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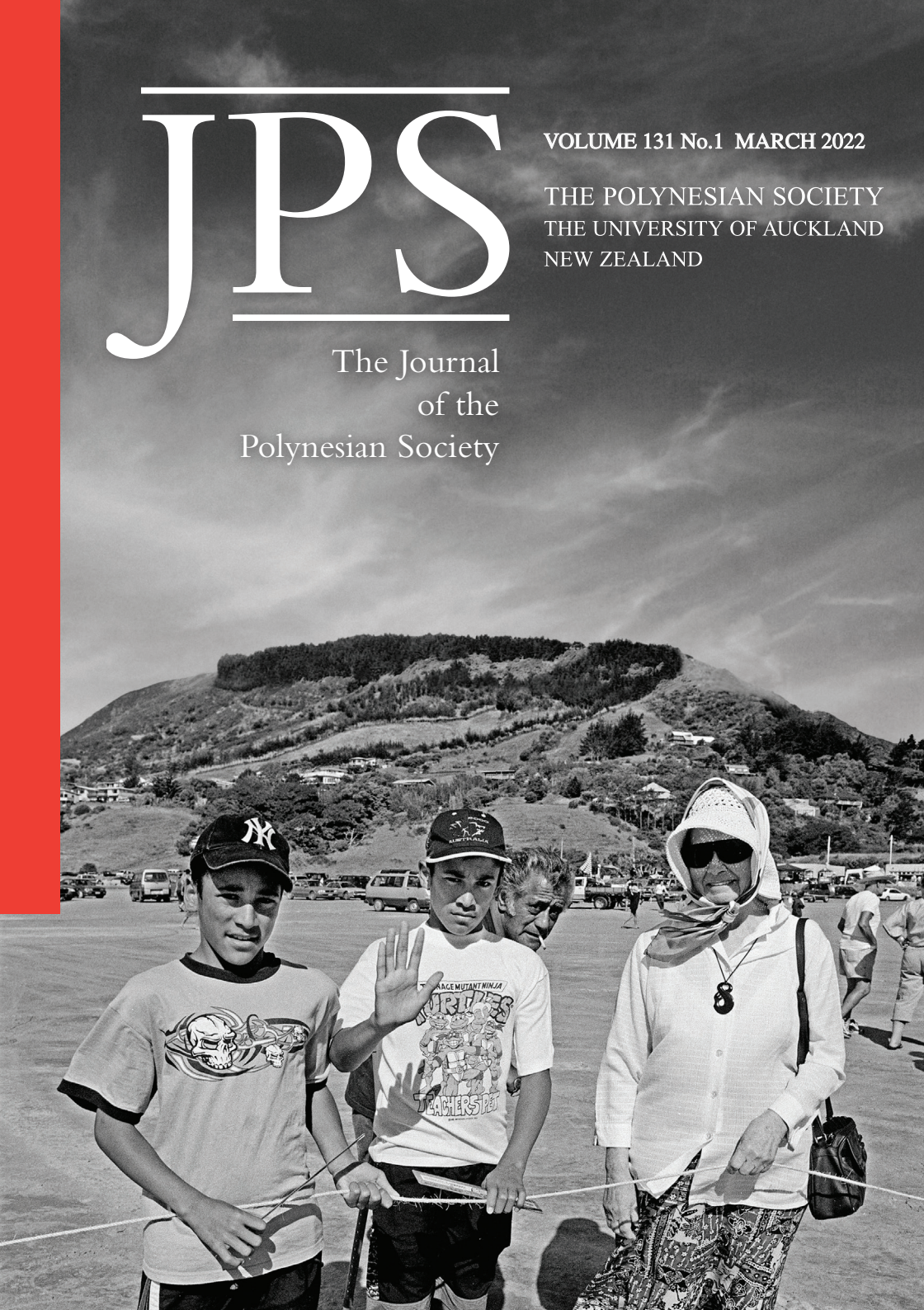

AN HISTORICAL ANALYSIS OF WAKA UNUA AND THE MĀORI SAIL

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ABSTRACT: Waka unua, Māori 'double-hulled canoes' with rudimentary Oceanic spritsails, have long been considered the most devolved of sailing vessels in East Polynesia, compared to an assumed sophistication of voyaging canoes in the prehistoric colonising era. This traditionalist or conventional hypothesis is discussed with reference to early historical data from New Zealand, including both written descriptions and drawings, according to the conviction that neither is intrinsically more reliable or informative than the other. Analysis of these sources, particularly those that refer to the Moutohorā (Bay of Plenty) canoe observed in 1769, does not support the conventional model. Instead of expedient construction, waka unua hulls were built to a New Zealand-wide pattern. Similarly, instead of an Oceanic spritsail, the Māori sail was an Oceanic double spritsail which had independent spars rather than a fixed mast. It was deployed before the wind and struck in reaching conditions. There is no plausible historical evidence of the Oceanic spritsail or lateen in New Zealand before the 1820s and it is argued that the Oceanic double spritsail was the only sailing rig used in pre-European New Zealand. Some inferences for understanding early East Polynesian voyaging are noted.

Keywords: New Zealand Māori, waka unua hull and sail technology, historical analysis, ethnography, traditionalism, Oceanic spritsail, Oceanic double spritsail, Polynesian voyaging

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Debate about the nature of Polynesian voyaging is now in its fifth century and showing no sign of losing its impetus. If anything, there has been greater interest in the topic during the last 50 years than earlier, and that is largely the result of a methodological shift from ethnological and ethnographic exposition to analysis of sailing performance by computer or wind-tunnel simulation, or directly by Oceanic sailing. Early in this "experimental turn", however, one of its pioneers (Finney 1976: 11), realising that ethnographic records required "more basic 'armchair' scholarship", called for reappraisal of the work of Hornell and other early ethnographers of Pacific seafaring and for further examination of primary historical sources. There was no immediate response and nor has Finney's point been addressed in any substantial way since. I take it up here in reference to Māori seafaring technology, specifically the *waka unua* 'double-hulled sailing canoe'.

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As Finney implied, the new experimental approaches (e.g., Finney 1979; Levison *et al*. 1973; Lewis 1972), directed initially at navigation more than naval architecture, were content with data about Polynesian canoes drawn from existing ethnographic commentary, notably by Haddon and Hornell (1975), that had been shaped by the conventional or traditionalist hypothesis of Polynesian voyaging. Traditionalists assumed, as Best (1925: 16–17) wrote, "that we have a more detailed account of the fittings and management of the deep-sea vessels used by the ancestors of the Maori five centuries ago than of the modern type used on these shores a hundred years since". This reading of traditions embraced a Māori principle that ancestral exceeded contemporary capabilities, including in seafaring. Traditionalist propositions in that vein (Table 1) were derived, inter alia, by Barstow (1879), Best (1915, 1925), Smith (1910, 1915) and Buck (1954) from sources held as originating in Polynesian oral traditions (Anderson 2008: 240; Sorrenson 1979; 1992: 109). By the mid-twentieth century these constituted a widely accepted conventional narrative of Polynesian voyaging, its orthodoxy reinforced by acerbic responses to the alternate hypotheses of Sharp (1957, 1963) and Parsonson (1969).

Soon after, experimental voyaging was contextualised as an anthropological mission—"primarily a social movement" (Finney 2006a: 332)—which required "getting Hawaiians fully involved in retracing their ancestral migrations. The [*Hōkūleʻa* voyaging canoe] project would then have a dual significance, both for scientific research and for cultural revival" (Finney 1979: 20). The potential incompatibility of those two objectives was accommodated by focusing the project upon a core traditionalist assumption of cultural deterioration, in this case that Polynesian voyaging technology and practice had been advanced early and declined later. As cultural decline (Durrans 1979: 153) implied that historical observation was an unreliable guide to former seafaring technology, the voyaging "renaissance" (Finney 2006a) sought to recapture its supposed sophistication during the East Polynesian migration era by combining the most advanced attributes of historical canoe and rig design from throughout Polynesia (Finney 1994: 45; Kane 1991).[1] Experimental voyaging in these enhanced vessels then encouraged widespread acceptance of early superiority in voyaging technology, and still does (e.g., Eckstein and Schwarz 2018: 94–95; Matsuda 2012: 22; Thomas 2021: 167; Williams 2021: 40).

Early advance logically entailed later retreat, and "in some islands canoe technology had declined by the time of European contact" (Irwin 2006: 80, referring to Mangareva, Rapa Nui (Easter Island) and New Zealand (Niu Tireni); Finney added Hawaiʻi, 2006b: 144. All are marginal islands). Decline was inferred broadly from archaeological and traditional evidence of less frequent long-distance voyaging and more specifically from the construction and performance of historical canoe hulls and sailing rigs.

Thus, in discussing archaeological remains of Māori canoe hulls Irwin *et al*. (2017: 42) conclude that changes in hull shape reduced hydrodynamic lift required for windward sailing, and that sailing capability had been in "more general decline ... with a shift from multi-hulls to monohulls, a loss of roll stability, more paddling and downwind sailing". The changes were not random but constituted a trajectory of decline in sailing performance. That proposition has been attributed to bottlenecks in knowledge transmission (Taylor 1855: 6–9), cultural degeneration (noted by Dening 1963: 120), or adaptation to changes in sailing conditions (Irwin *et al*. 2017; Johns *et al*. 2014). The fundamental question remains, however, of whether or to what extent such decline actually occurred.

An alternative or "historicist" model (Anderson 2017, 2018a) rejects the conventional narrative of early technical sophistication (Table 1). It observes that building the elevated performance attributed to migration canoes into "experimental" canoes demonstrates little more than a circular argument and asserts that inferred long-term trends in Polynesian seafaring technology do not, in fact, conform to traditionalist assumptions (Anderson 2000, 2001, 2008; Parsonson 1969; Sharp 1957, 1963). Instead, East Polynesian seafaring is seen analogically as a palimpsest in which traces of early technology—hulls suited to both paddling and sailing and a mastless sail rig, the Oceanic double spritsail (ODS hereafter)—have been patchily overwritten by external influences, such as stayed masts and the Oceanic lateen; by ensuing development, e.g., of the Polynesian Oceanic spritsail; and by localised innovations, often adaptive, e.g., *waka taua* 'war canoes' (Anderson 2010: 7–8; 2018a; Parsonson 1969). In this perspective, seafaring technology began modestly and remained much the same or became progressively more varied and specialised.

The two voyaging models are not entirely opposed. There is agreement on some propositions while others remain debated (Table 1: 1–5 versus 6–11). Of the latter, propositions 6–8 (Table 1) are open to further consideration through the kind of historical analysis envisaged by Finney. The objective in doing so here is to see whether closer analysis of the New Zealand evidence than hitherto (Anderson 2001, 2017, 2018a) lends more support to one or the other of the hypotheses in contention. Attention is directed at double-hulled canoes because these have been regarded as the principal vessels of long-distance voyaging in East Polynesia and it is from arguments about continuity or change in their hulls and sails that inferences are drawn about East Polynesian seafaring capability. The New Zealand historical and ethnographic evidence is crucial to that debate because it is thought to document the technological decline envisaged in traditionalist perspectives with particular clarity. Following notice of the double-hulled canoes seen in 1642 by the Dutch, I focus upon waka unua hulls and sailing rigs observed in New Zealand ca. 1769–1840.

Table 1. Comparison of East and South Polynesian migration voyaging and colonisation characteristics from traditionalist and historicist perspectives (+ consensus, − no consensus).

	Traditionalist propositions		Historicist propositions
	Migration voyaging		
1.	Initiated by strife in source islands	+	Initiated by strife in source islands
2.	Multiple canoes, large colonising propagule	+	Multiple canoes, large colonising propagule
3.	Largely ended in fifteenth century	+	Largely ended in fifteenth century
	Navigation and wind systems		
4.	Astral navigation and routeing knowledge	+/−	Astral navigation and dead reckoning
5.	Similar wind systems past and present	+/−	Periodically different wind systems in past
	Sailing rig and performance		
6.	Oceanic spritsail	−	Oceanic double spritsail (ODS)
7.	Effective reaching and windward ability	−	Ineffective beam reaching; no windward ability
8.	Relatively fast passages	−	Relatively slow passages
	Colonising strategy		
9.	Systematic strategic exploration	−	Mostly contingent exploration
10.	Frequent long-distance return voyaging	−	Seldom long-distance return voyaging
11.	Often delayed colonisation	−	Seldom delayed colonisation

These are discussed independently because historical hulls and sails were not matched inseparably. In Remote Oceania there was usually one type of sailing rig used in each archipelago[2] and it was adapted to different types of hull. In addition, the same sail type could be rigged differently between regions or periods, e.g., the Oceanic lateen sail in shunting and tacking configurations (Doran 1981). In New Zealand, the ODS, and later the Oceanic spritsail and square sail, were observed on both double- and single-hulled canoes. From analysis of written and depicted sources it is argued that waka unua hulls were not devolved manifestations of higher technology earlier or elsewhere in East Polynesia but built, rather, to a pattern that could have arrived in New Zealand at the time of initial migration. It is argued also that the original Māori sail was not the Oceanic spritsail favoured in early exegesis of East Polynesian migration myths and traditions but an ODS rig that continued in use until the 1820s.

WAKA UNUA IN 1642

Canoes seen at Tai Tapu (Golden Bay) in December 1642 were described by Haelbos (Sharp 1968: 4) as hulls "bound together two and two", but Abel Tasman wrote more explicitly that "their boats consisted of two long narrow prows side by side, over which a number of planks or other seats were placed in such a way that those above can look through the water underneath the vessel", i.e., there was a space between the hulls (Sharp 1968: 122). Apart from a few single hulls shown on the shore in Witsen's 1705 engraving (Mack 2006), all canoes appear to have been waka unua, of which up to 22 were seen at a time. Whether that apparent prevalence was matched elsewhere in mid-seventeenth-century New Zealand is unknown, but waka unua were certainly more common in the South than the North Island by the late eighteenth century (Anderson 1998: 124–27).

The waka unua were initially wary of the Dutch ships at anchor, but when a *praeutien* 'small prau', a small Indonesian canoe, was paddled between the ships it was attacked fiercely, its canoe form and propulsion perhaps convincing Māori that its crew were just ordinary people and vulnerable accordingly. Later, when 11 heavily crewed waka unua came within range, they were bombarded by ships' cannon and "turned with speed for the land, two of the Same Setting a type of Tingang Sails" (Sharp 1968: 123).

Drawings complement the narrative. None of the originals from New Zealand survive, but some had been copied, and these pose questions about what was seen. Waka unua were drawn with their hulls attached, gunwale to gunwale and with hulls of equal length (Fig. 1), features not typical of waka unua in the eighteenth century. Most interestingly, the canoe leading the waka unua back to shore from bombardment is shown with a West

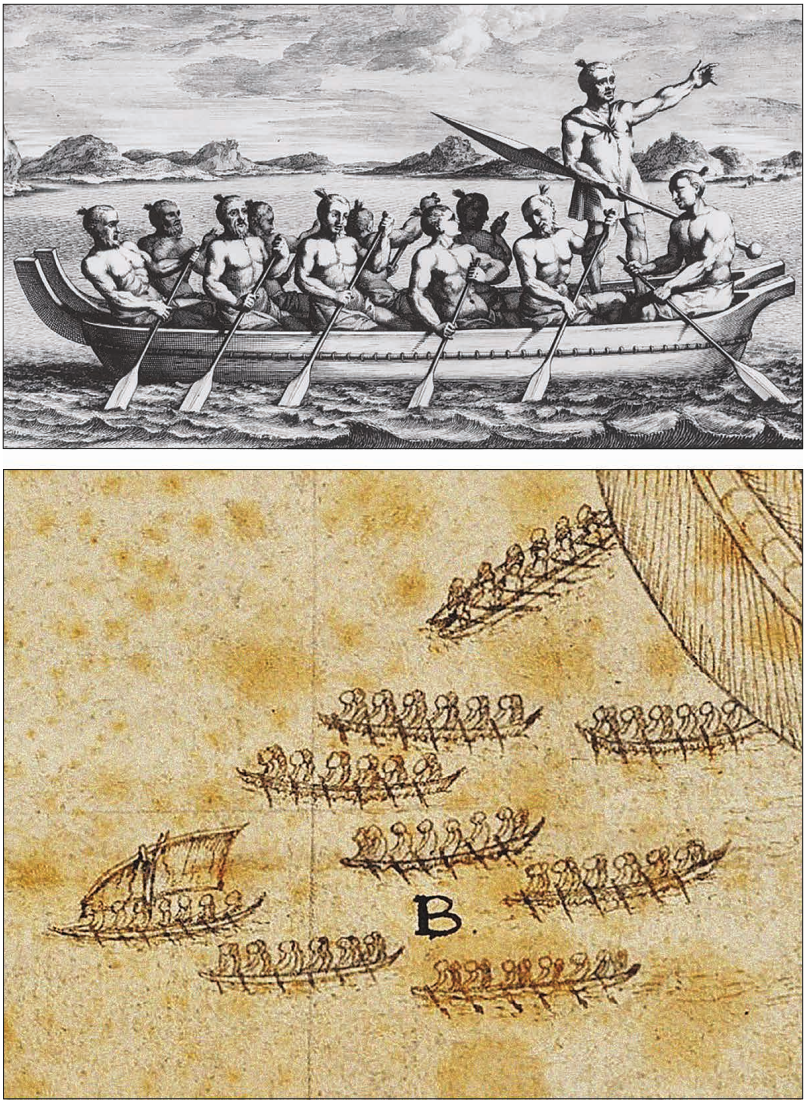

Figure 1. Above: Waka unua near Dutch ships, drawn by Frans Visscher of the *Heemskerck* and the first printed illustration of New Zealand (by Witsen in 1705: Mack 2006). Below: Waka unua fleeing Dutch cannon, Blok fragment, National Archive, The Hague: http://abeltasman.org.nz.

