An early sophisticated East Polynesian voyaging canoe discovered on New Zealand's coast

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The colonization of the islands of East Polynesia was a remarkable episode in the history of human migration and seafaring. We report on an ocean-sailing canoe dating from close to that time. A large section of a complex composite canoe was discovered recently at Anaweka on the New Zealand coast. The canoe dates to approximately A.D. 1400 and was contemporary with continuing interisland voyaging. It was built in New Zealand as an early adaptation to a new environment, and a sea turtle carved on its hull makes symbolic connections with wider Polynesian culture and art. We describe the find and identify and radiocarbon date the construction materials. We present a reconstruction of the whole canoe and compare it to another early canoe previously discovered in the Society Islands.

maritime archaeology | conservation | waterlogged wood | Maori

A review of radiocarbon dates for East Polynesian colonization indicates that a period of settlement in a central group was followed by dispersal to the remaining uninhabited islands, which continued into the 13th century A.D. (1). The canoes available at the time were able to support an extensive and rapid episode of maritime migration (2), and there is evidence for long-distance interisland voyaging after settlement (3–5). Until now, reconstructions of the canoes used have been based mainly on much later observations from European explorers and ethnohistory (6, 7) supported by linguistic reconstructions of a vocabulary of canoe parts from ancestral Austronesian languages (8). The Anaweka *waka* (canoe) is one of only two conserved archaeological canoes dated to an early period (9, 10). It is interpreted as part of an ocean-going sailing canoe and, together with the remains of a canoe previously discovered over 30 y ago on Huahine in the Society Islands (11), provides insights into East Polynesian maritime technology. The Anaweka *waka* also relates to oral traditions about the voyages of named canoes and individuals (12) and must be regarded as one ancestral form from which Maori canoes of the historic period developed.

A Description of the Anaweka Canoe Find

The canoe was recovered on the remote northwestern end of the South Island, New Zealand (Site M25/135) a short distance from the sheltered Anaweka estuary (Fig. 1). It was exposed during a major storm event and later recovered from a sand dune adjacent to a natural logjam of driftwood at the mouth of a freshwater stream. Investigations have revealed no associated artifacts or archaeological features.

The find is a complete section of the hull of a complex and robust composite canoe, carved from a single timber. The wood was identified as New Zealand matai, *Prumnopitys taxifolia* (13, 14), and four lashing holes were packed with caulking consisting of pounded folded wads of bark identified as totara, *Podocarpus totara*, although pounding made identification difficult (14).

The hull section is 6.08-m long (Fig. 2). One side is straight and the other is straight for much of its length, then curves outwards and returns in a smooth line that terminates in a point where it meets the other side. We interpret this shaped end as being from one end of the canoe hull; the other end has a butt joint for attachment to another section of hull. The hull is 85-cm wide at its widest point and 76 cm at the butt end. Lashing holes around all edges have been chiseled transversely through the timber and the canoe averages 5-cm thick at lashing holes. The internal surface is finished with regular adzing and the outside surface carefully smoothed to prevent drag through the water. The edges are flat and evenly finished by abrasion or possibly sawing (15, 16), where they were attached to adjoining parts of the canoe.

Striking features of the hull are four transverse ribs carved at intervals along the hull, and a straight longitudinal stringer or girder runs from the rib by the butt end along the length of the hull. The ribs are tapered from the stringer toward both sides of the piece but are heavier on the side with the curved profile, suggesting that was the lower side in the canoe. The ribs average about 17-cm wide and 6-cm deep where they meet the stringer. Integral ribs of this kind are unknown historically in New Zealand but were reported in the Southern Cook Islands by a British official, Major Large, to Elsdon Best in 1913 (17). Interestingly, smaller carved ribs are present in traditional canoes from the Southern Cook Islands in the collections of the Auckland Museum and the National Museum of New Zealand, Te Papa Tongarewa. We note that some aspects of canoe design, such as outrigger attachment, have been described in great detail (6), but ethnohistoric descriptions of internal structure remain sparse.

The stringer is of much lighter construction than the ribs and it extends above the ribs where they cross. Clearly, the ribs supported the rounded profile of the hull and would have helped prevent the timber from splitting. The stringer would have provided some longitudinal stiffness to the hull, but lashing holes set along the length of the stringer suggest its primary function was for the attachment of other pieces of hull. Forces at the stringer have caused it to break away at the lashing holes between both the first and second ribs and the second and third (Fig. 2), and repairs are evident where new holes have been drilled deeper into the timber below the stringer to replace the broken ones. The stringer averages around 13-cm deep where it is intact but only 8 cm where it has broken away, and it is ~3-cm wide.

