extent than more highly skilled craftsmen.[10] In the Putoura assemblages, some reworked adzes are reshaped with skill, while others appear to be reworked without great skill and have extensive step terminations creating irremovable lumps. Although tentative, the data suggest that at least some reworking of broken adzes may be a form of learning, whereby apprentices were given broken specimens to practice knapping activities on. The question of how to identify apprentices and the types of items they may have worked on at Eastern Polynesian quarry sites deserves more attention in future studies.

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[9] Articles on lithic production and craft production (Bamforth and Finlay 2008; Ferguson 2008) emphasise stone tool production as a skill requiring extensive training and practice within a social context of learning.

[10] Apprentice training in lithic technology can include novice experimentation on waste or discarded items and recycling rejected tools into other forms (Ferguson 2008: 53). Novice work can include deviations from expected chaîne opératoire and failure to complete rejuvenations successfully (Bamforth and Finlay 2008: 6).

MANUFACTURING TECHNIQUES AND REDUCTION MODELS

The high overall frequency of blanks and preforms highlights that TPP-035 was an area of *in situ* adze production, as does the high volume of debitage associated with the discarded adze blanks and preforms. The recovery of a pick and hammerstone (Table 2), fabricators used in adze manufacture, likewise suggests *in situ* production. My preliminary analysis suggests that the flakes recovered from the workshops are in a range of size categories, from large to medium to small, also suggestive of an *in situ* production locale.

Observations on the specific manufacturing techniques used at the TPP-035 workshops are offered below for the dominant manufacturing type — the reduction of flake blanks. Illustrations of the preforms and blanks are found in Figures 7 and 8. In all cases the front is depicted first, the side view second, and the back last, with the bevel at the bottom of the drawing and the butt at the top.

> *Step 1*: In many cases, the first stage of manufacture involved ridge preparation on the dorsal face of the flake blank before the flake blank was removed from the core (also described by Leach and Leach 1980: 128 for the Riverton adze quarries).
>
> *Step 2*: Flake blanks were oriented in a standardised fashion with ventral surface to the front, dorsal surface to the back, and striking platform to the poll.
>
> *Step 3*: Flake blank reduction commenced with the striking of uni-directional flakes from the margins of the front face down the sides.

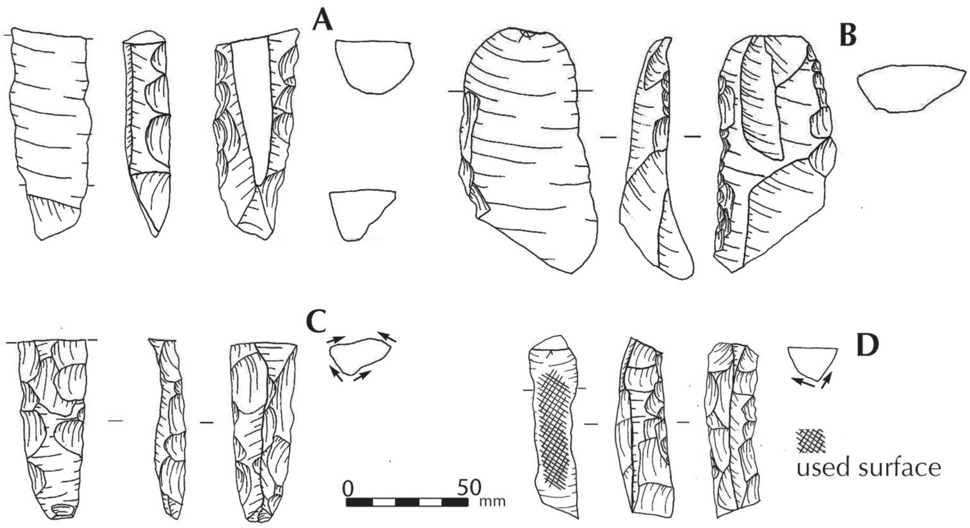

Figure 7: Preforms and blanks fashioned from flake blanks from TPP-035. A: Object 12, preform fragment. B: Object 13, early adze blank fragment; prismatic basalt cortex (not visible) is present along the striking platform of the flake blank. C: Object 14, Duff Type 3D adze blank/chisel fragment. D: Object 15, adze blank/chisel fragment, similar to Object 14. Fashioned from a flake blank but rejected and then used along the flat face of the front.

Step 4: Once new striking platforms were created, flake blanks were flipped and side flaking commenced from the dorsal surface; this step was only carried out if the sides required further shaping and straightening after Step 3.

Step 5: Further rough shaping of the blank; front and back surfaces were uni-directionally flaked.

Step 6: Bi-directional flaking of the preform: front, back, sides.

Step 7: Bevel reduction.[11] Thinning flakes were struck down the back using the front face of the cutting edge as a striking platform (i.e., parallel to the long axis of the preform).

Step 8: Tang development/butt reduction.[12] Thinning flakes were struck along the front to produce a concave poll, and were used to reduce the back and sides.