Polynesian "tongiaki" style of lateen rig (see Fig. 4) as the "tingang" sail. Tingangs (sampans) were shallow-drafted workboats in Southeast and East Asia (Anderson 2012). Tasman owned a trading "tenggang" in Java and he took two smaller examples on the expedition for ship-to-ship communication (Sharp 1968: 338), one of them being the boat attacked. Tingangs mostly used lugsails, slung by the yard from a short mast, in a way that resembled the seventeenth-century tongiaki rig shown in the Blok fragment (Collins 1987). Could the Māori example have been a lateen sail?

Except possibly in the current case no such evidence has been recorded in New Zealand apart from a late nineteenth-century observation (Best 1925: 260). A cautious approach to the Dutch evidence would note, first, that the attacking canoes got only just in range of ships' cannon and the sailing rigs were raised while the canoes were being paddled rapidly back to shore—in other words the sails were seen only at a considerable distance with the naked eye, marine telescopes not then being available. Second, as the stayed mast and tongiaki sail could hardly have been erected rapidly it is more likely that the rig was of a type that remained fully assembled when lowered and could be raised or lowered by running stays, as was observed of the ODS in the eighteenth century (below). Thirdly, Isaac Gilseman's narrative drawing (Fig. 1) could have used a tongiaki sail drawing from van Speilbergen's 1616 Tongan visit as a model, or been made in early 1643 when the Dutch reached Tonga and sketched double canoes with equal-length hulls and tongiaki sails, or been drawn much later in the Netherlands. The Māori sail was probably not a lateen, but whether it was an Oceanic spritsail or ODS is beyond the reach of current evidence.

WAKA UNUA OF THE EIGHTEENTH CENTURY AND LATER

Double-hulled canoes occurred in New Zealand up to the early nineteenth century. They were known generally as *waka unua* (*hunua*, *hūhunu*) and possibly *waka māhanga* (Beattie 1939: 107; Best 1925: 30–32; Evans 2000: 38–40). The last example of waka unua seen afloat was in Akaroa Harbour in 1849 (Anderson 1998: 126). *Waka hourua* (or *taurua*), the term now common for modern double-hulled canoes, referred earlier to canoe hulls lashed together directly as fishing or construction platforms (Best 1925: 30; see also Nelson 1991: 26). In the North Island, waka unua were seldom recorded historically and coastal travel was almost entirely in single-hulled canoes, mainly waka taua and *waka tētē* 'fishing and travelling canoes'. As early Pākehā 'European' observations were predominantly northern there are fewer historical records of waka unua than might have been expected.

The records that do exist are thought to indicate a decline in ocean-going technology compared to the double-hulled sailing canoes of Tahiti and Hawai'i, as implied in Buck's (1954: 290) comment that "when the seafaring men of the Pacific settled in New Zealand, they became landsmen". Haddon

and Hornell (1975: I: 195) asserted that waka unua were vessels of "simple and primitive construction" that lacked any apparent connection to the voyaging *pahi* 'offshore sailing canoes' of central East Polynesia. They were propelled by an Oceanic spritsail of an "extremely archaic and primitive design" (Haddon and Hornell 1975: I: 208) that was considered "the consequence of degradation and not a direct inheritance" and reflected by Māori abandoning overseas voyaging (Best 1925: 246; Haddon and Hornell 1975: III: 46). More recently, Finney (2006b: 144) regarded waka unua as inshore craft propelled by paddle and "auxiliary spritsails", and Irwin (2006: 88–89) proposed that the "stable double-hulled sailing canoe" of migration voyaging had been replaced by coastal sailing vessels with the result that "the early historic Maori canoe under sail is not an appropriate model for the migration period" (see also Irwin *et al*. 2017: 42 on general decline). Historical Māori canoes, then, have been considered as devolved in relation to the assumed characteristics of prehistoric voyaging canoes in the traditionalist paradigm (Table 1: 6–8) and thus in long-range capability (Table 1: 9–11). This conventional view of changing canoe technology, opposed by Anderson (e.g., 2000, 2018b), can be compared with data from early historical records.

Hulls of Waka Unua

The Royal Society expedition in 1769 observed several types of Māori canoe and placed them in an implicit classification which assumed that single-hulled canoes, the most common type, were architecturally basic components of the less common double-hulled and outrigger canoes.[3] Thus Joseph Banks wrote in 1770 that, in addition to single-hulled fishing and war canoes, "they sometimes joind two small [single] canoes together and now and then made use of an outligger" (Beaglehole 1962: II: 23). In 1773, Tobias Furneaux saw "five Double canoes that is two lashed together by several sticks laid across the two Canoes, at the distance of two feet asunder" (Beaglehole 1961: 738). Johann Forster remarked that "sometimes 2 of these [single] canoes are lashed together by cross-sticks which makes them go stiffer [i.e., they are more stable to rolling]" (Hoare 1982: 300), and George Forster (2000: 124) that "some of the canoes were double, that is, fastened along side of each other, by means of transverse sticks, lashed on with ropes". William Anderson observed in 1777 that while large single canoes could be beamy enough to sail without an outrigger, smaller canoes commonly had one, and "they often fasten two [single canoes] together by rafters which we then call a double canoe" (Beaglehole 1967: II: 811). In Northland, de Surville and du Fresne recorded no waka unua, but John Savage (1807: 62) saw single-hulled war canoes and said that Māori "sometimes lash two of them together". In Queen Charlotte Sound, 1820, Nicolai Galkin wrote that "sometimes two ... [single-hulled] craft are bound together by stakes" (Barratt 1979: 65). These ambiguous references to single canoes fastened together,

despite contemporary evidence that in double canoes they were separated, might have contributed to a later impression of casual or hasty construction.

The eyewitness accounts indicate that waka unua were encountered fairly infrequently, and when the evidence was considered by traditionalist scholars a semantic shift occurred in which infrequent encounter, denoted by "sometimes", "some", "now and then", etc., took on meanings of construction haste and transience of purpose. Elsdon Best (1925: 23) proposed that there had been two forms of Māori double canoe: those "connected by cross-beams securely lashed" which distinguished "the permanent double canoe of [tropical] Polynesia" from those "connected together in a more temporary manner for a coastal voyage or fishing expedition" (Best 1925: 35). His distinction was difficult to sustain, because the difference was largely about intention, and he accepted that waka unua used for coastal passages and fishing in the South Island in the eighteenth and nineteenth centuries "were indeed of a permanent type and not merely two single craft temporarily lashed together" (Best 1925: 31). In fact, his only example of a temporary waka unua referred to a vessel in 1873 that, nonetheless, had its cross-beams "securely lashed" (Best 1925: 35).

Absence of evidence notwithstanding, the idea that historical waka unua had been constructed expediently in New Zealand was soon adopted widely. Haddon and Hornell (1975: I: 195–97), in their evolutionary scheme of watercraft development, proposed that waka unua represented "the most primitive type of double canoe known", and they followed Best in proposing that some were only single canoes "converted into double ones to meet a passing need or emergency". Te Rangi Hiroa (Sir Peter Buck) (1950: 201) then elevated this conjecture into the generalisation that Māori "double canoes … were usually single canoes lashed together temporarily for a particular occasion", a conclusion that has continued into the present (e.g., Neich 2006: 240).

It is possible, of course, that this was sometimes the case, but no early historical data suggest expedient construction of waka unua, and all the canoes that came out to the European ships were involved in "particular occasions" that were extraordinary in the experience of everybody concerned. To consider this matter further it is useful to focus upon the case of the Moutohorā canoe.

The Moutohorā Double Hull. On the evening of 1 November 1769, a large waka unua paddled up to the *Endeavour*, anchored near Moutohorā (Whale Island) in the Bay of Plenty; it was the first seen in the Cook expedition. The next day, under sail, it ran alongside the *Endeavour* for an hour or more (Fig. 2). Recent reference to it follows the traditionalist consensus, Irwin (2006: 87, 89; see also Irwin and Flay 2015: 426) proposing that it consisted of a war canoe and a fishing or travelling canoe, and was representative of

"the double-hulled canoes still in use [in the eighteenth century that] were described as temporarily improvised by lashing two hulls together". Finney (2006b: 132) declared the Moutohorā vessel an "ad hoc Maori 'double war-canoe' … The ungainly craft had evidently been assembled for the occasion by temporarily lashing closely together, and planking over, the hulls of a long, elaborately carved war canoe and a shorter, plain canoe."

The only contemporary reference to its construction is by Banks: "a large double canoe, or rather 2 canoes lash'd together at the distance of about a foot which was coverd with boards so as to make a kind of deck" (Beaglehole 1962: I: 423). Familiar as he was with engravings from Gilseman's 1642 sketch showing waka unua hulls joined at the gunwales (e.g., in Dalrymple's 1767 book: Beaglehole 1962: II: 16), Banks appears to emphasise that the hulls he saw were separated. It is doubtful indeed that such a waka unua could have been constructed in the few hours between Māori sighting the *Endeavour* in the late afternoon and visiting it at 7 pm, or even a makeshift vessel with hulls fastened together directly. Besides, as most Māori visited the *Endeavour* in single canoes the expedient construction of a waka unua, not asserted at the time, would hardly seem necessary.

The Moutohorā canoe (Fig. 2) has a large hull set to starboard. It is in the general form of a waka taua, although the carved prow (*tau ihu*) does not project forward of the hull in the fashion common to waka taua historically, and feather work is absent. This hull has an estimated waterline length of 15–16 m

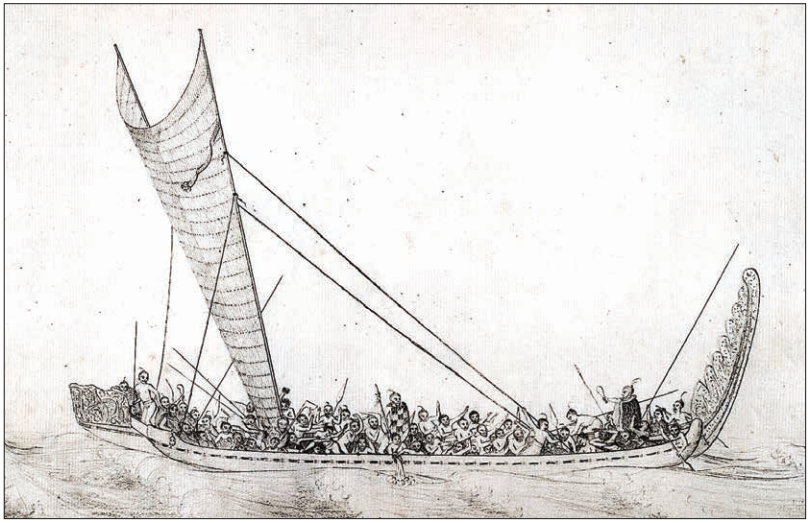

Figure 2. The Moutohorā waka unua under double spritsail, by Herman D. Spöring 1769. The British Library, London: Add.Ms.23920 f.48.

(Anderson 2008). There is a smaller, plain, hull to port. The starboard hull is 1.22 times the port hull in overall length, and about 1.1 times by waterline length. The connecting beams are not shown. The smaller hull is not in the form of other single canoes. It has an unusual prow shaped like a plain box, unlike the usual waka tētē prow with a carved head and extended tongue. The uncarved, rounded stump at the stern is equally unusual. The immediate question is whether the Moutohorā waka unua is *sui generis* or an example of construction to an established pattern. There are three other cases of waka unua for which there is comparable evidence: two from Queen Charlotte Sound and one from Dusky Sound (all identifying codes hereafter are British Library references to the items, as reproduced in Joppien and Smith 1985).

The Queen Charlotte Sound and Dusky Sound Waka Unua. Sydney Parkinson saw several waka unua, including the Moutohorā canoe. His pen-and-wash *A New Zealand War Canoe* (Add.Ms.23920 f.49) is suggested—from a human head included in it—as originating in Queen Charlotte Sound, but it may not be largely from direct observation (below). The vessel comprises, to starboard, a larger hull with carved prow and stern pieces and a smaller plain hull to port (Fig. 3). The starboard hull is 1.2 times the length of the port hull but waterline lengths are similar. As in the Moutohorā case, the tau ihu is largely within the hull, and the port hull has the same box-shaped prow and rounded stern.[4] The hulls are set close together and joined by seven beams.

Figure 3. Double canoe by Sydney Parkinson 1770. The British Library, London: Add.Ms.23920 f.49.

Hodges (Joppien and Smith 1985: II: 50) drew a waka unua containing 17 Māori men who visited the *Resolution* in Queen Charlotte Sound in June 1773 (this drawing might also be a composite of observations). The port hull has a long, carved prow and elevated stern, and there is a smaller, plain, hull to starboard. The larger hull is 1.3 times the smaller in overall length, but they are the same in waterline length.

In Dusky Sound, Captain Cook saw a small waka unua which he judged "just capable to transport the whole family [who had visited the *Resolution*] from place to place" (Beaglehole 1961: 117), and Hodges placed the canoe, poorly delineated, in his painting of *Resolution*'s watering place (Joppien and Smith 1985: II: 24). William Wales wrote that "the Canoe was composed of two small ones, hollowed out of a tree each, and fastened to one another about a foot asunder by cross pieces. The Stems and Stern-posts rose much higher than the body of the Canoe and the head was attempted to be carved like the upper parts of a man" (Beaglehole 1961: 777). Wales added that one hull "is considerably larger than the other, I think that on the starboard side [is longer than the other, they] being 18 feet & 14 ft respectively." Therefore, the starboard hull was 1.3 times the port hull in overall length. Wales also wrote that the hulls had wash boards fitted closely above the dugout hulls and that the two hulls were set slightly closer forward than aft, "which is a useful precaution" (Beaglehole 1961: 780). The Forsters (Forster 2000: 83; Hoare 1982: 242) made similar remarks.

No other eighteenth-century Māori waka unua has been described or depicted in comparable detail, but double canoes were seen in southern New Zealand up to about 1850. Some had hulls of equal shape and size, as in Foveaux Strait examples sketched by John Boultbee in 1827 (Starke 1986: 44, 83), but Teone Tikao recalled that South Island waka unua had a large and a small hull (Beattie 1994: 286–87). It is worth noting here that, in the Cook Islands, James Webber drew a small double canoe with hulls of dissimilar size and decoration at Atiu in April 1777, and that a double canoe, strikingly similar to the Webber example, was photographed on Atiu by Te Rangihiroa in 1925 (Dodd 1972: 110).