Significance

Conservation of a large section of an early, sophisticated sailing canoe recently discovered on the New Zealand coast provides an opportunity to study maritime technology directly associated with the colonization of East Polynesia. A sea turtle carved on its hull makes symbolic connections with ancestral Polynesian culture. We describe the artifact, identify and radiocarbon date construction materials, and reconstruct a likely form of the canoe in the context of archaeological and ethnohistoric information. The canoe is contemporary with early archaeological settlements around New Zealand and on-going voyaging between Polynesian islands.

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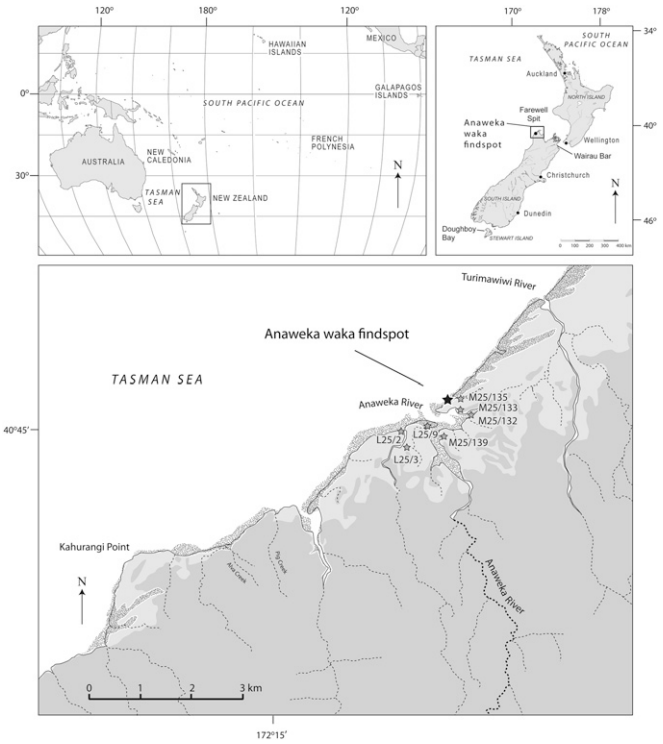

Fig. 1. The waterlogged canoe section was found just north of the narrow entrance to Anaweka Inlet on the northwestern coast of New Zealand's South Island. The figure shows locations of archaeological habitation sites recorded in the immediate vicinity. Sites contemporary with the *waka* are also known both north and south of the find spot. The foundation site of Wairau Bar, dating from the early 14th century A.D., is located on the northeastern coast of the South Island.

Eight squared notches up to 15-cm long were cut into the stringer along its length. There was one notch between the shaped end and the first rib, two between the first and second ribs (both near the ribs), three between the second and third ribs (two near the ribs and one in the middle), and two notches between the third and fourth ribs (one in the middle and the other beside the fourth rib). The stringer does not continue between the fourth rib and the butt end. New smaller notches were cut into the remains of the broken stringer in addition to the lashing hole repairs described. Clearly the notches and lashing holes in the stringer had a functional relationship. It is likely that the notches were used to locate the ends of beams set transversely across the hull to engage an adjoining hull section, with both sections lashed together from the stringers.

There are no grooves in the timber for recessing cordage at the lashing holes on the sides of the canoe, which could be explained if battens covering the joints had been included in the lashings as in historical Maori canoes. Similarly, there are no grooves for lashings on the outside of the hull at the butt joint to prevent abrasion when landing.

The Sea Turtle

A remarkable feature is a sea turtle carved in raised relief at the shaped end of the canoe (Fig. 3). A raised ridge behind the turtle could represent its wake as it moved through the water, or is possibly suggestive of an extended tail. Turtle designs are rare in Maori carving although known on four small prehistoric stone amulets (18, 19). Gill records a steady trickle of turtle sightings in New Zealand waters since 1885 (20), suggesting that turtles would have been known. It is also probable that the turtle motif relates to the early age of the canoe and its cultural associations with tropical East Polynesia.

Throughout Polynesia, traditional societies held sea turtles in high regard and, with one exception (Tokelau), restricted their consumption to high-status individuals (21). Turtles featured in visual art, myths and ritual. Rolett (22) and Kirch (23) derive their symbolic and religious significance from ancestral Polynesian culture. Sea turtles were known to make long migrations in open ocean. They came from the deep sea onto land and they also crossed symbolic boundaries. On occasion they could represent humans or gods. Turtles were associated with voyaging to the afterworld and assisted in a successful passage of the spirit after death (21, 24). A sea turtle on a 600-y-old Polynesian canoe is a unique and powerful symbol.

Sea turtles have been associated with Pacific pottery more than 3,000 y old. Terrell and Schechter (25) have suggested that many of the faces on Lapita pottery vessels may be variant representations of sea turtles, not of human beings, and there could be "...culturally (and probably emotionally) significant allusions to a popular legend, myth, or narrative about a person who rode on the back of a sea turtle" (26).