Step 9: Final preform shaping by extensive hammer dressing or pecking (Figs 6, 8D). Figure 8D demonstrates how this technique was used in the final production stage to transform a preform into a finished adze. The unpecked portion is not well shaped; final pecking removed a substantial portion of the preform volume and considerably refined the finished shape.

Step 10: Adze blades and cutting edges were typically polished after the final shaping by hammer dressing was completed.

MANUFACTURING SEQUENCES

Preparation and shaping of the dorsal face of the flake blank before its removal from the core is a highly effective technique for producing symmetrical preforms, with known distribution in New Zealand, Pitcairn, and the Marquesas Islands (Leach and Leach 1980: 128). The present study adds the Society Islands to this list. Similar to the debut of flake blank reduction at other Polynesian quarries (e.g., Tataga-matau, Leach and Witter 1987, 1990; Kapōhaku, Weisler 1990; Mauna Kea, Cleghorn 1982: 196), early blank manufacture at Putoura emphasised reduction with uni-directional flaking. Yet in contrast to Weisler's findings (1990: 38), there was a high incidence of bi-directional flaking used to thin the sides of reverse triangular preforms at the TPP-035 workshops, in addition to shaping and thinning the back and refining the transverse cross-section. Bi-directional flaking was the most prevalent production strategy for reverse triangular adzes, similar to results in other

[11] This represents the dominant trend, but it is not surprising that there is some variability in the relative sequence of adze reduction stages at TPP-035 (see also Cleghorn 1982: 220, 328–329). Some late stage blanks had evidence for bevel reduction before the commencement or completion of bi-directional flaking.

[12] This represents the dominant trend, but there is some variability in the timing of bevel reduction. Some late stage blanks had evidence for tang development or butt reduction before the commencement or completion of bi-directional flaking.

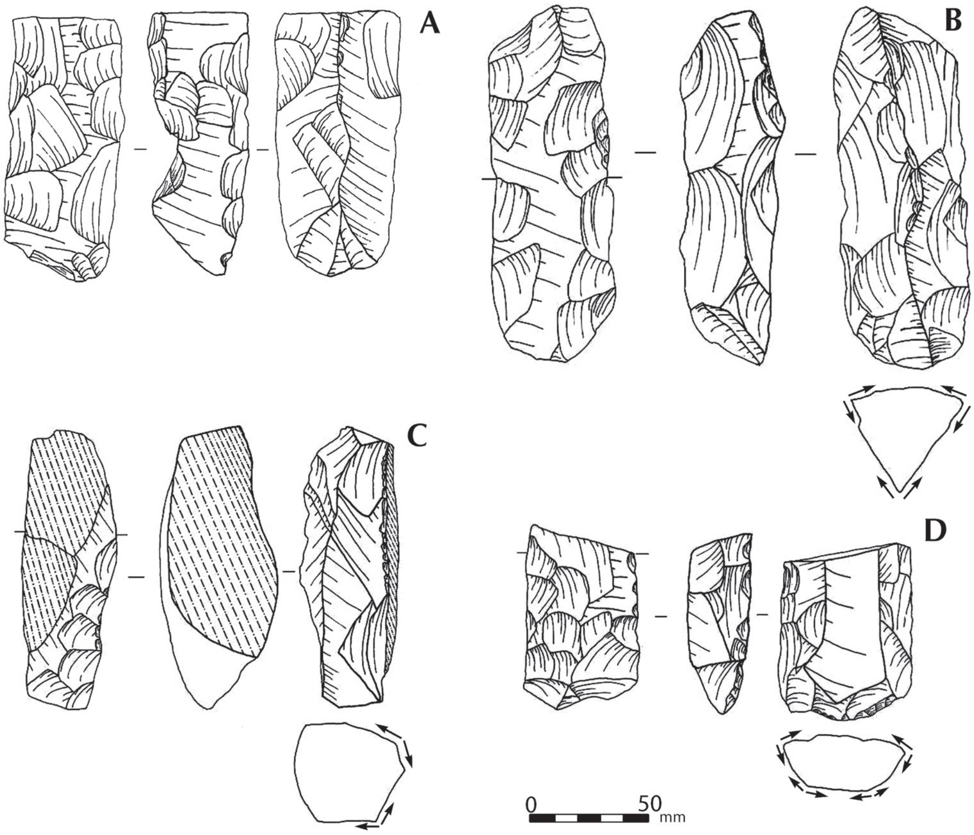

Figure 8: Adze blanks from TPP-035. A: Object 16, Duff Type 4A adze blank fragment. Note bevel formation flakes. B: Object 17, thick heavy blank, fashioned from flake blank. Note bevel formation flakes (back) and tang formation (side). C: Object 21, trapezoidal-sectioned adze blank fragment, broken at mid-body. D: Object 34, late stage adze blank, broken along the poll after the shoulder. Note extensive pecking/hammer dressing, represented by dashed lines.

studies for rectangular preform production (Cleghorn 1982; Leach 1981) and triangular-sectioned adzes (Leach and Leach 1980). The present study broadly supports the idea that more surfaces are bi-directionally flaked further along in the reduction sequence, as suggested by Weisler (1990) and Cleghorn (1982). However, where original flake blanks or cores were close to the desired shape, uni-directional flaking was employed exclusively to shape preforms, similar to methods of 'expedient manufacture' found in New Zealand (Leach and Leach 1980) and elsewhere (Anderson *et al*. 1994; Turner *et al*. 2001). As at other quarries (Cleghorn 1982), bevel and tang formation typically occurred after the cross-section was relatively complete; however at Putoura, tang and bevel formation typically occurred in the final stages of manufacture, after side straightening had been completed.