Cook (Beaglehole 1955: 283) wrote that all Māori canoes were built to the same plan—and regional uniformity of design occurred elsewhere in East Polynesia (e.g., Haddon and Hornell 1975: I: 21, 112–20, 127–29). It is apparent, however, that while waka unua used hulls of the same general shape and size range as those used in single canoes, they were not exactly the same and may have been different in other ways not evident in historical evidence. Eighteenth-century waka unua seem to have been built according to a New Zealand pattern, just as there were distinctive patterns of naval architecture in Tahiti, Hawai'i and the Marquesas. The Moutohorā, Queen Charlotte Sound and Dusky Sound canoes were spread over more than 2,000 km of sailing distance and numerous territorial boundaries apart, yet

they followed the same conventions, if not completely in each case: two hulls set close together, about 30 cm apart in two cases; one hull about 1.2 times the overall length of the other and having high carved ends, with the waterline length of the hulls being more nearly equal; the small hull plain with low ends and shaped differently from a waka tētē. The sample size is small, but these traits define, provisionally, a distinctive vessel in which the smaller hull differed from all other Māori hull forms. Under the traditionalist assumption that waka unua were cobbled together from whatever was immediately available, other hull combinations (waka taua plus waka tētē, two waka taua, two waka tētē), could have been expected. In fact, no such combinations were observed historically.

It is worth considering why a double canoe might have been constructed with more elaborate superstructures in one hull and with waterline lengths not precisely equal. In West Polynesia the shunting tactic of going about under an Oceanic lateen rig enabled the smaller hull of a double canoe—usually set to port, as in New Zealand—to be kept to windward in order to counteract the capsizing force of wind pressure on the sail. With a tacking rig (e.g., the Oceanic spritsail) each hull is alternately to windward, and hulls of different sizes would affect steerage and require frequent rig adjustments in reaching conditions. In sailing before the wind, however, such drawbacks are minimised and might have been tolerated for other reasons, *mana* 'power, prestige, authority' for example. In Spöring's and Parkinson's drawings, all but one of the chiefly figures in their fine cloaks appear to stand in the larger carved hull or on the platform, not in the smaller hull. Separating individuals and groups of different status was an abiding nautical concern, including in Austronesian boats (Appel 2012), and generally resolved by demarcating appropriate spaces from stem to stern. Multi-hulled vessels offer an additional opportunity; crew distribution in waka unua could have reflected the kinship dichotomy of *tuakana–teina* 'older–younger', with the senior line in the carved hull.

THE EARLY MĀORI SAIL

In East Polynesia, the eighteenth-century Oceanic spritsails in Hawai'i, the Marquesas and the Societies and Oceanic lateens in the Tuamotus are well documented, but, in contrast, contemporary sail types remain unknown or uncertain across the entire southern half of East Polynesia: Southern Cooks, Australs, Gambiers, Rapa Nui and South Polynesia. Best (1925: 256) observed that "we have no data to show the actual form of sail employed by the Maori in his voyages from eastern Polynesia" but assumed that it was the Oceanic spritsail. That opinion has become "a general consensus that the East Polynesian sail was an Oceanic spritsail" (Irwin 2006: 88), which is thought the earliest sail in the region (Di Piazza *et al*. 2014; Finney 2006b; Irwin and Flay 2015: 423). This is debatable.

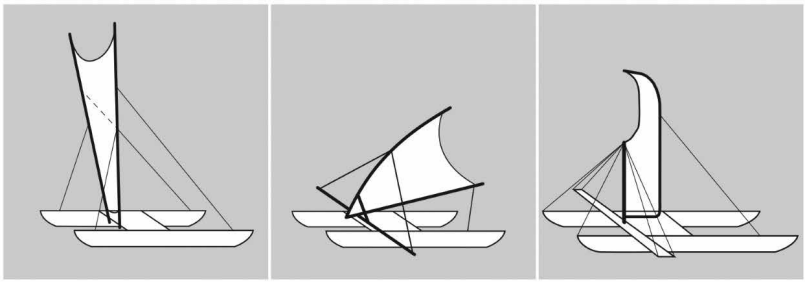

Figure 4. Three types of Polynesian sailing rigs. Left to right: Oceanic double spritsail (ODS), New Zealand; Oceanic lateen (tongiaki rig), Tonga; Oceanic spritsail, Tahitian form.

The terminology and typology of Indo-Pacific sails are fluid, but the focus here is upon two-spar rigs (Irwin 2006) where a triangular or trapezoidal sail, apex down, is fixed along both spars (Fig. 4), usually by lacing. In an Oceanic spritsail, one spar is also a mast fixed in position with stays (including shrouds), and the other, attached to the mast above the gunwales, is a boom that can swing to take the wind on either face of the sail, allowing the canoe to sail across the wind or closer. Conversely, when the spars are not joined, or joined only at the foot, they appear as "double sprits" (Fig. 4). An Indian Ocean form had sprits joined and a square sail attached only at the top of each sprit, but in Oceania there was a simpler form, the "Melanesian spritsail" (Horridge 2008), or "Melanesian double-mast sprit-sail" (Needham *et al*. 1971: 589). A tall rectangular sail was attached along each side to lateral spars that were not fixed together. Needham and colleagues (1971: 599) argued that this derived from an ancient Chinese sail that "seems clearly to depict the 'double-mast sprit-sail' now known only in Melanesia". Its wider Pacific history is largely unknown. It is beginning to emerge archaeologically in west Pacific rock art (Lape *et al*. 2007: Fig. 4) but not yet in historical linguistics (e.g., Di Piazza 2015b), although amongst various Māori terms for spars or masts are *ua* or *hua* in southern New Zealand with the sense of a lever rather than a fixed mast (Harlow 1985: 91).

In western Oceania, a region where quadrilateral sails occur in various rigs, double spritsails are recorded historically from various localities around New Guinea (Haddon and Hornell 1975: II: 213, 219, 222, 280–81, 331). In summary:

> each side of the sail ... was attached to a vertical spar or pole by a series of loops of a light rope, not by continuous lacing. There was no fixture for stepping the spars. When the sail was set the spars were simply allowed to stand in the

> bottom of the hull. The use of the sails and spars was purely temporary and there was no fixed mast. (Haddon and Hornell 1975: III: 53)

The rigging of these sails varied. Those set on canoes which kept the outrigger constantly to windward had fixed stays, but, in New Zealand, the double spritsail rig occurred on double or single canoes (outrigger sails are not recorded) and was of a correspondingly simpler form.

The historical probability and implications of a Māori ODS are widely ignored in orthodox discussions of Polynesian seafaring (e.g., Doran 1981; Evans 1998; Finney 2003; Howe 2006; Thomas 2021), with only oblique concessions to its possible existence: a self-supporting "modified lateen" (Howe 2003: 109); a "double-mast sail" (Irwin *et al*. 2017: 42); an "archaic quadrangular form" (Irwin and Flay 2015: 425). Historical observations are more explicit.

Eighteenth- and Early Nineteenth-Century Observations

Māori sails were described enigmatically in the earliest observations. In the first single-hulled canoe encountered in 1769, Parkinson (1972: 88) saw "a lugsail [generally quadrilateral] made of matting", and William Monkhouse recorded a fishing canoe that had "a roll of straw mat—It might be a sail" (Beaglehole 1955: 579). Once observations had accumulated, James Cook epitomised the case in 1770 (Table 2). Māori "hardly ever make use of sails at least that we saw and those they have are but ill-contrived being generaly *a peice of netting spread between two poles which serve for both masts and yards*" (Beaglehole 1955: 284; my italics here and in further historical quotes. Eighteenth-century ships' "yards" included sail yard and boom). As Cook is saying that both spars served the same function, rather than one as a mast and the other as a yard, his phrase is about as succinct a description of a ODS rig as might be wished. Banks wrote that Māori were very expert in paddling,

> [b]ut in sailing they are not so expert, we very seldom saw them make use of Sails and *indeed never unless they were to go right before the wind.* They were made of mat and *instead of a mast were hoisted upon two sticks which were fastned one to each side, so that they requird two ropes which answerd the purpose of sheets and were fastned to the tops of these sticks*; in this clumsey manner they saild with a good deal of swiftness and were steerd by two men who sat in the stern with each a paddle in his hand. (Beaglehole 1962: II: 23–24)

Banks reinforces Cook's point that there was no mast and boom, for which only a single sheet would be needed, but rather two spars, each of which required a sheet (indicating independently moving spars). Again, this is a very clear description of an ODS rig. Early French observations suggest

that sails were scarce in northern New Zealand. In 1772 du Clesmeur wrote of Bay of Islands canoes that "we have seen no sails in any of them, very light paddles being used" (McNab 1914: 477), while Jean Roux thought that Māori on board the *Marquis de Castries* were puzzled at the restricted movement of the ship under sail (p. 371).

George Forster (2000: 124) describes three canoes sailing in Queen Charlotte Sound in 1773, an activity "seldom seen among them. The sail consisted of a large triangular mat and was fixed to a mast, and a boom joining below in an acute angle, which could both be struck [i.e., the rig taken down] with the greatest facility." This observation is one of two early descriptions thought "unambiguously of triangular Oceanic spritsails" by Irwin and Flay (2015: 425). It is not, however, from a known journal entry. It is in George's 1777 book based on his father's journals (Forster 2000: xxviii) where it attenuates Johann Forster's journal entry, itself a recollection, that he once saw a canoe with "*a large mat instead of a sail* … fixed to *a kind of mast* & folds out, so that *the other beam* below forms an acute angle with the mast & the sail is in a triangular shape *or nearly*, *tapering towards the bottom*" (Hoare 1982: 301). As Johann records a narrow and probably quadrilateral sail and is uncertain about whether the spars were joined, an Oceanic spritsail cannot be inferred. Anders Sparrman, a colleague of the Forsters, wrote that "sails are only used on smaller craft, such as double fishing and transport canoes. As this sail is only used stretched between two parallel horizontal [presumably he meant vertical] poles, *it can only be used when the wind is aft*" (Hansen 2007: 531). In 1777, William Anderson also noted that sails were seldom used and emphasised the importance of paddling (Beaglehole 1967: II: 811).

These descriptions, and others below, are difficult to reconcile with the conventional assumption that eighteenth-century Māori sails were Oceanic spritsails, the latter being described quite differently when they were seen at that time. For example, Banks on the Māori sail (above) can be compared with his description of Oceanic spritsails in Tahiti (in Beaglehole 1962: I: 367) as attached to "one or two *masts ... made of a single stick*". A sail was "*pointed at the top* and the outside curved" bordered by a frame about one-third longer than the mast, and "with these sails their Canoes go at a very good rate and *lay very near the wind*."

Useful descriptions and depictions of Māori sails did not resume until the 1820s, despite references to sailing; John Nicholas (1817: II: 12) recorded the *Active* with six canoes nearby sailing before the wind off Northland in 1814. The Russians, however, "saw no craft with sails" at Queen Charlotte Sound in 1819 (Barratt 1979: 65). In 1820, Richard Cruise (1824: 35) recorded that carved (single) canoes in the Bay of Islands, each 60–80 feet long in a fleet of 50, "generally carried two sails each made of straw matting", and in 1824, René Lesson, surgeon on *La Coquille*, wrote that such sails were triangular rush mats,

"*quite useless for sailing close to the wind*" (Sharp 1971: 93). In 1827 Augustus Earle painted the scene of *A War Speech Previous to a Naval Expedition* (Murray-Oliver 1968: 128–29) in which there is shown an ODS constructed, it seems, from bundles of rushes bound together in a vertical position and aligned for sailing downwind (Fig. 5). This mode of sail construction and its capability is described, about 1835, by Joel Polack (1838: II: 23):

> [C]anoes in sailing are *only capable of going before the wind*; the natives do not understand any other method ... The sail is made of raupo flags [stems] or kiákiá [kiekie] grass, etc., of a triangular shape; it is fastened *to two small rickers or poles, which serve for both masts and yards* and fixed upright between the gunwales. *The sheets are made of plaited flax, fastened to the end of each pole*, but they are very clumsy. These vessels are safe in a brisk breeze, but from keeping in the trough of the sea are continually wet in windy weather.

Later, Polack (1840: I: 224–25) adds of single-hulled sailing canoes that "beating against a head sea or adverse wind [is] impossible, as these vessels have little hold from their shallowness in the water". The sails are "most clumsy and heavy … triangular, formed of bulrushes dried in the sun, and tacked together, the upper edge being cut into vandykes [pointed or zigzag shape]".[5] Southern Māori recalled that canoes under the traditional sail were dangerously tender with the wind on the beam and had no windward capacity (Anderson 1998: 125). In the light of these accounts the evidence most often cited of a waka unua under sail can be considered.

The Moutohorā Sail and Contemporary Drawings. On 2 November 1769 the *Endeavour* was running before a breeze of 7–10 knots when "the Double Canoe … follow'd us again today under sail and kept abreast of the Ship near an houre talking to Tupia" (Cook in Beaglehole 1955: 190). Banks wrote that "a Sailing canoe that had chased us ever since daybreak came up with us" (Beaglehole 1962: I: 423). This (Fig. 2) was the first Māori canoe seen under sail in the eighteenth century and, as the only case in which there exists both a specific description and a precise depiction of the sail, the two much at odds, it has been the subject of debate.

The description, most probably by midshipman James Magra (later, Matra) may have been based on a journal, but it is known only from a later book (*A Journal of a Voyage* 1771) in which original observations were rewritten into a narrative form.[6] The canoe

> carried a sail of an odd construction, which was made from a kind of matting, and of a triangular figure; the hypotheneuse, or broadest part, being placed at the top of the mast, and ending in a point at the bottom. One of its angles [the sides of the sail] was marled [fastened with cord] to the mast, and another to a spar with which they altered its position according to the direction of the wind, by changing it from side to side. (*A Journal of a Voyage* 1771: 82–83)

Table 2. Early historical observations of sail rigs 1769–1839 (* = same observation).

Recorder	Oceanic spritsail		Oceanic double spritsail (ODS)			Origin of evidence
	Sailing on reach	Mast & yard	Two sail spars	Sheet each spar	Sailing downwind	
Parkinson Nov. 1769			X		X	Journal
Spöring Nov. 1769			X	X	X	Direct view*
Matra Nov. 1771		X				Recollected?*
Parkinson Jan. 1770			X	X	X	Journal
Parkinson March 1770			X	X	X	Journal
Cook 1770			X	X	X	Journal
Banks 1770			X	X	X	Journal
Sparrman 1773			X		X	Journal
J. Forster 1773		?	?			Journal*

Recorder	Oceanic spritsail		Oceanic double spritsail (ODS)			Origin of evidence
	Sailing on reach	Mast & yard	Two sail spars	Sheet each spar	Sailing downwind	
G. Forster 1777		X				Reworked*
Nicholas 1814					X	Recollected
Lesson 1824					X	Recollected
Earle 1827			X	X	X	Direct view?
Lesson 1827		?	X			Journal
Pâris 1827		X				First Oceanic spritsail
Williams 1833			X	X		Recollected
Polack ca. 1835			X	X	X	Last ODS
Dieffenbach 1839	X	X				Recollected
Wakefield 1839	X	X			X	Recollected

Figure 5. Waka under double spritsail. Top left: Sydney Parkinson 1770 (The British Library, Add.MS.23920 f.44). Top right: Augustus Earle 1827 (Alexander Turnbull Library PUBL-0015-09). Below: Henry Williams [1832] 1835, who, to show their shape, drew the sails fore-and-aft.

This passage is often cited exclusively to define the Māori sail and it is taken as the principal historical reference to an Oceanic spritsail on Māori canoes (e.g., Beaglehole 1955: 190; Irwin 2006: 88–89; Irwin and Flay 2015; Johns *et al*. 2014). It is the other "unambiguous" description of an Oceanic spritsail cited by Irwin and Flay (2015: 425), who write that "Magra had the opportunity to see the whole sail and his description is consistent with an Oceanic spritsail". No basis exists for asserting that Magra saw more of the sail than others on board, nor for arguing that eighteenth-century sail depictions are "less formal" attempts at the Oceanic spritsails drawn by Pâris in 1827 (Irwin and Flay 2015: 425). These points serve, rather, to support a broader contention that

> early historical sketches can be ambiguous because they show sails and spars in different configurations according to the direction of the boat in relation to the wind, which makes it possible to misinterpret different *points* of sail as different *types* of sail ... [and] they may not accurately record every detail, particularly of ropes and rigging. (Irwin and Flay 2015: 428, their italics)

If valid—contemporary depictions are regarded elsewhere as especially useful in understanding former sails and rigging (Whitewright 2017)—the point cannot be confined to drawing. Written descriptions can be equally deficient or misleading, as indeed is Magra's account, on several grounds.