Radiocarbon Dating

Radiocarbon dating was carried out by three laboratories: Waikato Radiocarbon Dating Laboratory (Wk) and the Institute of Geological and Nuclear Sciences (GNS), New Zealand, and Beta Analytic Inc., United States (Beta).

Wood. We expected to find inbuilt age in the canoe hull and wished to verify that it was older than the caulking. Three wood samples were sent for analysis (Fig. 4 and Table 1). One was taken from toward the center of the tree bole (Wk 36538) and submitted to the Waikato Radiocarbon Laboratory for an accelerator mass spectrometry (AMS) date. A further sample was taken from the outer surface and divided into two pieces (Beta 350733 and 350734)

Fig. 2. An internal view of the hull showing the pointed end and butt end, and lashing holes for attachment of other timbers on all sides. Four transverse ribs are carved at intervals along the hull and a straight longitudinal stringer or girder runs from the rib at the butt end along the length of the hull. The ribs are tapered from the stringer toward both sides of the piece but are heavier on the side with the curved profile, suggesting this was the lower side of the canoe. The stringer has both notches and lashing holes for attachment of other parts of the hull. Sections of the stringer have been broken, and replacement notches and lashing holes cut into the hull indicate repairs and reuse.

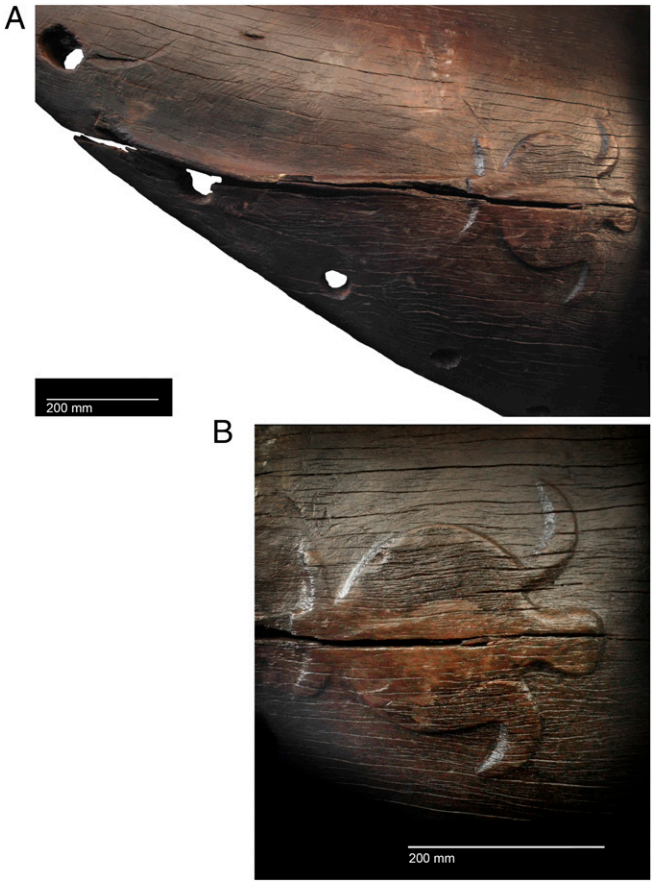

Fig. 3. (*A*) A sea turtle is carved in raised relief at the shaped end of the canoe strake and a ridge behind it extends to the end of the strake. If the ridge represents the pattern formed as the turtle swam although water, it provides a clue as to the direction of movement. Turtle designs are rare in pre-European Maori carving; however, turtles are known in New Zealand waters. It is likely that the turtle motif relates to the early age of the canoe and its cultural associations with tropical Polynesia. (*B*) Detail of the sea turtle.

before dispatch to Beta Analytic. Both had acid-base-acid pretreatment, Beta 350733 was cellulose extracted, and both were dated with AMS. Results indicate a difference of ~100 y between the inner and outer tree samples, which fits reasonably with sampling locations on the hull. Sample Beta 350733, which was cellulose extracted, is slightly older than its counterpart Beta 350734.

Caulking. Four caulking samples were taken from three lashing holes and the dates range from 560 ± 30 B.P. to 687 ± 15 B.P. (Fig. 4 and Table 1). Samples Wk 34276 and GNS 196536 were each taken from a different lashing hole. Wk 35545 and Beta 351803 were a split sample from a third hole sent to different laboratories, and there is a discrepancy of 100 y between the two dates. Traditional canoes were frequently relashed, but we consider it unlikely that one lashing hole contained material from separate recaulking events. Mcfadgen et al. (27) indicate that a major fluctuation in the Southern Hemisphere calibration curve in the 14th century A.D., makes it difficult to obtain high-resolution chronologies, and the dates for the caulking coincide.