CONCLUSIONS

This case study of the Putoura assemblages has provided an in-depth view of adze manufacture at two moderately sized workshops situated in the middle sector of the Papenoʻo Valley. Of note is that Maʻohi knappers at TPP-035 utilised dual reduction strategies, working both flake blanks and cores. Adze were manufactured in a range of sizes. Type 3A adzes were the dominant forms produced, but there was some typological variability, with trapezoidal, rectangular, circular, and reverse sub-triangular cross-sections each represented in low frequency. For the majority of late stage reverse triangular preforms, knappers used tri-lateral shaping to refine the preform shape and cross-section. At Putoura, bi-directional flaking of the back/side edges is not found in early blank reduction but is a technique associated with later preform refinement.

Further research on the valley's substantial lithic assemblages is required to refine models of spatial patterns in adze production throughout the valley and its relationship to social status, craft specialisation, and site function. Yet three patterns emerge from the present analyses.

First, there appears to be some association of adze production with ceremonial temple sites (marae) and smaller ritual locales (shrines). This pattern is atypical for most locales in the Society Island archipelago, where evidence for stone tool production on marae or shrines is scarce. To provide a comparison: of the 145 marae and shrines so far recorded in the ʻOpunohu Valley (Moʻorea), none have extensive or even moderate surface or sub-surface remains associated with adze manufacturing activities (Green 1961; Green and Descantes 1989; Green *et al*. 1967; Kahn 2005b, 2007, 2008). Undoubtedly, more archaeological data are needed to link the surface lithic remains at Papenoʻo Valley temple sites unequivocally to *in situ* adze production activities.[13] Yet, on the basis of current data, it seems justified to argue that at least some adze manufacture at this regional production centre took place under ritual constraints, as is suggested by data from other major adze production quarries in Eastern Polynesia with abundant high quality raw materials, such as Mauna Kea (Hawaiian archipelago) and Eiao (Marquesas Islands). However, whether large scale adze production in the Papenoʻo Valley was controlled by craft specialists or elites is an unresolved question.

Second, my preliminary synthesis of the available data suggests an association between certain habitation/domestic sites in the Papenoʻo Valley and adze manufacture. The extent to which this is related to the status of the site occupants is at present unknown and will require more complete artefact assemblage analyses in addition to synthesis of field records and site notes. Current data suggest that this may be a pattern found in areas rich in high quality raw materials for adze manufacture. Adze production workshops associated with domestic sites are limited in non-resource rich zones in the Society archipelago; an exception is a small-scale workshop found in clear association with a high status residence during excavations carried out in the ʻOpunohu Valley on Moʻorea (Kahn 2005b, 2007).

[13] This will require varied types of data, including stratigraphic data linking production locales on or nearby temple complexes to cultural deposits associated with the marae, and dating of cultural deposits that can speak to the issue of site contemporaneity. Further analysis of the archived Papenoʻo fieldnotes may uncover such data, but it is more likely that resolving this question will involve additional fieldwork.

A third pattern is somewhat surprising, and concerns the frequency of adze repair and reworking found at the TPP-035 workshops. Economic models postulate that in zones of high raw material abundance, less effort will be expended on tool reuse and recycling, while such activities are expected to be more frequent at sites found a greater distance away from the source. Overall, the Putoura assemblages have a moderate degree of reworking, yet five of the six complete adzes had clear signs of repair. That an adze collection from a resource rich zone of good to high quality raw material has some evidence for reworking broken preforms, and substantial evidence for reworking used adzes, suggests that we need to rethink our views on adze reworking and maintenance. Tool rejuvenation activities did not just take place in zones at a far distance from sources of high quality raw materials as economic models suggest, but appear to be more frequent than previously documented. Turner (Turner *et al*. 2001: 56, see also Turner 1992) noted similar results from New Zealand adze assemblages, arguing that "At all New Zealand sites where adze production took place, reworking of broken adzes was a feature regardless of stone availability." In Polynesia, a long-standing focus on detailed analysis of only complete adze specimens, which can easily be typed using the Duff typology, has come at the detriment of ignoring incomplete specimens, which often exhibit reworking evidence. The frequency of preform, blank, and adze rejuvenation is a question that warrants further analysis in Society Island adze studies, as research elsewhere has documented that salvaging and reusing preforms may affect counts for certain adze types, in addition to adze shape and size (Leach and Leach 1980; Turner 2005).

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