First, a large mast would have to be fixed by shrouds or stays, and the boom would need to be attached to the mast and controlled by a sheet, but Magra, evidently puzzled by what he saw, wrote nothing at all about the rigging. Second, a triangular sail with its hypotenuse at the top would require spars splayed out at 90 degrees or more (as noted by Beaglehole 1962: II: 24). Such a "butterfly" rig occurred historically on some outrigger canoes in Vanuatu, but its sail shape and rigging are highly distinctive (Di Piazza 2015a) and do not occur in any eighteenth-century drawings of Māori or other Polynesian sails. Third, Magra's muddled description of the sail head leaves his assertion that the sail foot was pointed also in question. Lastly, while the movement of spars might have recalled, for Magra, the trimming of Oceanic spritsails in Tahiti, the error in that view was exposed when the Moutohorā canoe left *Endeavour*. Turning away on a reaching course, the Māori seamen "doused the sail and stood back [to windward] under paddle" Parkinson ([1773] 1972: 102). The same procedure had been observed elsewhere by Monkhouse who noted that a canoe dropped her entire rig when she could not sail around the *Endeavour*'s pinnace, and then attempted to raise it (Beaglehole 1955: 568). The weaknesses in Magra's description, and its questionable status as a primary observation, do not justify the modern consensus that it referred to an Oceanic spritsail, let alone unambiguously.

Most importantly, Magra's description is contradicted by a detailed pencil drawing, made on the day it was observed, of the same canoe (Fig. 2). *New Zealand War Canoe: The Crew Bidding Defiance to the Ships Company* (Add. Ms.23920 f.48) is titled and dated in the handwriting of Herman Spöring, a 35-year-old Swedish draughtsman of natural history who was personal secretary to Joseph Banks. Spöring was employed mainly in botanical drawing, but after the death in Tahiti of Alexander Buchan, one of the original artists on the *Endeavour*, Spöring stepped into his role. Lysaght (1979: 10, 24) describes Spöring as a brilliant and talented draughtsman whose pencil sketches were exquisitely detailed, sensitive and accurate. Bernard Smith (1992: 63) wrote that Spöring's drawing of a Tahitian canoe showed "his eye was for construction; it is, you might say, an engineer's drawing. When he draws, Spöring does not look for the visual effect as Parkinson does, but for a linear description." He was a documentary draughtsman, in Smith's (1992: 54) terms, and his drawings of watercraft are precisely representational (the most accurate modern depiction (Kane 1991: 19) also shows the canoe rigged as Spöring drew it, but from astern).

As reading of descriptive ethnography through the lens of the conventional voyaging model largely fails to recognise the ODS, it is important to emphasise the complementary legitimacy of analysing historical depiction. European drawing of Oceanic boats, sometimes wildly inaccurate earlier, improved considerably on Dutch voyages in the seventeenth century (Purdue 2002). Later, as Smith (1979: 84; see also Joppien and Smith 1985: I: 1–8) argues, a "steady, relentless, and continuing rise of empirical naturalism", 1750–1890, got off to a fast start in "the visual arts programme" of Cook's three voyages, and "under his command the value of visual records was for the first time fully recognized and adequately provided for". Given Spöring's acknowledged skill and, implicit in the detailed drawing, his lengthy observation of the Moutohorā canoe, greater confidence can be reposed in the depiction than the description. The difference between what he shows and what Magra wrote more probably reflects Magra's uncertainty about the "odd construction" he saw, and perhaps Magra's youthfully careless ways (Cook described him as "good for nothing" (Beaglehole 1955: 323)), than a lapse in Spöring's practice. The sailing rig drawn by Spöring is a full and precise depiction of an ODS, the first recorded in Remote Oceania.

The shape and set of the sail in Spöring's drawing are duplicated by Parkinson (Salmond 2006: 265) in three background canoes of *New Zealanders Fishing* (Fig. 5) in Queen Charlotte Sound (Add.Ms.23920 f.44), and one in his drawing (Add.Ms.23920 f.41) of Motuarohia, Bay of Islands. In addition, there is a working sketch of a similar sail in Tolaga Bay by Spöring (Joppien and Smith 1985: I: 176). Secondary depictions of ODS occur in engravings, about 1772, by John Barralet (Joppien and Smith 1985: I: 198–201).

Figure 6. Moutohorā waka unua. Above: Straight spars and sail foot extending close to canoe gunwales. A spearman and another with rock stand in the larger hull. Below: Sheets being handled in each hull and two steersmen with small paddles. The British Library, London: Add. Ms.23920 f.48.

Parkinson's main depiction of a sail, in *A New Zealand War Canoe* (Add. Ms.23920 f.49), shows (Fig. 3) a waka unua and its crew—drawn out of proportion to each other—carrying what could be seen as a masted rig with spars joined at the base. However, the Tahitian mast style is improbable (Irwin and Flay 2015), and from the angle of view the spars would appear to converge whether they did or not. The stays are feasible for reaching with a masted sail but, in what appears to be Parkinson's preliminary sketch *New Zealand Canoe, the Crew Peaceable* (Add.Ms.23920 f.51), no "mast" or stays are shown, only the same crew holding sheets as in Add.Ms.23920 f.49 (Fig. 3). It is thought that the latter was drawn in March–April 1770 (Joppien and Smith 1985: I: 199), a period when the *Endeavour* was coasting around the southern South Island and then on passage to Australia. As no sailing canoes were encountered during that period—in fact none had been seen since January 1770—the drawing was not made from direct observation.

It seems to be one of many drawings in which Parkinson was experimenting with his material to create different scenarios. His double canoe is very like his single canoe without a sail (*New Zealand War Canoe: Bidding Defiance to the Ship* Add.Ms.23920 f.50); the tau ihu, small dog, man in a striped cloak, unclothed man in the bow and other features are in common. There are also similarities between Parkinson's double canoe and that drawn earlier by Spöring (two men handling sheets, one partly clothed, the other almost naked, and a small dog nearby). It seems that Parkinson was combining various sources on the *Endeavour* and that his waka unua does not represent a particular vessel. As evidence, it must be regarded as secondary, but his drawing Add.Ms.23920 f.44 (Fig. 5) confirms the existence of an ODS in Queen Charlotte Sound.

The Moutohorā and British Museum Sails. The Spöring drawing shows a tall, narrow and approximately triangular sail. It seems to be an example of laced-rush construction (probably *raupō* 'bulrush' (*Typha orientalis*)), with vertical sections of dried reed tied together in panels; this would produce a lighter sail than woven-flax matting, especially when wet. The sail is attached to straight spars angled forward, neither of which is stayed as a mast. Each spar has a sheet and forestay attached and if the latter are running stays, then the spars could be moved back and forward separately to trim the sail. The forward raking of both spars with the centre of effort of the sail above the bow of the small canoe is consistent with running before the wind, as was the case. Some further insight might be gained from the geometry of the sail.

The Spöring drawing does not show the foot of the sail, but almost. There is a panel seam behind the right shoulder of the man carrying the *tewhatewha* 'axe-shaped club', and beneath the horizontal left arm of the man sitting aft of him can be seen the starboard gunwale of the small hull (Fig. 6a) and,

above it, of the large hull (Fig. 6b). Therefore, the lowest seam and part of the panel beneath it (Fig. 6c) must be the basal panel because an additional panel would fall below the level of crossbeams and gunwales. Toward the stern are four crew handling the sheets, and there is one steersman with a small, handheld paddle in each hull (Fig. 6, below). Many of the 56 men and two dogs have crowded into the small hull, closest to the *Endeavour*.

To grasp the shape of the sail more precisely I measured it on a large photographic image (305 × 471 mm) provided by the British Library of the original drawing (which measures 267 × 416 mm). The curve of the sail head (Fig. 7, left) can be measured in two parts: (a) around the forward (leeward) face of the sail from where it is attached to the port spar to where it disappears at the left edge of the sail drawing (i.e., where the leeward sail face appears to meet the second seam below the head on the aft (windward) face of the sail), and from that point, (b) the length of the head on the aft face of the sail as it curves around to meet the starboard spar. The length of (a) being twice that of (b), I assumed that a 2:1 ratio of (a) to (b) pertains down the sail, so that if the length of (a) is measured along any of the 25 visible seams on the forward face of the sail then the length of (b) can be estimated, and therefore the total width of the sail at that seam. Digital measurement would be more precise, but the general shape is sufficiently accurate (Fig. 7, right). Measurements of the sail head and the second, fifth, eighth, sixteenth and twenty-fourth seams below the sail top were used to establish the width of the sail down its length. It can be seen that, from its foot, the lateral edges of the sail diverge at an acute angle (10°) from the centreline up to the fifth seam where the divergence increases toward the head. This represents curvature which was either built into the sail or caused by increased sagging as the sail broadens toward the head. In other words, with its straight spars, the sail is flatter toward the foot, and bellies out toward the head, working to some extent like a spinnaker.

In the original drawing and Figure 7 (right), it can be seen that if the sail spars remained straight they could not have joined at the approximate position of the sail foot, which must have been above the starboard gunwale of the small hull (Fig. 6a). The convergence angle of the sail sides below the fifth sail seam indicates that the spars would have to meet, if they did, well below the gunwales. If the length overall of the main hull is 18.3 m (Anderson 2008), then the maximum sail length is 9.2 m down to the small hull gunwale, and the spars would project an additional 2 m below that, meeting 1.25 m below the waterline; clearly impossible (Fig. 7, right). The proposition that one spar curved to meet the other below the foot of the sail is practically impossible in Spöring's drawing and there is no historical evidence to suggest that this spar form occurred in eighteenth-century New Zealand, or later for that matter. It is more probable that the spars remained

straight but terminated well before they could have been fixed together and were, therefore, attached separately to the canoe to form an ODS rig.

Attachment of the spars to the canoe is not shown, but probably each was lashed to a crossbeam or to a thwart in each hull. The two men in front of the sail—possibly adjusting running stays led back to the spars—stand in different hulls, and the port spar is behind two lines of men in the small hull and held by a man (about to throw a rock) in the large hull, indicating that

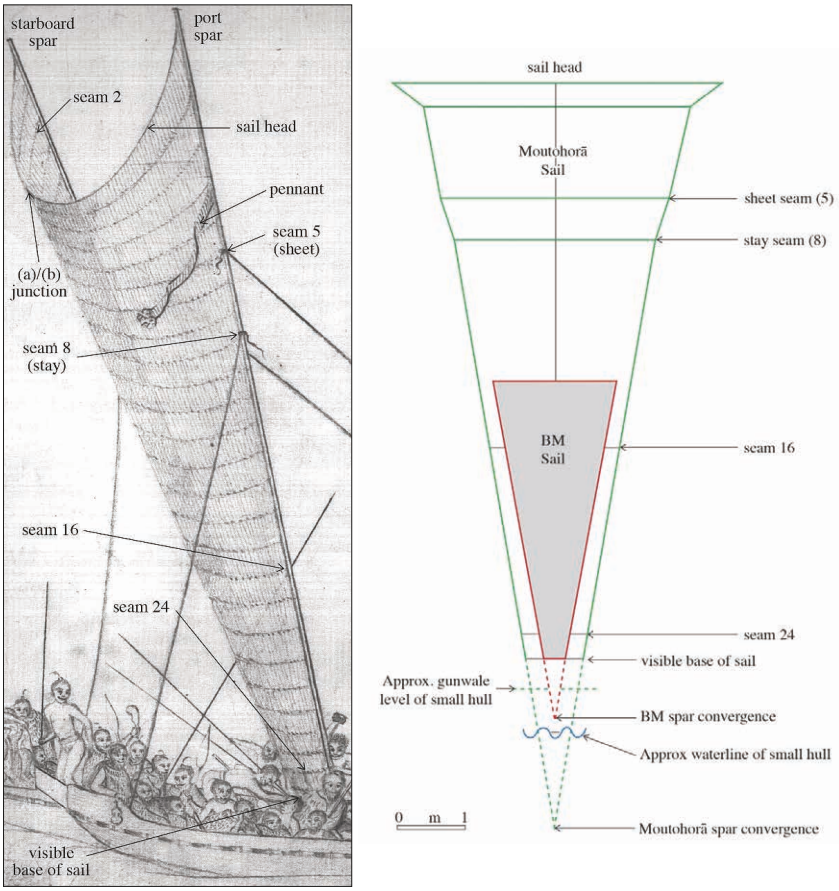

Figure 7. Left: Moutohorā sail by Herman D. Spöring. Right: Plan shape of the British Museum Māori sail upon plan shape of the Moutohorā sail.

it is attached near the starboard gunwale of the small hull. This Moutohorā rig, like early square sails and others used historically in sailing before the wind, is bilaterally symmetrical and in that respect differentiated from Tahitian and Hawaiian claw sails (Lewis 1972).

The Moutohorā sail can be compared with the Māori sail in the British Museum. The latter sail does not have impeccable provenance, but evidence indicates that it was collected in the eighteenth century and was probably in the Cook collection (Starzecka *et al*. 2010: 31). I measured and photographed the sail in 2009. My measurements (length of woven flax sail = 4.21 m; width at head = 1.91 m; width at foot = 0.34 m) are similar to those obtained by others, and the variations amongst us seem to depend on whether the measurements include the feathers at the head (Starzecka *et al*. 2010: 31 have the maximum length as 4.35 m) or the cord loops at the sides (file notes for NZ 147 in the British Museum have width at head as 1.98 m, and at foot as 0.38 m). The sail, excluding loops, feathers, cords and pennant, is shown in Figure 7 at the same scale as the Moutohorā sail, assuming the latter was 9.2 m long (above). The plan similarity is striking, suggesting that eighteenth-century Māori sails might have been constructed to a template from which they varied mainly by size and "cloth" (i.e., laced or bound rush, or woven flax construction). The loops for fixing the sail onto its spars recall those on the Melanesian double spritsail (above).

The Oceanic Spritsail in New Zealand

The Oceanic spritsail is the rig preferred in conventional opinion for colonisation voyaging to New Zealand (Best 1925: 251–55), and Irwin *et al*. (2017: 42) add a functional conjecture that "the Maori sail was generally set as an Oceanic spritsail in pre-European times ... because it was easier to manage and less prone to capsize." If that preference had existed, however, then the Oceanic spritsail should have been more obviously in use in the historical data ca. 1769–1825 (Table 2, Fig. 8). My reading of the evidence is that there was no Oceanic spritsail recorded in New Zealand until the 1820s.

Māori had shown a lively interest in foreign sailing technology since the eighteenth century, and similar observations continued into the 1820s, for example by the *Astrolabe* artist, de Sainson, that for Māori, "our masts and the handling of the sails aroused the keenest interest" (Wright 1950: 205). Māori travel on European ships, migration of Polynesians to New Zealand and early European settlement all added their influences. Thus, the adoption of European square sails, oars and steering oars on waka unua can be traced back to at least 1827, in Foveaux Strait (Starke 1986). In the same year, Pierre-Adolphe Lesson (2022: 420–21) on the *Astrolabe* described, enigmatically, a triangular sail at Tolaga Bay for which

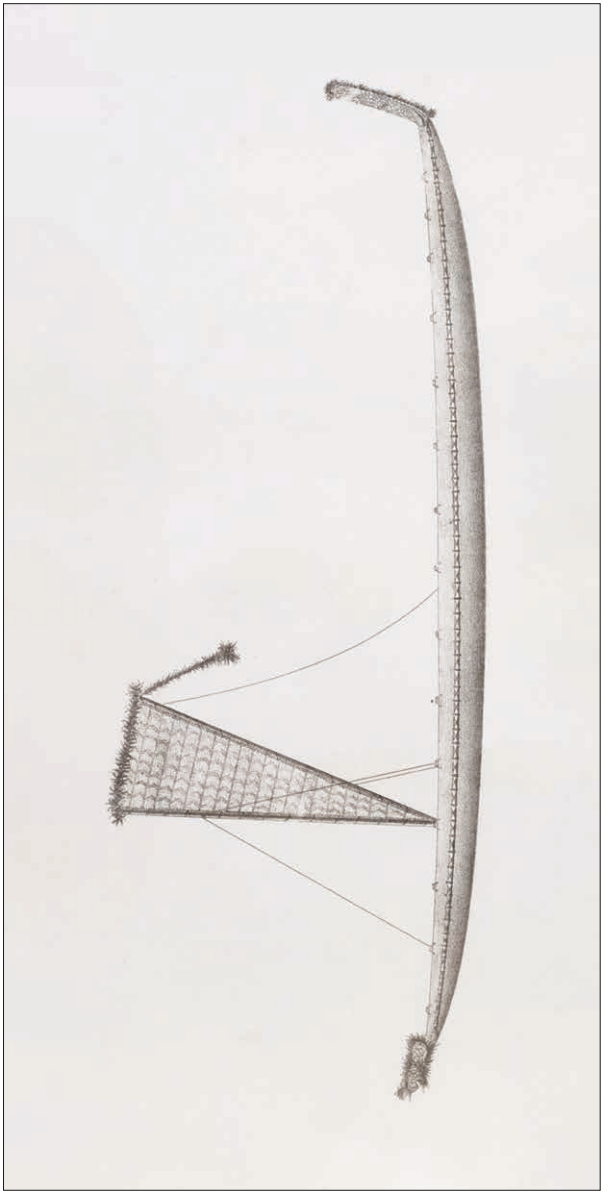

Figure 8. Māori canoe in 1827 with Oceanic spritsail, showing forestay, shrouds and single sheet (Pâris 1841).