We are mindful of the possibility of inbuilt age when using totara bark for dating because of the considerable lifespan of totara trees and its slow-growing bark. Inbuilt age has been reported for two dates from sites at Puwera, where old totara bark was used for roofing (28). Another anomalous date for totara bark has been reported for a site in Takahe Valley (29, 30). Botanist P. Simpson (31) notes that it would be possible for outer totara bark to be hundreds of years old. However, he also noted that the inner zone of the outer bark (external to the dense leather-like inner bark) is softer, easily divided, and folds readily without cracking, making it more suitable for recaulking a canoe. Simpson also advised that the older outer bark is porous, brittle, light-weight, and flammable. Downes (32) and Best (16) both documented inner bark selection for manufacture of cultural items as it formed a pliable, waterproof sheet. Caulking made of the inner part of the outer bark would impart inbuilt age in the order of decades, as opposed to centuries if the outer surface was used.

We consider a date of around A.D. 1400 to be a satisfactory estimate for the last voyage of the Anaweka *waka*. This date is within a century of the age of Wairau Bar, a colonization-phase settlement on the northeastern coast of the South Island (Fig. 1), where recent high-precision dating indicates settlement during the early A.D. 1300s (33). Archaeological sites contemporary with the Anaweka canoe occur further south in the South Island (34).

What Kind of Canoe Was It from?

The age, location, size and sophistication of the find all suggest that it was from a sea-going sailing canoe, but the obvious question is what type of canoe it was. A huge historic and distributional literature exists on Oceanic canoes; however, several canoe complexes allow easy summary (7). The earlier forms of canoe in East Polynesia were the only ones to reach New Zealand. Both double canoes and single outrigger canoes sailed to New Zealand, and Maori traditions refer to both kinds (17). Underwater parts of Oceanic boats were generally double-ended in shape, but above the waterline some were unequal-ended (35), and the general consensus is that ancient Polynesian voyaging canoes had a distinct bow and stern (6). The canoes had a two-spar rig and sail that was stepped forward, and they changed direction relative to the wind by tacking (turning the bow of the boat through the wind). Double canoes with hulls of similar length were well balanced with the wind coming from either side; however, tacking single outrigger canoes had poor balance with the outrigger to leeward (on the side away from the wind), which is a reason why Polynesian voyaging canoes were often double, although their load-carrying capacity was another advantage.

Considering hull form in more detail, Haddon and Hornell (6) distinguished what they termed a "five part canoe" with a dugout underbody, a plank or wash-strake fixed on edge along each side and the addition of end-pieces as decking at both the bow and the stern, from a "built-up canoe" with a much-reduced underbody, sometimes in more than one piece, and with the sides raised by more than one plank or wash-strake supported by internal frames. However, McGrail (35) noted that it is difficult to draw a line

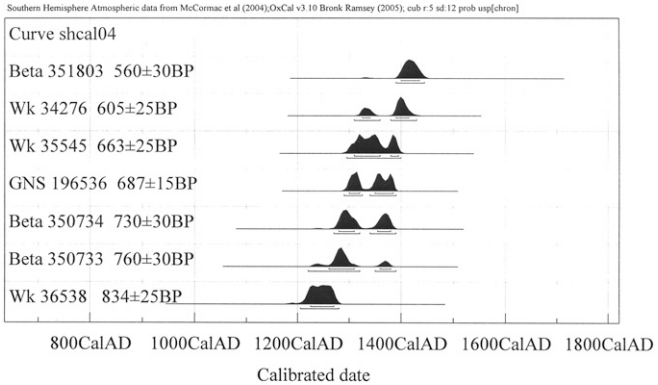

Fig. 4. Calibrated radiocarbon dates (Oxcal) of samples of the canoe hull (wood) and caulking (fiber).

Table 1. Radiocarbon determinations of wood and caulking for the Anaweka *waka*

Provenance	Laboratory no.*	Material	CRA	δ13c	Cal range (68%) A.D.
Anaweka caulking*	Beta 351803	Fiber	560 ± 30 B.P.	−25.1	1320–1340
		Bark			1390–1410
Anaweka caulking	Wk 34276	Fiber	605 ± 25 B.P.	−25.6 ± 0.2%	1326–1341
		Bark			1390–1415
Anaweka caulking*	Wk 35545	Fiber	663 ± 25 B.P.	−25.6 ± 0.2%	1313–1357
		Bark			1380–1392
Anaweka caulking	GNS 196536	Fiber	687 ± 15 B.P.	−24.9 ± 0.2%	1302–1320
		Bark			1351–1366
					1375–1386
Anaweka hull	Beta 350734	Wood	730 ± 30 B.P.	−25.0	1270–1280
		Matai			
Anaweka hull	Beta 350733	Wood	760 ± 30 B.P.	−22.5	1260–1280
		Matai			
Anaweka hull	Wk 36538	Wood	834 ± 25 B.P.	−25.5 ± 0.1%	1226–1266
		Matai			

*Caulking sample taken from the same lashing hole and divided into two pieces before dispatch for AMS dates; see *Radiocarbon Dating*, *Caulking*. CRA, Conventional Radiocarbon Age.

between a log-boat raised by the addition of side-strakes and a plank boat with a log-boat base. Planked canoes were often found on islands without good timber, and Haddon and Hornell (6) assert that nowhere in New Zealand is there evidence for elaborate plank-built boats, such as the *pahi* of the Society and Tuamotu Islands. By the time of European arrival, Maori canoes were beamy dugouts with deep planks attached and with no frames (17).