> two masts are therefore necessary to hold it in the air. The masts or spars meet at the bottom of the canoe, where they are held vertically by shrouds, and they are lowered by making them pivot downward. It should hardly be possible to keep these sails up when the wind is strong.

Two contemporary drawings of single-hulled canoes at Tolaga Bay by François-Edmond Pâris (1841) show somewhat different rigs. Small sails of pointed triangular shape were fixed to masts with forestays and shrouds, but the booms are attached above the gunwales. These are clearly Oceanic spritsails. The lateral edges of the sails are of equal length, suggesting they were intended mainly for offwind use. Asymmetrical plan shapes are otherwise common in Oceanic spritsails used for reaching.

It is difficult to tell how widely the Oceanic spritsail was used in New Zealand, or for how long, because it was seldom identified specifically amongst a predominance of contemporary European rigs with stayed masts and trailing booms. Judging by the drawn evidence in particular, however, Māori sails were almost entirely in European styles and materials by the 1840s (e.g., Wakefield 1845: 233). Thus the Oceanic spritsail had only late and brief currency in New Zealand.

ARCHAEOLOGICAL AND EXPERIMENTAL EVIDENCE

Debate about interpreting historical evidence of Māori sails aside, scholars agree that resolution is most likely to be achieved through discovery of archaeological remains (preserved wood and fibre artefacts, rock art) that bear directly on technical points in contention, but the evidence needs to be evaluated critically. As a case in point, waterlogged wooden pieces from Huahine (French Polynesia) are often cited as evidence of an early voyaging canoe (Sinoto 2016), but renewed excavations (Anderson *et al*. 2019) question the stratigraphic position, integrity of association and interpretation of the material. Similarly, whether the Anaweka plank (Irwin *et al*. 2017; Johns *et al*. 2014) is from a single- or double-hulled canoe is uncertain, and reconstruction of the vessel with an Oceanic spritsail and a large, curved, West Polynesian steering oar is conjectural (Irwin and Flay 2015: 439; Johns *et al.* 2014: 14732); only small, straight-shafted steering paddles are attested historically and archaeologically (e.g., Irwin 2004: 97–98).

Except as fragments, no pre-European Māori sail, rigging or mast is known archaeologically. The existence of a single mast-step in a canoe hull could suggest a fixed mast (but note Best 1925: 258), although ODS spars could have been loosely stepped or free-standing. A possible mast-step was found in a hull of European age, but no formal mast-step, as noted by Barstow (1879), has been seen in the current range of remains. A hole through the

butt of a pre-European dugout end section (*haumi*) could have been used to step a mast (Irwin *et al*. 2017: 38, 41), but the primary purpose of the feature was doubtless to join the section to the main hull (Best 1925: 112–16).

The sailing performance of the ODS has not been measured precisely. During the "Lapita Voyage", Anderson and Boon (2011) constructed a small double-hulled canoe with a makeshift ODS. In a light breeze it worked from running to broad-reaching, but stalled at a beam reach. Irwin *et al*. (2017: 42) rigged a model of the British Museum Māori sail successively as an ODS and Oceanic spritsail and tested them in a wind tunnel. Forward of a broad reach both rigs produced similar driving force, but the ODS was harder to trim, and heavy wind loading high in the sail threatened the roll stability of the canoe. The ODS seems workably stable and effective in running, but otherwise has characteristics that compromise sailing ability and safety (Irwin *et al*. 2017). These data need to be refined by full-scale trials at sea.

CONCLUDING REMARKS

A century ago, traditionalist narratives of colonisation argued that Māori had ancient Eurasian origins, were preceded by non-agricultural Polynesians or non-Polynesian "Maruiwi", migrated as a "Great Fleet" and arrived in large, sophisticated voyaging canoes that were soon no longer constructed. All but the last of these propositions has been revised under scholarly critique since the mid-twentieth century (Anderson *et al*. 2014: 43–67; Sorrenson 1979). The persistence of the last is not easily explained but it lies, in part at least, in its connection to mid-twentieth-century ethnographic and historical views of Polynesian voyaging that were translated into an "a-historical social anthropology" (Salmond 1991: 432) which gave rise to the Polynesian voyaging movement. Participants in that were "not trying to replicate ancient seafaring exactly. They [were] selecting cultural elements from their past to symbolize ancient achievements and virtues and to affirm their own identity as heirs to a great seafaring tradition" (Finney 2006c: 388). Selection of canoe technology to create specialised sailing vessels with advanced Oceanic spritsails reinforced a conviction of early maritime sophistication and its implication that subsequent technological history had nowhere to go but into material decline.

The perspective is essentialist: ethnicity and advanced seafaring are taken as reciprocally constitutive of ancestral East Polynesian identity, technology and performance that declined with migration dispersal. Recent suggestions that "the ancestors of Polynesians invented blue water sailing" (Salmond 2021: 278) or that early Polynesian seafarers achieved technological superiority through independent invention (e.g., by Thomas 2021: 167) articulate related assumptions of Polynesian exceptionalism. If, however, as Plubins (2021: 440) points out, "Polynesian sailing skills and achievements simply overshadowed everybody else's ... [then given] ...

the material simplicity of their society[,] superb sailing technologies were theoretically available for discovery to most world peoples, and yet never materialized except in this community." Exceptionalism, at the very least, is in want of demonstration.

Several conclusions of the Māori case outlined here indicate that substantial reconsideration of such ideas is in order. First, it is apparent that the proposition of initial, sophisticated sailing technology declining into its historical manifestations issues from no persuasive body of evidence. Nor was early technical advancement necessary for colonising dispersal. East Polynesian voyaging canoes did not need to be large, specialised sailing vessels with high freeboard. Eighteenth-century Tahitians preferred small double canoes of low freeboard around 10–11 m long[7] for offshore seafaring (Banks in Beaglehole 1962: I: 366), outrigger canoes were used in the Tuamotus and even seagoing sailing rafts are in Marquesan voyaging traditions and were recorded in Mangareva, albeit with a former tradition of canoes (Haddon and Hornell 1975: I: 49, 93).

Second, Māori canoe technology exhibits no overall trajectory of decline, only of change, regarded as adaptive, that is inferred from fragmentary archaeological data and regional patterns of variation (Anderson *et al*. 2014: 28; Irwin *et al*. 2017). At European contact waka unua were scarce to the north but common to the south where their multi-hull stability, also of outriggers, was needed in the relatively demanding sailing conditions and long passages involved in the seasonal rounds of low-density foraging populations. Conversely, waka taua were common to the north and scarce to the south, probably representing in New Zealand, as worldwide (e.g., Anderson 2010: 7–8), the endemic expeditionary warfare associated with clan rivalries in higher-density, complex foraging and agricultural populations. Waka unua, outrigger and single-hulled canoes can be assumed as continuously present since Māori arrival. There is no evidence of lost or degenerated technology, but rather of functional specialisation in single-hulled *waka tīwai* 'river canoes', waka tētē and waka taua, and of innovation in reed boats (*mōkihi*) and the Moriori *waka korari*, based on a double-hulled frame.

Third, the idea that waka unua were generally constructed expediently from whichever single canoes were at hand has no historical basis other than in its frequent repetition. The possibility that it happened from time to time cannot be rejected, and distinguishing expedient from pre-planned construction is difficult on the relatively slim data available. Nevertheless, the unusual characteristics of the smaller hull relative to those on other types of single canoe suggest a class of canoe constructed similarly throughout New Zealand. If so, the Māori case conforms with circumstances elsewhere in East Polynesia where each archipelago had its particular style of double-hulled canoe (two styles in Tahiti).

Fourth, historical analysis of written and drawn evidence does not support the conventional conclusion that the Māori sail was, or was derived from, an Oceanic spritsail. Historical observations up to the 1820s were describing a different sail, found elsewhere in Oceania but unrecorded previously in East Polynesia, which is clearly recognisable as an ODS. Its dissimilarities with an Oceanic spritsail are multiple: until the 1820s the Māori sail was seen with two spars of the same length and diameter, no mast was distinguished, the spars were not joined, there was a forestay and sheet to each spar but no shrouds or other stays, the sail was set athwart the hull and it was deployed off the wind. The ODS was used on waka unua, waka taua and probably other canoes as well. There were numerous situations between 1769 and the 1820s when an Oceanic spritsail could have been observed on Māori canoes—and for its performance might well have been preferred—yet no explicit observation exists. That the earliest unequivocal record is in 1827, by which time other foreign sail types occurred on Māori canoes, suggests that it was recently adopted.

Last, the pre-European existence in New Zealand of an ODS unaffected by lateen rigs raises the distinct possibility that it was the original East Polynesian migration sail and, therefore, probably of Remote Oceanic colonisation generally. Its comparative limitations in performance would have made migration voyaging under sail alone more difficult than is conventionally assumed, with implications for thinking about prehistoric long-distance interaction (Anderson 2000, 2018b). East Polynesian double canoes historically, however, had low freeboard that enabled a combination of paddle propulsion with sailing. Canoes of such moderate design were quite suitable for long passages if their crew had the skills and determination demonstrated historically by Polynesian seafarers. Passage-making by combined sail and paddle (or oar), which enlisted the flexibility and safety of planned redundancy in propulsion, was a strategy common in seafaring history worldwide, from the North Atlantic to the Indian Ocean and across the Pacific.

In summary, it is contended that the technological history of Māori seafaring was not one of decline, but rather of continuity, innovation and regional variation. In particular, historical waka unua with the ODS rig represented voyaging technology which had been retained since the migration era, unaffected by later technological changes in tropical East Polynesia. If that hypothesis is valid, then multiple migrations from "Hawaiki" and similarly early migration from New Zealand to the Chatham, Auckland, Kermadec and Norfolk islands (and contact with Australia) indicate the exceptional Oceanic voyaging capability of the waka unua and ODS in the hands of accomplished seamen.

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NOTES

1. Finney's first experimental canoe, *Nalehia*, was built to an historical plan.
2. Pâris (in Rieth 2008) attributed this to adaptational pressure.
3. "Canoes" in these observations referred to vessels inclusive of superstructures, spars, rigging, etc., not simply to hull form (see Best 1925: 18).
4. Carving conventions in tau ihu seem to have followed general forms for waka taua and waka tētē for the main hulls of larger and smaller waka unua respectively, but whether there were consistent differences in waka unua requires specific research.
5. Polack (see also Shortland 1856: 44) thought single canoes were sailed along troughs to reduce wind exposure, but as they would be exposed as each swell passed beneath, the greater concern might have been for the integrity of compound dugout keels caught across wave peaks.
6. The Magra narrative varies from journal entries by Cook and Banks. They say the canoe was with them for about an hour, Magra says "several hours". They say it broke off contact upon a musket shot. Magra says that occurred only when a cannon was aimed, but misfired.
7. In 2009, I crewed on an 11 m double canoe that took a stormy passage from Makira to Santa Cruz in her stride as part of a voyage from the Philippines.

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MAPPING ANCIENT ARCHITECTURE VIA UNPILOTED AERIAL VEHICLE–ACQUIRED LIDAR: A CASE STUDY OF HŌLUALOA ROYAL CENTRE, KONA DISTRICT, HAWAIʻI ISLAND

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ABSTRACT: At present there is no systematic record of the size, form or density of architecture at Hawaiian royal centres. We report on the results of a UAV LiDAR survey of one of the best-preserved examples of a royal centre in the archipelago: Hōlualoa Royal Centre, Kona District, Hawaiʻi Island. The resolution of our data (0.3–0.1 m) is far superior to previous airborne LiDAR surveys (1.0 m); however, several factors, including thick understory vegetation, made resolving archaeological targets challenging. We nonetheless were able measure the volume of building material of the largest features, which allows us to compare structures in this royal centre with other monuments in the region. This study highlights the advantages, and limitations, of UAV LiDAR as well as the need for more high-quality quantitative data on architecture at royal centres.

Keywords: archaeology, ancient architecture, royal centres, UAV LiDAR, Hawaiian Islands

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At the time of initial European contact, in AD 1778–1779, "royal centres" were hubs of social, political and religious life in the four independent kingdoms of the Hawaiian Islands (Kauaʻi, Oʻahu, Maui and Hawaiʻi) (Fig. 1). These centres are described by Kirch (2018: 383) as "clusters of temples, houses for the king, his wives, and retainers, dwelling compounds of other high-ranking chiefs, storehouses, canoe sheds, and other specialized facilities". While the

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McCoy, Mark D., Jesse Casana, Austin Chad Hill, Elise Jakoby Laugier and Thegn N. Ladefoged, 2022. Mapping ancient architecture via unpiloted aerial vehicle–acquired LiDAR: A case study of Hōlualoa Royal Centre, Kona District, Hawaiʻi Island. *Journal of the Polynesian Society*, 2022, 131 (1): 71–92. | https://doi.org/10.15286/jps.131.1.71-92

royal court and retainers had no fixed location, and would move with the ruling family, centres were located within heavily populated areas, and some had resident priests who lived in special precincts. They were the location of large ceremonies, such as during the makahiki 'harvest celebration' season, and were also used as places to assemble military forces ahead of a major campaign. In the nineteenth century, the archipelago was consolidated under a single kingdom (AD 1810), traditional religious practices were abolished by royal decree (AD 1819) and a new palace was dedicated on O'ahu ('Iolani Palace, AD 1882). Naturally, the role of royal centres changed over that time and many have been transformed by modern development and restoration (on restoration and care for sites of religious ritual see Kawelu and Pakele 2014).

Nearly everything we know about royal centres—including basic information like their location, function and history—comes from oral histories written down in the nineteenth century (Ii 1959; Kamakau 1961; Malo 1951) or from early European accounts (Beaglehole 1967; Vancouver 1798). Archaeology began to contribute to our understanding of royal centres beginning with maps made by early surveyors Henry Kekahuna (Kawelu 2015: 96; Tengan and Roy 2014) and John Stokes (Flexner *et al.* 2017). Their schematic maps, while only focused on a handful of centres, were often annotated with traditional knowledge specific to that location. Each royal centre had a unique layout with a dense and complex combination of different types of architecture. These include some of the largest stone platforms ever constructed for temples (*heiau*) and massive free-standing walls, also called Great Walls, that enclosed areas reserved for special purposes. Other smaller stone walls were commonly used to enclose spaces, and early maps also show small features that may have served as building foundations. In some cases, features had a specialised function specified in tradition, such as bleachers for viewing sports or rituals. Some centres had artificial ponds and tracks created for *hōlua*, the sledding game, including the largest track ever created (see McCoy 2018 for more details on the layout of royal centres).

Except for early excavations (e.g., Ladd 1969a, 1969b), archaeological research focused on royal centres has been surprisingly rare (Kirch *et al.* 2009; Kolb 1991; McCoy *et al.* 2021; Rieth *et al.* 2013). Much of the focus of sustained academic research in the Hawaiian Islands has focused on how changes in the economy, society and religion affected people living far from royal centres where these changes are thought to have been easier to unpack from the archaeological record (e.g., Kirch 2014; Ladefoged *et al.* 2020). Consequently, they are often sidelined in broader discussions of ancient Hawaiian society. For example, Bayman *et al.* (2021: 48) include "royal residences and palaces" in a list of things that they see as "equivocal or altogether lacking in the Hawaiian archaeological record". While other claims they made have been challenged (Hommon 2021; Kirch 2021; McCoy and Ladefoged 2021), this point has not been specifically disputed.