Consideration of the Anaweka canoe gives rise to a number of points: (*i*) We presume that it comes from a bilaterally symmetrical canoe hull because no other kind was known in Polynesia, but probably not from a canoe with end symmetry. (*ii*) The complete hull can be expected to have been no less than twice as long as the existing piece, having two or possibly three sections and the superstructure at both ends would have added extra length. This would have been a suitable size for ocean sailing (36). (*iii*) The butt end of the Anaweka hull section is like East Polynesian canoes of historic times, but unlike a common European contact period Maori dugout hull form with separate short ends (*haumi*), attached with mortise-and-tenon joints. Haddon and Hornell (6) suggest mortise-and-tenon became more common in New Zealand and several were found at the 17th century wetland site of Kohika (37). (*iv*) The Anaweka find is not symmetrical in transverse section, indicating that it is not from the bottom of a canoe but from one side of the lower hull. The lowest keel portion of the canoe is missing, as well as a strake or finished gunwale above. In addition, there was probably a matching piece (mirror image) on the other side of the hull. (*v*) The piece is like a plank or strake in having lashing holes for attachment to an underbody on one side and another strake or gunwale on the other, but it is unusually wide and thick. More significantly, ribs and stringers and shaped ends of this kind have not been reported on Maori canoes. (*vi*) The ribs could be derived historically from internal frames which, in Oceanic boatbuilding, were inserted transversely after the planks were laid to provide bracing for the hulls of planked canoes with smaller underbodies or keels than dugout canoes (38). (*vii*) The derivation of the stringer is unclear. It is unlike any internal cleats known historically for the attachment of planks. We consider that the notches and lashing holes along the stringer were probably used to brace and attach other substantial parts of the hull, and possibly also to support decking, flooring or other fittings. However, it is unlike any flooring support described for Maori canoes by Best (17).

In summary, the Anaweka piece could be regarded as an early adaptation of East Polynesian canoe technology to New Zealand, being part of a large and sophisticated composite canoe comprising substantial hollowed-out parts, but not readily classifiable as either a planked canoe or a dugout. Such a form could have been made from the very large trees that became readily available in New Zealand after settlement. This view corresponds with the early date.

An alternative explanation is that this unusual piece might have been a patch replacing a damaged part of some large canoe, perhaps deriving from some other Polynesian island. However, we consider this unlikely because the piece has a coherent form and structure and also because there is independent evidence for the early use of the same technology. A small broken piece of a canoe found in 1997 at Doughboy Bay, Stewart Island (Fig. 1) (39), now in the Southland Museum and Art Gallery (Z4653), represents a close parallel. It was quite unlike anything else known at the time but can now be seen to share features with the Anaweka *waka*, including an integral carved rib and stringer, lashing holes, and the same form of butt end. Preliminary radiocarbon results for this artifact indicate an age in keeping with the Anaweka *waka*.

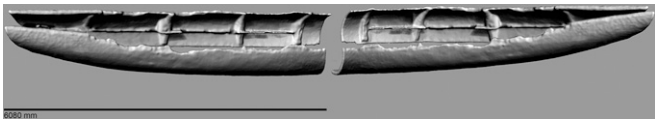

Fig. 5. Scanned images of inside and outside surfaces of the Anaweka canoe section are shown in the left side of this four-part digital reconstruction, and their mirror images on the right, giving an impression of an entire hull in two or possibly three sections. In this orientation the canoe lacks a central underbody and upper strakes or gunwales. The curved edge of the shaped end lies approximately vertical and timbers separating the sides at both ends would have been necessary to avoid a line of lashings along the angle of the keel, unknown ethnohistorically.