Jennings and Earle (2016: 478) see royal centres as "modest in comparison to central places" elsewhere in the world when it comes to "spatial scale and monumental construction" (see also Bayman and Dye 2013: 97). To support this claim, they reference the area of two royal centres (in hectares) but provide no quantitative data on monuments. Again, the absence of supporting quantitative evidence was largely undisputed. Beginning in the 1990s, the volume of building material (m^3) was used by Kolb (1991) to estimate the amount of labour put into Hawaiian monumental architecture. For example, for Pihana Heiau (Kolb 1991, Table 5.5), after considering transport and construction costs, a single labour day would have been required for every 4.5 m^3 of building material. However, concerns about the conversion of building material to labour days (Mulrooney *et al.* 2005: 26) and about calculating the volume of building material at certain sites and construction periods (Kirch 2010: 233) has had the unintended consequence of discouraging further quantitative study of architecture.

We believe that at present almost all archaeological generalisations about royal centres are disputable, and unwarranted (i.e., without empirical support), in the absence of a systematic record of the size, density and form of architecture at royal centres. To begin to create such a database we turned to remote sensing. Remote sensing, and especially via airborne LiDAR, has been central to the geospatial revolution in archaeology (McCoy 2020a, 2021) since technical advances now give us maps of ancient architecture at a resolution that mimics traditional field survey in challenging environments like tropical forests (e.g., Chase *et al.* 2012). We have argued that unpiloted aerial vehicle (UAV)–acquired LiDAR is specifically valuable in that it can allow archaeologists to rapidly collect data at a consistent resolution on the order of hectares (Casana *et al.* 2021; McCoy *et al.* 2021). While we are not alone in our enthusiasm for UAV LiDAR in archaeology (Barbour *et al.* 2019; Opitz and Herrmann 2018; Poirier *et al.* 2020; Risbøl and Gustavsen 2018; VanValkenburgh *et al.* 2020), the relative novelty of the technology means for most regions we lack systematic studies that deal with the challenges of mapping ancient architecture via LiDAR. As more archaeologists turn to LiDAR to augment traditional field survey, or in some cases as a replacement, it is important to know both the technique's strengths and weaknesses.

For this study we focused on a royal centre located in Hōlualoa (Kona District, Hawai'i Island) (Fig. 2). It was one the first places listed on the National Register of Historic Places in the Hawaiian Islands (Yent 2003), having been given legal protection as an "archaeological district" (Hōlualoa 4 Archaeological District, State Site No. 50-10-37-23661). It includes two complexes, one that traditions tell us was used for religious rituals, celebrations and sport (Keolonāhihi Complex) and the other a rare example of royal residence, or what elsewhere would be designated as a palace (Flannery 1998), built by Queen Keākealaniwahine. In these complexes,

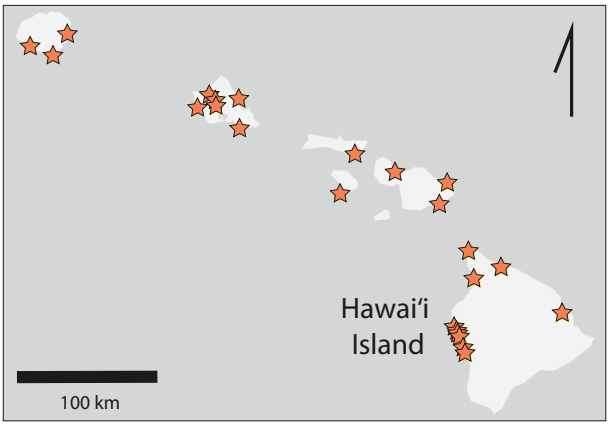


Figure 1. Locations of royal centres. The Hawaiian Islands has two dozen locations that were designed as royal centres.

and the area immediately around them, more than 50 "sites" have been reported on field surveys constituting a landscape that includes six temples, 26 household compounds, agriculture fields and historic-era stone boundary walls. However, this research has been sporadic, stretched over a century of surveys (see review in Yent 2003), and excavations have been extremely rare, with most structures lacking basic chronometric information. And so, while it is hard to imagine another location in the Hawaiian Islands with the same range of forms and functions of architecture, at present we lack a coherent picture of the archaeological landscape.

We chose to focus on the royal centre at Hōlualoa because we suspect it may be among the best preserved of known royal centres. We also saw it as a strong candidate for low-altitude UAV-acquired LiDAR survey given that even though there is thick vegetation across the study area it is possible to resolve some features on previous high-altitude, fixed-wing, airborne LiDAR. Unfortunately, our results, when viewed from the perspective of LiDAR as providing an alternative to pedestrian survey, were disappointing. Due to thick vegetation only the largest of the many remnants of architecture were detectable (Fig. 3). We see our work as contributing to "an emerging arena of research [that] is beginning to employ remote sensing as an independent and complementary means of interrogating the archaeological record and, in so doing, is providing insights into the human past that could not be achieved through conventional fieldwork" (Casana 2021: 168). From this perspective, our results succeeded in that they allowed us to compare

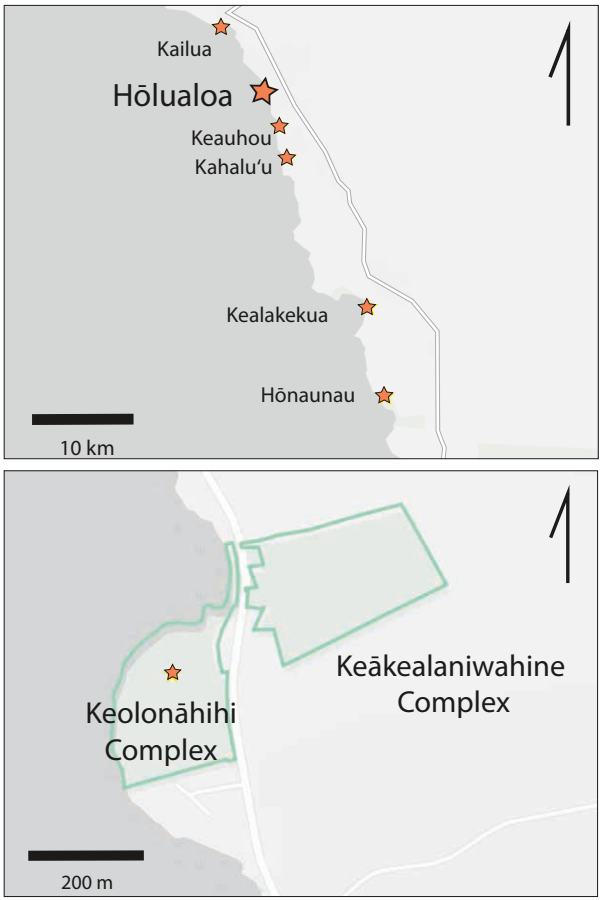


Figure 2. Location of Hōlualoa Royal Centre, Kona District, Hawai'i Island. Within the Kona District there are six royal centres within a 30 km stretch of coastline (top). Our study area focused on two complexes within the Hōlualoa Royal Centre (bottom).

architecture between two royal centres (Hōlualoa and another Kona centre at Kealakekua), specifically in terms of the volume of building material used (m^3) (McCoy *et al.* 2021). These limited results go a small way toward creating a systematic record of the size, density and form of architecture at royal centres, but leave a great deal yet to be done.

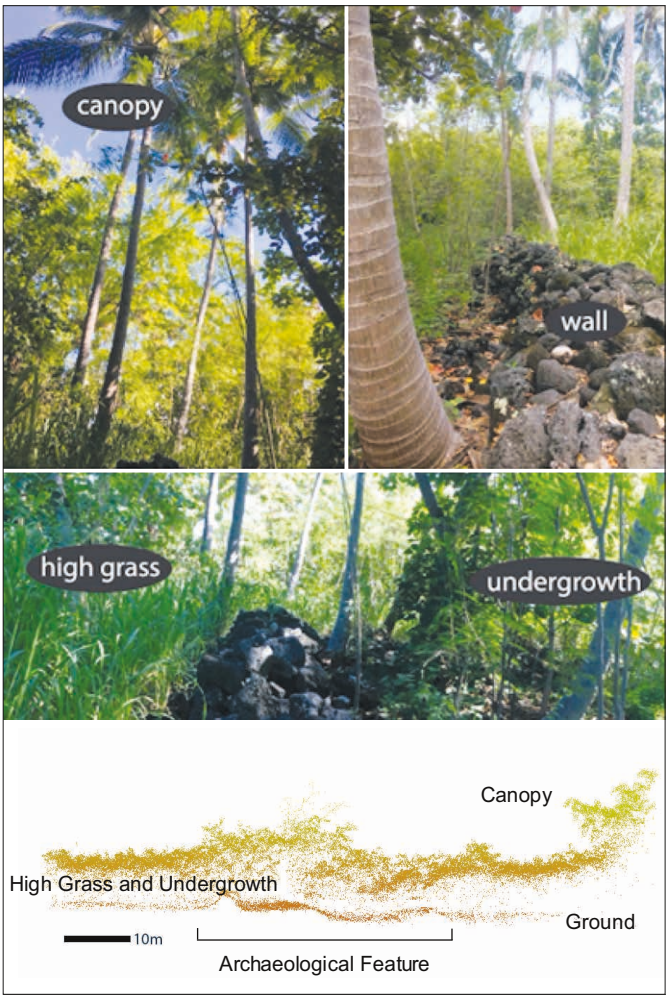


Figure 3. Examples of vegetation in the Hōlualoa Royal Centre. Our UAV LiDAR survey faced several challenges including high palm canopy (upper left), numerous low stone walls and platforms (upper right) and a thick undergrowth of brush and high grass (lower). We also show a representative cross-section profile of a raw point cloud from LiDAR collected via UAV. The point cloud includes the top of the canopy (first return, top of image) and ground (last return, bottom of image), as well as points representing vegetation in between the canopy and the ground.

STUDY AREA

Culture History of the Hawaiian Islands

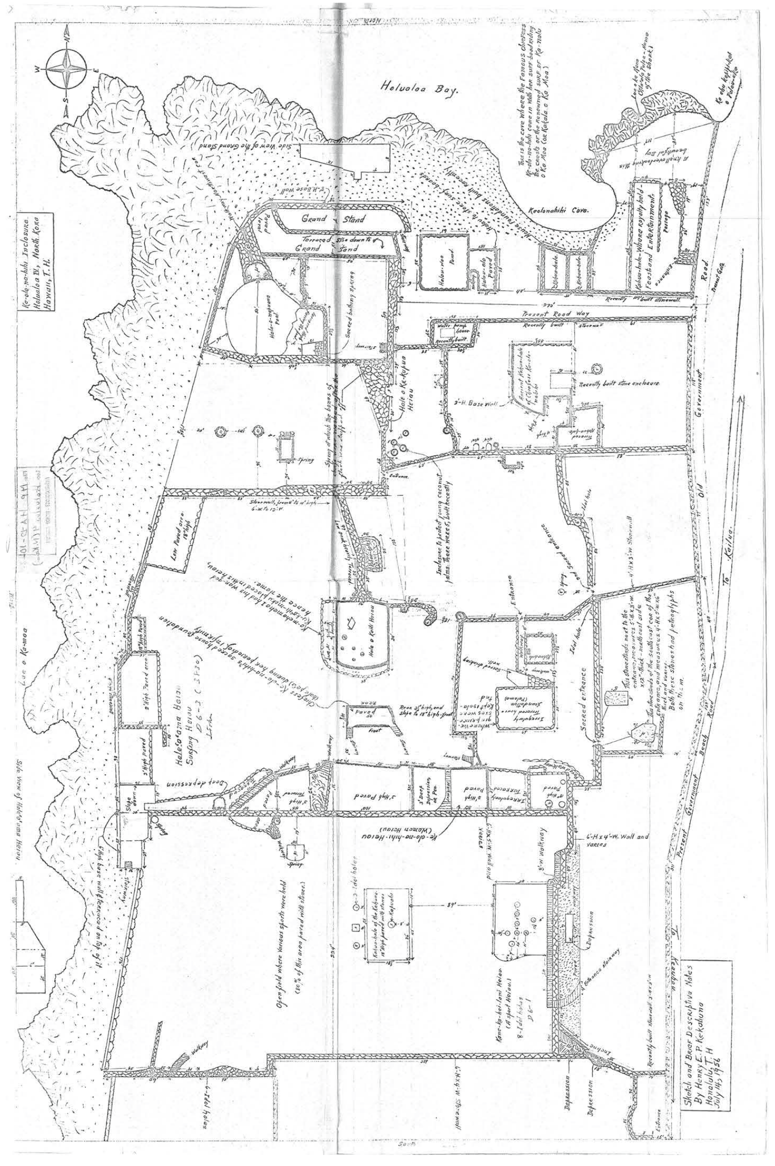
The Hawaiian Islands were first settled from Central Eastern Polynesia, likely the Marquesas Islands, around AD 1000, with subsequent voyages from the Society Islands described in oral histories in the following centuries (Athens *et al.* 2014; Kirch 2011). Later voyages are closely associated with the historical figure of Pa‘ao, a Tahitian priest who introduced a number of traditions around AD 1200–1400. Initially classified as a “chiefdom” (Cordy 1981; Kirch 1984, 1985; Sahlins 1958; Service 1962), we now believe that there was a fundamental shift around AD 1550–1700 to an archaic state society (Hommon 2013; Kirch 2010). The material record of this change can be seen in the increase in population, the increase in scale and intensification of agricultural production, the construction of monumental architecture (especially heiau) and the establishment of royal centres.

The function of the royal centre within the broader political, economic, religious and social spheres is something that remains poorly understood (McCoy 2018). Oral histories, combined with the presence of a variety of monumental structures, make it clear that royal centres were used for religious ceremonies and major gatherings (Ii 1959; Kamakau 1961; Malo 1951). The court of island kingdoms, unlike other pre-modern states, was mobile (Hommon 2020). There were times when the court would settle within royal centres, but it was always temporary. There were, nonetheless, full-time residents in and around royal centres, including some precincts set aside for priests and others for the local community.

In part due to a lack of excavations and a revision in the chronometric techniques we use (Rieth and Athens 2013), there are no direct dates on the construction or use of royal centres except for Kealakekua Royal Centre in the Kona District of Hawai‘i Island. New radiocarbon dates suggest the Great Wall, a massive free-standing stone wall that enclosed the religious precinct of Kealakekua Royal Centre, was likely built around AD 1640 (McCoy *et al.* 2021). This is consistent with oral histories that describe the shift of the island’s capital to Kona initially around AD 1600 by King ‘Umi-a-Līloa and carried on by his successors. By the time of initial European contact in AD 1778–1779 there were six royal centres, including one at Hōlualoa, spread across a 30 km section of the island’s west coast.

Previous Research

The oral history of Hōlualoa provides us with a broad framework for the development of the royal centre. The coastal complex is associated with Keolonāhihi, a chiefess and daughter of Tahitian voyaging priest Pa‘ao (Pinehaka 1974); therefore it is likely this was an important location centuries before the island’s capital was moved by King ‘Umi-a-Līloa in AD 1600.


Heluoloa Bay.
Grand Stand
Keolonahihi Cove.
Present Road Way
Old Government Road
To Kailua

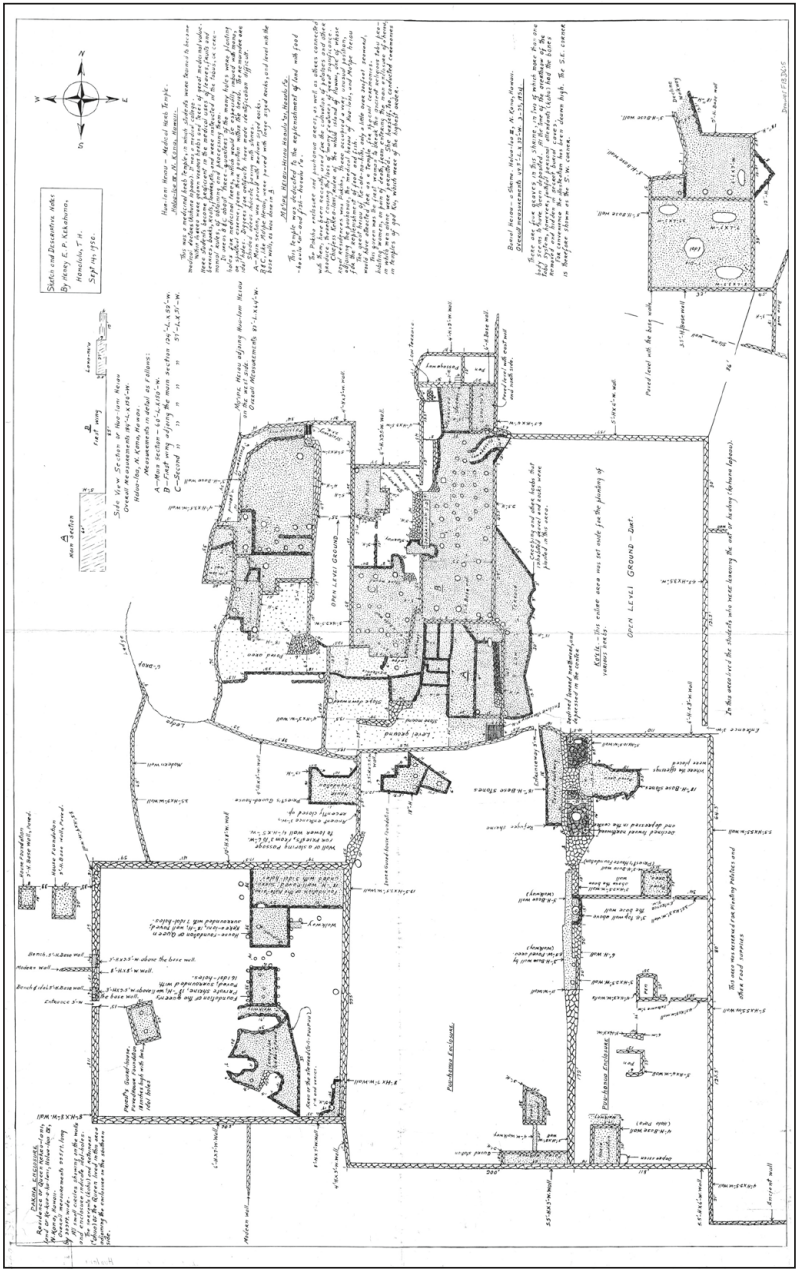


Figure 4. Detailed maps of Hōlualoa Royal Centre. Sources: Kekahuna (1950, 1956).

Queen Keākealaniwahine, a descendant of ʻUmi-a-Līloa through her mother, Queen Keakamāhana, is credited with building the inland complex.

Of the early maps of the royal centre the most detailed were those created by Kekahuna (1950, 1956) (Fig. 4). The layout of structures is shown schematically with annotations as to traditional uses of different features. Features include walls of varying sizes and platforms as well as a number of other forms, such as depressions where wooden carved statues (*ki ʻi*) once stood. These maps formed the basis of the first overall map created when Hōlualoa was nominated for and accepted onto the US National Register of Historic Places (Fig. 5). Unlike earlier maps, Figure 5 shows an attempt to give an overview of both major complexes and modern and historic-era features, including roads and stone boundary walls created to control livestock, as well as neighbouring sites and locations where features had been disturbed. It also includes information from cultural resource management archaeology surveys in the area (see Yent 2003).

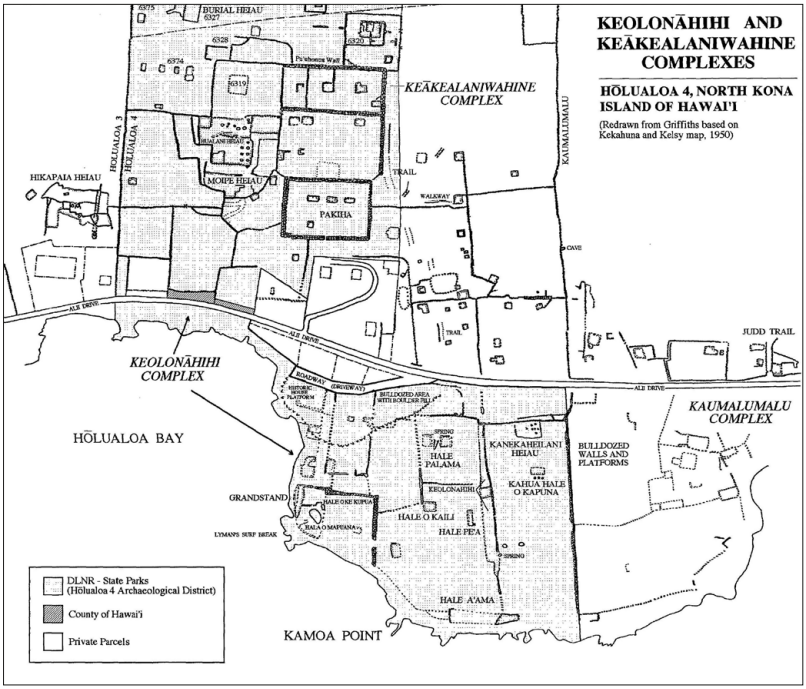


Figure 5. National Register map, Hōlualoa Royal Centre. Source: Yent (2003).

Figure 6. Sites currently recorded in the Hawai‘i Cultural Resource Information System (HICRIS) for Hōlualoa Royal Centre. Features are recorded as polygons, lines and points.

One of the challenges in recording field observations here, and elsewhere in Hawai‘i, is the inconsistent use of complex, site and feature identification systems (McCoy 2017, 2020b). The first surveys adopted local place and site names (i.e., Kanekaheilani Heiau). By the 1970s, the State of Hawaii's Historic Preservation Division began compiling site records, and last year launched a GIS database called HICRIS (Hawai‘i Cultural Resource Information System) (https://shpd.hawaii.gov/hicris/). At present, only a third of the total site records have been migrated into HICRIS (Fig. 6). We have used the current database to compile a list of previously recorded sites to use in our remote sensing study.

MATERIAL AND METHODS

UAV Visible Light

In 2019, our team flew a visible-light survey over Hōlualoa (Fig. 7). We used a DJI Phantom 4 Pro, flown at 40 m above ground level, with flight planning and autonomous mission control executed using the third-party

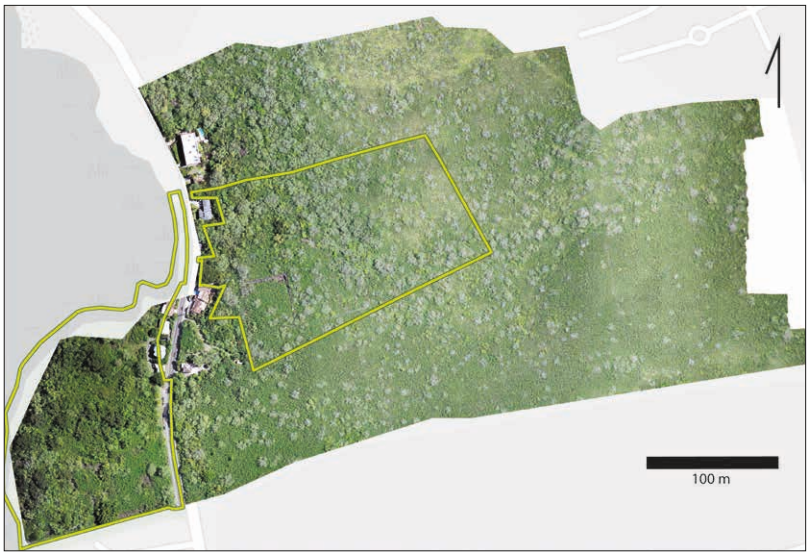


Figure 7. UAV survey: visible light, Hōlualoa Royal Centre.

Pix4Dcapture application. Aerial images collected with at least 80 percent overlap in all directions were processed using Agisoft Metashape to produce a digital surface model and orthoimage of the site with a ground sampling distance (resolution) of 4 cm^2. The survey covered an area of 0.4 km^2 georeferenced using ground control points to UTM NAD 1983, Zone 4N. While dense vegetation makes it unlikely that visible-light surveys will reveal any archaeological features, these data provide a good perspective on the nature and density of vegetative cover.

UAV LiDAR

At the same time we conducted a UAV LiDAR survey over Hōlualoa, using a Geodetics Geo-MMS LiDAR system deployed on a DJI M600 drone (Fig. 8). The Geo-MMS system utilises a Velodyne VLP-16 sensor integrated with a proprietary IMU and two dual-frequency GNSS receivers. Three flights were undertaken using a methodology described by Casana *et al.* (2021), at an altitude of 40 m above ground level with a transect spacing of 50 m. Two flights were completed over the western half of the study area to try to ensure significant penetration of the canopy, and one flight over the eastern area producing an average of 330 points per m^2. Flight planning and autonomous

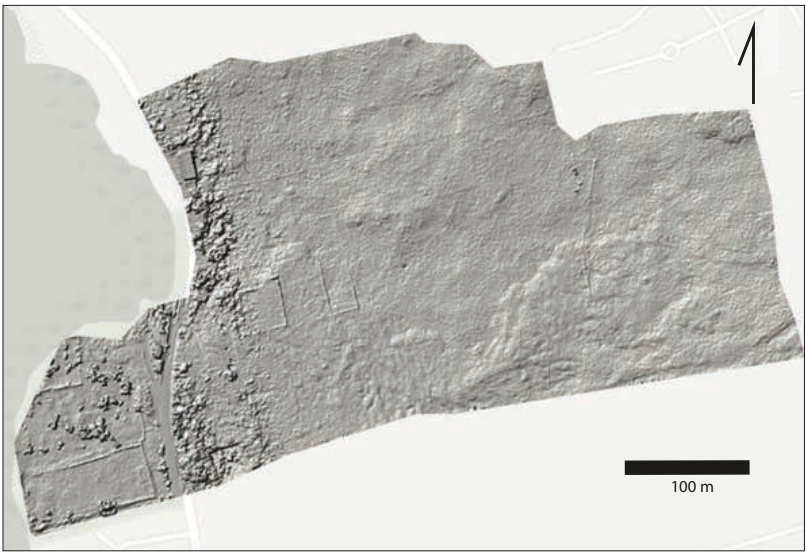


Figure 8. UAV survey: LiDAR, Hōlualoa Royal Centre.

mission control was accomplished with UgCS Pro. Raw LiDAR data were then processed to integrate post-processed kinematic GNSS data and generate a georeferenced point cloud output (134 million points) using the Geodetics LidarTool software. The resulting point cloud was further processed to generate a bare-earth digital terrain model (DTM) through a combination of SAGA GIS and LASTools. Hillshades were generated from the DTM using SAGA GIS to best visualise the surface for analysis. The resulting point-cloud data covered 0.4 km^2 and 30 ground points per m^2. Elevation above sea level was corrected using bare-earth airborne LiDAR flown by FEMA in 2006 (UTM NAD 1983, Zone 4N; vertical datum: NAVD 88, vertical units: metres).

RESULTS

The analysis of the LiDAR data reported here improves significantly on the resolution of existing free and accessible LiDAR data (Fig. 9). Data sets recorded by NOAA in 2006 and 2013 are available for part but not all of the study area. Derived bare-earth DTM have relatively low resolution for archaeological site mapping, and most obvious features revealed by the resulting DEMs (digital elevation models) are only reported at 1 m grid

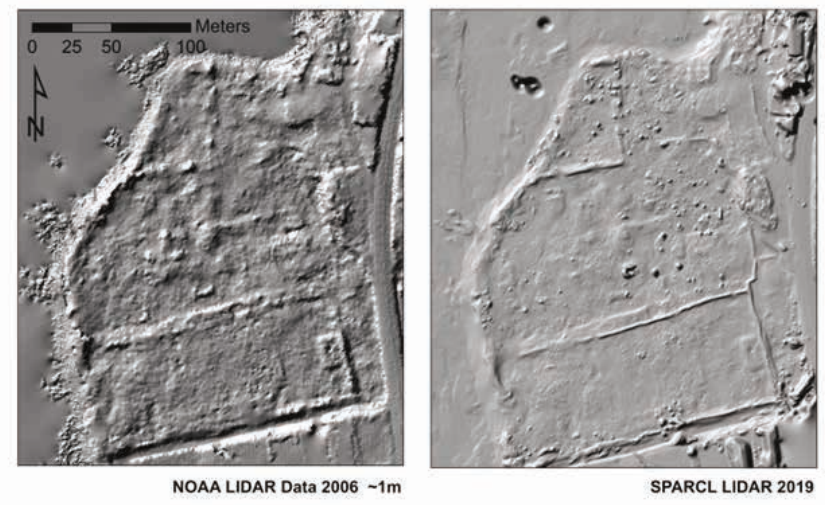


Figure 9. Comparing previous airborne LiDAR with UAV survey LiDAR, Hōlualoa Royal Centre.

resolution (OCM Partners 2021: 2013 USACE NCMP Topobathy Lidar: Big Island (HI), https://www.fisheries.noaa.gov/inport/item/49745). The data set reported here, in contrast, provides significantly more ground points per metre, to produce a finer DEM (10–30 cm resolution) over the entire site.

However, even though this data is better quality than what was otherwise available, most of the previously recorded architectural features could not be resolved in the LiDAR data, likely due to the dense vegetation that covers many of them. Not only was there significant tree cover, which blocks many points from penetrating to the ground, there was also significant vegetation near the ground and considerable dead vegetation build-up on the ground and features, which are all difficult to filter from points that are actually ground. Combined with the inherent noise of "lower-cost" LiDAR sensors like the Velodyne VLP-16, it proved difficult to resolve subtle archaeological features. In fact, even the large enclosure walls can only be mapped incompletely.

We nonetheless selected 16 sections of walls that can be resolved in the LiDAR data to examine the volume of building material using the image mensuration technique (ArcGIS Pro 2.4.1) (Fig. 10, Table 1). There are four categories of walls visible on UAV LiDAR: very large (7–5 m^3 per linear metre, LM), large (5–2 m^3 per LM), medium (2–1 m^3 per LM) and small (less than 1 m^3 per LM) walls (Table 1).

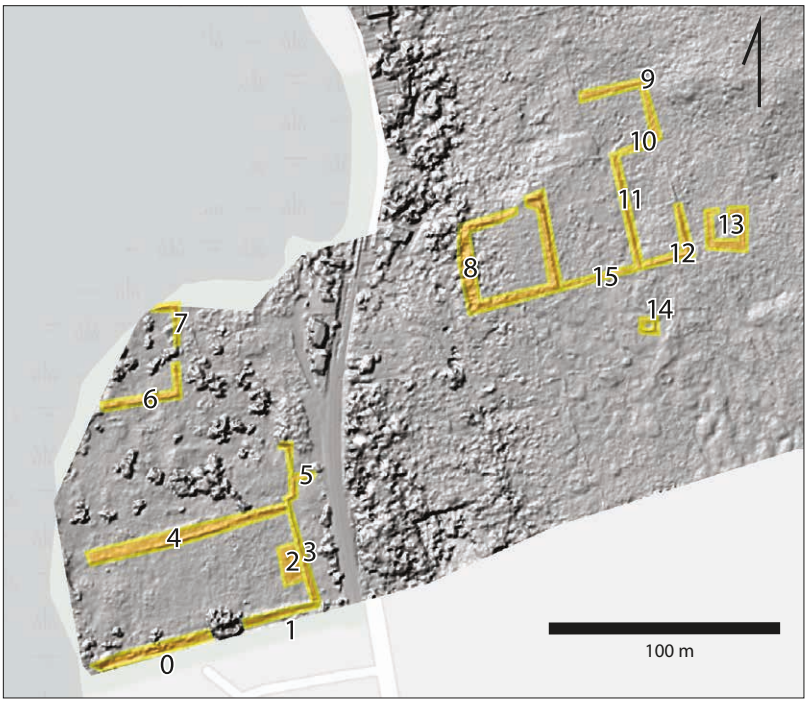


Figure 10. Polygons represent large architecture remotely mapped in Hōlualoa Royal Centre. Keolonāhihi Heiau (4 on the map) was found to account for a large proportion of the total volume of the coastal complex. The Pakiha Enclosure (8 on the map) accounts for a large proportion of the building volume measured in the inland complex. See Table 1 for more information on the sizes of features.

Our previous study of UAV-acquired LiDAR from the royal centre at Kealakekua found this technique provided good estimates of building material volume. However, for the Keolonāhihi Complex, maps from the 1950s note a great deal of variability in height and width of walls, problematising a comparison between field survey results and LiDAR-derived DTM data. The Keākealaniwahine Complex, however, shows a good match for the Pakiha Enclosure, specifically the extremely large northeast corner, which Kekahuna reports at 13.6 m^3 per LM and for which the UAV LiDAR gives a value of 12 m^3 per LM. At another structure identified as a *pu'uhonua* 'refuge', Kekahuna gives the volume as 2.55 m^3 per LM, and

UAV LiDAR returned a result of 2.99 m^3 per LM. These data suggest that our volume estimates at this site are reliable.