The Anaweka Canoe Reconstructed

The Anaweka find is akin to a single piece of a jig-saw puzzle, or perhaps like attempting the reconstruction of a new animal species from a single major bone; however, considerable progress can be made in this case. First, the long axis must surely lie in a horizontal plane, but which side is the upper and which is the lower is uncertain. Using architectural computer software the image was examined in different orientations and rotations. It was compared, in turn, with each side and the stringer held horizontally and the curved edge at different angles. A mirror image was created on the assumption that the former hull was bilaterally symmetrical, and Fig. 5 shows a hull with symmetrical sides and ends to give an impression of an entire hull in two or

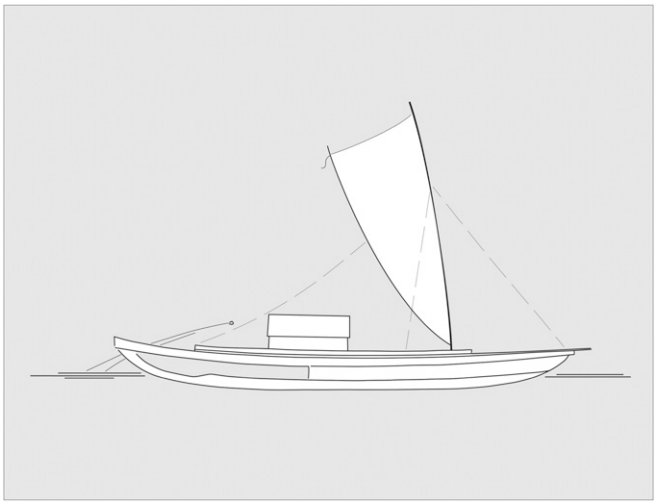

Fig. 6. A reconstruction of the complete Anaweka canoe by G. Irwin, based on the details of the hull section interpreted in the context of documentary and distributional evidence discussed in the paper. It is represented as a double canoe, but the possibility that it was a single canoe with outrigger cannot be excluded. No remains of a sail or spars were found at Anaweka, but various rigs with two spars and inverted triangular sails were recorded in early sketches by Europeans in Tahiti, Hawaii, the Marquesas, and New Zealand, before 1780 (48). It is likely that the whole rig was put up and taken down as one, as with Maori sails in historical times, and the rig could have been set up in different ways according to the direction of the canoe in relation to the wind.

three sections. In this orientation the canoe lacks a central underbody, upper strakes, and gunwales. The curved edge of the shaped end lies approximately vertical and in this reconstruction timbers separating the sides at both ends would have been necessary to avoid a line of lashings along the angle of the keel, which would be subject to abrasion on landing, and no known example exists of a canoe with its ends joined at the keel line.

If the turtle was swimming forward accompanying the canoe, not backward, which seems a reasonable proposition, it must have been at the back of the canoe. If the keel section is missing, as suggested, then the turtle was visible near the waterline rather than directly underneath the canoe.

If the Anaweka canoe was a double canoe, which seems likely, the documentary evidence suggests a canoe with a deck and shelter, a low bow and an upraised stern, and a sail set forward as in historic canoes of the Society and Southern Cook Islands, which have been identified as likely Polynesian homelands of Maori (40, 41). Fig. 6 is a reconstruction of a canoe that is consistent with the material remains as well as with the wider context of documentary evidence. It has a shallow underbody and the hull is raised by two wide planks or strakes. However, no remains of a sail or spars were found at Anaweka.

A canoe with a hull of this general type, a Tahitian *tipaerua*, was drawn by John Webber during Cook's third voyage to the Pacific (6). These canoes ranged up to 20 m in length; they were used for deep-sea voyaging, and Haddon and Hornell suggest they could have been involved in early voyages to New Zealand (6). We can envisage the Anaweka *waka* as having shared characteristics with an ancestor of such a canoe.

In the late 1970s and early 1980s excavations in a swampy area of the Fa'ahia site on Huahine in the Society Islands by Sinoto (11, 42) found remains of a large canoe, including two 7-m planks with lashing holes for attachment, a steering paddle at least 4-m long, and a large unfinished bailer. No direct dates have been reported for the canoe remains, but radiocarbon dates from the site indicate occupation in the period A.D. 1050–1450 (43), in the same time range as the Anaweka canoe. Sinoto (11) and Finney (38) have both used the Webber drawing of a *tipaerua* as a template on which to locate and interpret the planks from Fa'ahia. The Anaweka piece is interpreted as lying above the underbody. The planks from Fa'ahia are lighter in construction and of a different form, and are interpreted as coming from higher in the hull where the top plank met the deck platform of a double canoe (11, 38). The Anaweka and Fa'ahia canoes were unlikely to have been of the same design, but it is possible that they could have come from the same design tradition. In that sense, the evidence from two widely separated locations in East Polynesia is complementary.

Conclusions

The Anaweka canoe was a large, sophisticated, and powerful craft. It was last caulked around A.D. 1400. The canoe had already been repaired and reused. It was active on the exposed open sea coast of the South Island where it could hardly have operated without a sail. The canoe was broken up and the large section of hull was found just north of the entrance to the sheltered inlet of Anaweka estuary. It was contemporary with Archaic archaeological communities, which were linked along the length of New Zealand.