The combined total volume measured at the royal centre is 4,653 m^3. The largest single structure by total volume measured on this survey is a massive wall that includes Keolonāhihi Heiau at 796 m^3, which accounts for 37 percent of the total volume of walls measured at the Keolonāhihi Complex (2,156 m^3). At Keākealaniwahine Complex, the Pakiha Enclosure, at 1,650 m^3, accounts for 66 percent of the total volume in that complex (2,497 m^3).

Table 1. Estimated volume of each mapped large architecture.

Fe. ID.	Cut m^3	Fill m^3	Area m^2	Total vol. m^3	Linear m (LM)	Vol. per LM
0	257	215	635	472	86	5.49
1	58	23	288	81	56	1.45
2	117	13	394	130	28	4.64
3	108	13	304	121	70	1.73
4	726	70	1,407	796	149	5.34
5	55	113	314	168	48	3.50
6	217	103	512	320	83	3.86
7	18	50	197	68	46	1.48
8	685	967	1,932	1,652	240	6.88
9	50	94	600	144	92	1.57
10	3	11	107	14	24	0.58
11	179	95	540	274	86	3.19
12	105	104	431	209	70	2.99
13	37	84	191	121	84	1.44
14	7	15	119	22	38	0.58
15	22	39	245	61	55	1.11

CONCLUDING REMARKS

We are, in our view, still a long way from having the type of systematic quantitative data necessary to warrant the use of monumental scaled construction at Hawaiian royal centres in cross-cultural comparisons (e.g., Jennings and Earle 2016). This is just one of many challenges for archaeology to contribute to our understanding of the Hawaiian past (see also McCoy *et al.*, in press). Our analysis enables us to now compare broadly the amount of building material used at different locations within royal centres or between different centres in the Hawaiian Islands. It is notable, for example, that the total volume of building material used in larger structures we examined at the Hōlualoa Royal Centre (4,653 m^3) is remarkably similar to the amount of material used to build the main temple in the Kealakekua Royal Centre, Hikiau Heiau (4,234 m^3). These results could indicate a broadly parallel degree of effort went into the construction of these monumental complexes, pointing to similarities in elites' ability to mobilise labour, or other normative cultural understandings of the scale of such building enterprises. However, much more empirical data, and strong linking arguments, are necessary to support these or other such claims.

At the Keolonāhihi Complex, on the other hand, we do not see the kinds of investment in large temples or massive enclosing walls that are on display at other royal centres in Kona, but rather a variety of other features within the complex. Keolonāhihi Heiau is noted as a women's heiau, but relatively little is written about it compared with other locations within the complex. The results of this survey highlight the need for further research on this monument.

Our comparative data also reveal that at the Keākealaniwahine Complex, the Pakiha Enclosure, with its massive wall that traditions tell us enclosed the royal residence, stands out from all other monumental buildings in terms of scale and thus presumed political and cultural significance. Historical sources make it clear that the presence of the island's ruler, which required people to prostrate themselves, was disruptive to daily life. If we assume these kinds of cultural protocols were necessary when in the presence of the ruling family these high walls may have both provided security but also helped facilitate daily life in the royal centre.

With these results, our surveys show some of the current limitations of aerial LiDAR surveys in densely vegetated areas like those in this study. In many cases, our UAV-derived LiDAR data failed to resolve previously recorded architectural features, largely due to the fact that they are obscured by vegetation. Far from being a panacea, in several instances our LiDAR data could only resolve the largest monumental features, and even these

only in the best-preserved sections, showing that the current technology is not a replacement for more traditional ground-based investigations in environments like those in this study.

We speculate that the relatively disappointing results from some sites in our study are likely a product of the relatively low-cost UAV LiDAR system we employed. The Velodyne VLP-16 sensor collects only two returns per pulse, as opposed to an unlimited number of returns collected by more costly systems, and also collects only 300,000 points per second, while other systems collect more than 1 million. These fundamental limitations restrict the ability of the sensor to penetrate very dense vegetation, and thus remain a stumbling block for surveys of this kind in similar environments. However, as UAV-deployed LiDAR technology continues to improve, we can expect better results with systems that offer higher point density and full-waveform returns, both of which will significantly increase the potential to penetrate tree canopy and ground vegetation. Researchers interested in conducting UAV LiDAR surveys of archaeological sites in densely vegetated areas should take these issues into account when planning what instrumentation is most suitable, as well as the time of year for surveys in environments with seasonal differences in vegetation cover.

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REVIEWS

BALLANTYNE, Tony, Lachy Paterson and Angela Wanhalla (eds): *Indigenous Textual Cultures: Reading and Writing in the Age of Global Empire*. Durham, NC: Duke University Press, 2020. 368 pp., biblio., illus., index, notes. US$28.95 (softcover).

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The cover of this fine collection of essays sets the book's agenda. Leaves of a book recounting the "extermination of Tasmanian Aborigines" (p. 7) are impaled by tea tree spears, in an image taken of Julie Gough's work, *Some Words for Change* (2008). Gough's point—and the point of the collection—is clear. In colonial settings, words have a particular power, and those texts which occlude indigeneity, or assume its failure to adapt, should be resisted. Instead, by paying attention to indigenous engagement with textual cultures richer stories can be told that capture "indigenous aspirations, experiences, and arguments articulated in the face of the (literally) unsettling claims of colonial authority" (p. 8).

Something of that richness is revealed in a series of chapters that range from New Zealand and Australia to Africa, and cross the Pacific to North America. Yet the collection goes beyond revealing possibilities to mounting a notably coherent set of arguments about the nature of, and research approaches to, indigenous textual cultures. As we might expect, all the contributors press against the marginalisation of indigenous voices. However, two of the field's shibboleths are also challenged: the link between literacy and "civilisation", and the idea that oral and literate cultures are fundamentally opposed, ideas associated with Jack Goody and Walter Ong in particular. The stakes are laid out clearly in Tony Ballantyne and Lachy Paterson's well-judged introduction, but the issues thread themselves through the book. Some examples illustrate the range and depth of this engagement. Laura Rademaker undermines the assumed connection between literacy and civilisation by charting the rejection of literacy by the Anindilyakwa people of Australia's Groote Eylandt when it failed to offer them the promised benefits of citizenship, while Emma Hunter complicates the link between colonialism and literacy by using the rise and spread of Swahili as a reminder of the "impossiblity" of generalising about textual cultures in colonial settings (p. 177). Various authors chart the intricate entanglement between orality and textuality. Here the Pacific features strongly, with chapters by Michael Reilly on Mangaia and Bruno Saura on family manuscripts from the Society and Austral Islands. The effects of the orality/literacy divide

also play out in chapters concerned with the place of indigeneous textuality in archives. Alban Bensa and Adrian Muckle use archival sources of New Caledonia's 1917 war to make the case that despite being seen conventionally as an "oral" culture, a Kanak writing and literacy tradition has been hiding in plain sight. Similarly, Noelani Arista explores the marginalisation of Hawaiian-language archival sources, despite their abundance. Such archival marginalisation has consequences, as Arini Loader reveals in her contribution tracing the telling and retelling of the life of Māori leader Te Rauparaha (Ngāti Toa Rangatira, Ngāti Raukawa). In an acute case of colonial archival capture, then effacement, Te Rauparaha's story was first penned by his son, Tāmihana Te Rauparaha. However, whilst a stream of authors borrowed freely and loosely from his text to collectively create the received settler version of his life, the original remained trapped, unacknowledged and out of popular consciousness, in an archive.

As these examples suggest, in keeping with the book's intention to challenge existing notions of indigenous textuality, a very wide range of source materials is considered, from personal journals kept during the eighteenth century by Mohegan Presbyterian minister Samson Occom to New Guinea's pidgin-language newspapers of the 1960s. In most chapters, attention is focussed on the discursive properties of these diverse texts. Yet there may be more to consider. A few contributors extend their analyses beyond the text: by considering the epitextual issue of copyright, Isabel Hofmeyr links writing with expression of indigenous citizenship. Others situate their analysis in the materiality of reading and writing cultures. Such a manoeuvre not only offers further insights into indigenous practices, but continues to push the debate away from the familiar orality/literacy divide towards a set of quite different concerns, contextualised with quite different scholarship. Keith Thor Carlson's chapter, on Canada's Salish people in the nineteenth century, takes a material turn. Rather than relitigating the orality debate, he draws on Harold Innis's argument—made more than 70 years ago in *Empire and Communications*—that some empires emphasised time in their communication systems, using media like stone or clay, whilst others privileged space, extending their administrative networks through the use of lightweight materials like papyrus. Using this idea—that the material matters—he then analyses the role media played in negotiating "the dynamic interplay of colonialism and modernity" in this colonial setting (p. 106). Using this framework, the tension is not simply between spoken and written words, but between time and space, or the meanings generated by Salish petroglyphs and carved longhouses and those set in motion by a European explorer's portable writing desk. In this case, it is not just that orality and literacy are not so easily disaggregated, but that textuality is also deeply entangled with materiality.

Analyses like this (and in the final chapter, which explores a variety of North American Indian modes of communication) suggest intriguing new research possibilities. They might even shed light on those in New Guinea who, as Evelyn Ellerman showed, preferred to smoke, rather than read, their newspapers. More immediately, it might inspire a further collection that would continue to build on the important scholarship on display in *Indigenous Textual Cultures*, which is essential reading for researchers in the field.

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NGATA, Wayne, Arapata Hakiwai, Anne Salmond, Conal McCarthy, Amiria Salmond, Monty Soutar, James Schuster, Billie Lythberg, John Niko Maihi, Sandra Kahu Nepia, Te Wheturere Poope Grey, Te Aroha McDonnell and Natalie Robertson: *Hei Taonga mā ngā Uri Whakatipu | Treasures for the Rising Generation*: *The Dominion Museum Ethnological Expeditions, 1919–1923*. Wellington: Te Papa Press, 2021. 368 pp., appendices, biblio., glossary, index, notes, photos. NZ$75.00 (hardcover).

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There is a version of Aotearoa New Zealand histories that emphasises a story of colonisers and colonised. *Hei Taonga mā ngā Uri Whakatipu | Treasures for the Rising Generation* offers something far more nuanced, richer and important. The book explores four expeditions undertaken by Dominion Museum anthropologists to different parts of Te Ika-a-Māui (the North Island of New Zealand) into the 1920s—the Gisborne Hui Aroha in 1919, Rotorua in 1920, Whanganui River in 1921 and Tairāwhiti East Coast in 1923. These expeditions provided crucial ethnological research for the Dominion Museum (today Museum of New Zealand Te Papa Tongarewa) and included Pākehā 'New Zealand European' researchers such as Elsdon Best, Johannes Andersen and James McDonald whose intention was one of gathering the remnants of Māori culture "scattered by the winds of change" (p. 115) caused by colonial conflict, land loss and societal disruption.

Hei Taonga mā ngā Uri Whakatipu reframes the expeditions around key Māori leaders (and their communities) who appear not as mere participants but as instigators. Apirana Ngata and Te Rangihiroa (Sir Peter Buck) are central here. Their purpose was not salvage but revitalisation, initiating and directing the expeditions to collect *taonga* 'traditional treasures'—as various as *waiata* 'songs', games, customary rites and material culture, in notes, film, and phonographic and photographic recordings—for future generations. In this way, the expeditions were marked by interactions that were collaborative,

reflecting networks of *whakapapa* 'lineage, genealogy' like "an intricately woven fabric" (p. 212) across *hapū* and *iwi* 'sub-tribal and tribal kin and political groups' and *whanaungatanga* 'relationships' between expedition researchers. This framing allows us to glimpse the strategic vision of these Māori leaders in response to an evolving state and society, which might otherwise be obscured. Although Ngata and Te Rangihiroa, for example, used the language of loss to acquire government funding and support, they viewed ethnological documentation and recording as an opportunity to sustain and revive Māori arts and culture.

Adding to this sense of a spiralling history of connection is the fact that many of the book's authors are descended from key figures involved in the expeditions, notably Ngata and McDonald, revealing intergenerational activities and symmetries that "make sense of what was, and posit what could be" (p. 9). The overall project is highly collaborative with 13 contributing authors (excluding the appendix of Ngata's writings) with backgrounds in history, anthropology and *mātauranga Māori* 'Māori knowledge'. Eschewing a formal introduction, the early chapters offer vignettes of the main actors, especially Ngata and Te Rangihiroa, whose friendship, familiar to readers of New Zealand history, is presented here with new liveliness. Subsequent chapters deal with aspects of each expedition, drawing on public newspapers, private correspondence and object files. Māori texts with accompanying translations offer a rich resource.

A stand-out theme offered across the various chapters and essays is how museum practices were entangled in the aftermath of the colonial wars and hapū/iwi responses. To the backdrop of demobilisation of Māori soldiers after the Great War, Monty Soutar recounts te Hui Aroha as a commemoration of imperial citizenship and loyalty (not always reciprocated by members of the British royal family). Strategic if paradoxical relationships and agendas unfold: Ngata and Te Rangihiroa, planning for revival within living memory of war and occupation, work alongside Best, who participated in the sacking of Parihaka and whose own work was premised on the looming extinction of the Māori race. Amongst the rich illustrations, striking pictures of veterans Heremia Rāwiri at Koroniti in 1921 and Teira Tapunga in 1923, proudly wearing their New Zealand Wars medals, point to how this military experience became a focal point for collective engagement and negotiations across generations, such as the changing *tikanga* 'practice' of *pōwhiri* 'welcome rituals'.

The nature of an edited collection covering such a diverse set of perspectives, analytic lenses and source material inevitably leads to some unevenness. Some images in the early parts of the book are included with little justification except to seemingly balance out the photograph-heavy

collecting of the Whanganui and East Coast expeditions towards the end of the book. The significance of the expeditions is assumed, rather than argued. The decision to avoid a traditional introduction with summaries of each contribution means there is some repetition: the 1918 influenza and its impact on Māori communities is discussed in the same way multiple times. A clearer editorial voice might have helped.

Nonetheless, the result here is something of a scrapbook or treasure box filled with surprises across film, photography and material culture (an example of which was the *pouhaki* 'flagpole' carved for the Prince of Wales's visit in 1920 and restored by James Schuster at the Cambridge Museum in 2008). Natalie Robertson argues for the 1923 expedition as the beginnings of Ngāti Porou's film engagement, which will enrich our understanding of Māori film histories in general. The accumulative impact of the book's threads is to recognise the potential of taonga to reshape museum spaces and practices of translation, interpretation and transportation in their material and spiritual dimensions. *Taonga*/*tūpuna* 'treasures/ancestors' continue to activate connections across time and place. In this way, the expeditions—at once familial, social and scientific—offer fruitful reflections for contemporary research projects organised across different kinds of knowledge with different purposes and intentions. As Wayne Ngata puts it in the collection's opening remarks, *Hei Taonga mā ngā Uri Whakatipu* is a story that calls attention to "a mix of translators, mediators, and negotiators" (p. 9) between (but not reducible to) the subjectivities of coloniser and colonised. The meetings and relationships in the past energise meetings and relationships into the future.

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PUBLICATIONS RECEIVED*

December 2021 to March 2022

KIRCH, Patrick Vinton (ed.): *Talepakemalai: Lapita and Its Transformations in the Mussau Islands of Near Oceania*. Monumenta Archaeologica 47. Los Angeles: UCLA Cotsen Institute of Archaeology Press, 2021. 558 pp., biblio., illus., maps, notes, index. US$120.00 (hardcover).

NGATA, Wayne, Arapata Hakiwai, Anne Salmond, Conal McCarthy, Amiria Salmond, Monty Soutar, James Schuster, Billie Lythberg, John Niko Maihi, Sandra Kahu Nepia, Te Wheturere Poope Gray, Te Aroha McDonnell and Natalie Robertson: *Hei Taonga mā nā Uri Whakatipu | Treasures for the Rising Generation: The Dominion Museum Ethnological Expeditions 1919–1923*. Wellington: Te Papa Press, 2021. 368 pp., appendices, biblio., glossary, index, notes, photos. NZ$75.00 (hardcover).

* The inclusion of a publication in this list neither assumes nor precludes its subsequent review.