The canoe was not many human generations removed in time from the period of New Zealand settlement by a considerable and diverse East Polynesian population (1, 33, 44, 45) involving many voyages spread over some generations (46). Some of these voyages, as told in tradition, may have involved returns (17). The Kermadec and Norfolk islands could still have been visited episodically and the sub-Antarctic Auckland Islands had been reached already (47). The age of settlement of the Chathams is yet to be resolved, but this group could have been part of a widespread sphere of early voyaging among New Zealand and its South Pacific neighbors.

The Anaweka *waka* provides new information about ancestral Maori canoe technology and insights into early technology and seafaring in tropical East Polynesia.

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1. Wilmshurst JM, Hunt TL, Lipo CP, Anderson AJ (2011) High-precision radiocarbon dating shows recent and rapid initial human colonization of East Polynesia. *Proc Natl Acad Sci USA* 108(5):1815–1820.
2. Irwin GJ (2010) Pacific voyaging and settlement: Issues of biogeography and archaeology, canoe performance and computer simulation. *The Global Origins and Development of Seafaring*, eds Anderson A, Barrett JH, Boyle KV (MacDonald Institute Monographs, Cambridge, MA), pp 131–142.
3. Collerson KD, Weisler MI (2007) Stone adze compositions and the extent of ancient Polynesian voyaging and trade. *Science* 317(5846):1907–1911.
4. McAlister A, Sheppard PJ, Allen MS (2013) The identification of a Marquesan adze in the Cook Islands. *J Polyn Soc* 122(3):257–274.
5. Weisler MI (2008) Tracking ancient routes across Polynesian seascapes with basalt artifact geochemistry. *Handbook of Landscape Archaeology*, eds David B, Thomas J (Left Coast Press, Walnut Creek, CA), pp 536–543.
6. Haddon AC, Hornell J (1997) *Canoes of Oceania* (Bishop Museum Press, Honolulu).
7. Doran E, Jr (1981) *Wangka: Austronesian Canoe Traditions* (Texas A&M Univ Press, College Station, TX).
8. Pawley A, Pawley M (1994) Early Austronesian terms for canoe parts and seafaring. *Austronesian Terminologies: Continuity and Change*, eds Pawley A, Ross M (Australian National Univ, Canberra, Australia), pp 329–361.
9. Johns DA (1993) *Recommendations and Implementation of Conservation Treatments for the Waterlogged Wood Artefacts from Fa'ahia site Huahine, Society Islands,*

report to Musee de Tahiti et des Iles. Available upon request from *www.museetahiti.pf/infos.php*.
10. Johns DA (2013) *Pre-Treatment Analysis and Condition Report for a Pre-Contact Canoe (waka) Recovered from Anaweka Estuary* (*South Island, New Zealand*), report to the Ministry for Culture and Heritage, New Zealand. Available upon request from *www.mch.govt.nz/contact-us*.
11. Sinoto Y (1979) Excavations on Huahine, French Polynesia. *Pac Stud* 3(1):1–40.
12. Taonui R (2006) Polynesian oral traditions. *Vaka Moana: Voyages of the Ancestors*, ed Howe KR (David Bateman, Auckland), pp 23–53.
13. Donaldson L (2014) *Wood identification. Report to D Johns* (SCION: Forests, Products, Innovation Rotorua, New Zealand).
14. Wallace R (2012) *Anaweka Wood and Fibre Identification. Laboratory Report to D Johns* (Univ of Auckland, Auckland).
15. Beck R (1984) *New Zealand Jade: The Story of Greenstone* (Reed, Wellington, New Zealand).
16. Best E (1977) *Forest Lore of the Maori* (Shearer AR, Government Printer, Wellington, New Zealand).
17. Best E (1976) *The Maori Canoe* (Shearer AR, Government Printer, Wellington, New Zealand).
18. Skinner HD (1974) *Comparatively Speaking: Studies in Pacific Material Culture, 1921–1972* (Univ of Otago Press, Dunedin, New Zealand).
19. Prickett N (1999) *Nga Tohu Tawhito: Early Maori Ornaments* (David Bateman, Auckland).
20. Gill BJ (1997) Records of turtles and snakes in New Zealand, 1837–1996. *N Z J Mar Freshw Res* 31:477–486.
21. Meijer V (2012) Continuity and change in Polynesian visual symbolic systems: An inter-island comparison of the context of turtle motifs on natural and anthropogenic stone in Polynesia. MA dissertation (Institute of Archaeology, Univ College London, London, United Kingdom).
22. Rolett B (1986) Turtles, priests, and the afterworld: A study in the iconographic interpretation of Polynesian petroglyphs. *Island Societies: Archaeological Approaches to Evolution and Transformation*, ed Kirch PV (Cambridge Univ Press, Cambridge, MA), pp 78–87.
23. Kirch PV (1994) The pre-Christian ritual cycle of Futuna, Western Polynesia. *J Polyn Soc* 103(3):255–298.
24. Luna RW (2013) Turtlephilia in the Pacific: An integrated comparative analysis from the perspectives of biological, cultural, and spiritual ecology in a particular case of biophilia. PhD thesis (Univ of Hawaii at Manoa, Manoa, HI).
25. Terrell JE, Schechter EM (2009) The meaning and importance of the Lapita face motif. *Archaeology in Oceania* 44(S1):45–55.
26. Terrell JE, Schechter EM (2007) Deciphering the Lapita code: The Aitape ceramic sequence and the late survival of the 'Lapita face'. *Camb Archaeol J* 17(1):59–85.
27. Mcfadgen BG, Knox IFB, Cole TRL (1994) Radiocarbon calibration curve variations and their implications for the interpretation of New Zealand prehistory. *Radiocarbon* 36(2):221–236.
28. Turner M, Bickler S, Clough R, Best S, Wallace R (2010) *Puwera Landfill Site, Portland, Whangarei: Final Report on Excavations at Sites Q07/1091, 1092 and 1103 in Fulfilment of NZHPT Authority No. 2004/50 and 2009/250* (Clough and Associates, Auckland).
29. Anderson AJ (1991) The chronology of colonization in New Zealand. *Antiquity* 65(249):767–795.
30. O'Regan G (1992) The antiquity of the Takahe Valley rock shelter site. *Archaeology in New Zealand* 35(3):172–176.
31. Simpson P (2014) *Totara Bark. Report to D Johns* (Botanist, Pohara, RD1 Takaka, New Zealand).
32. Downes TW (1928) Bird-snaring, etc., in the Whanganui District. *J Polyn Soc* 37(145):1–29.
33. Jacomb C, et al. (2014) High-precision dating and ancient DNA profiling of moa (Aves: Dinornithiformes) eggshell documents a complex feature at Wairau Bar and refines the chronology of New Zealand settlement by Polynesians. *J Archaeol Sci* 50:24–30.
34. Jacomb C, Walter R, Jennings C (2010) Review of the archaeology of Foveaux Strait. *J Polyn Soc* 119(1):25–60.
35. McGrail S (2001) *Boats of the World: From the Stone Age to Medieval Times* (Oxford Univ Press, Oxford).
36. Lewis D (1972) *We the Navigators* (Australian National Univ Press, Canberra, Australia).
37. Irwin GJ (2004) *Kohika: The Archaeology of a Late Maori Lake Village in the Ngati Awa rohe, Bay of Plenty, New Zealand* (Auckland Univ Press, Auckland).
38. Finney B (2006) Ocean sailing canoes. *Vaka Moana: Voyages of the Ancestors*, ed Howe KR (David Bateman, Auckland), pp 100–153.
39. Johns DA (2000) *Analysis and Treatment of a Waterlogged Stern Cover from Doughboy Bay, Stewart Island, New Zealand: Report to the Southland Museum and Art Gallery, Invercargill* (Univ of Auckland, Auckland).
40. Walter R (2004) New Zealand archaeology and its Polynesian connections. *Change Through Time: 50 Years of New Zealand Archaeology*, eds Furey L, Holdaway S (New Zealand Archaeological Association, Auckland), pp 125–146.
41. Davidson JM (1994) The East Polynesian origins of the New Zealand Archaic. *The Origins of the first New Zealanders*, ed Sutton DG (Auckland Univ Press, Auckland), pp 208–219.
42. Sinoto Y (1983) The Huahine excavations: Discovery of an ancient Polynesian canoe. *Archaeology* 36(2):10–15.
43. Anderson AJ, Sinoto Y (2002) New radiocarbon ages of colonization sites in East Polynesia. *Asian Perspect* 41(2):242–257.
44. Knapp M, et al. (2012) Complete mitochondrial DNA genome sequences from the first New Zealanders. *Proc Natl Acad Sci USA* 109(45):18350–18354.
45. Penny D, Murray-McIntosh R, Harrison GL (2002) Estimating the number of females in the founding population of New Zealand: Analysis of mtDNA variation. *J Polyn Soc* 111(3):207–222.
46. Irwin GJ (2006) Voyaging and settlement. *Vaka Moana: Voyages of the Ancestors*, ed Howe KR (David Bateman, Auckland), pp 54–99.
47. Anderson AJ (2009) Origins, settlement and society of pre-European South Polynesia. *The New Oxford History of New Zealand*, ed Byrnes G (Oxford University Press, Melbourne), pp 21–46.
48. Irwin GJ (2008) Pacific seascapes, canoe performance, and a review of Lapita voyaging with regard to theories of migration. *Asian Perspect* 47(1):12–27.