

THE POLYNESIAN VOYAGING CANOE:
THE REGIONALIZATION OF SEAFARING
TECHNOLOGIES

by

KRISTOPHER ELIAS RANNEY

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Professor Scott M. Fitzpatrick

Scholars in the field of Oceanic archeology and anthropology have radically altered the accepted narrative of human habitation of the Polynesian islands in recent years, emphasizing a rapid expansion of territory along with some evidence of trade and cultural exchange. This indicates a sophisticated seafaring culture, capable of maintaining contact between island groups for several hundred years after the initial dispersal. The canoes of Polynesia have thus been reexamined in terms of utility and complexity, but no dedicated effort has been adequately made to examine the regional derivative canoe designs against the various proposed prehistoric voyaging canoes, nor has there been an effort of backward analysis from those designs. By examining historic sources describing the canoes used at the time of European contact along with other datasets, the evolution of their design can be better understood. This is given with consideration of the ecological and cultural realities specific to the region, which in turn grants a clearer picture of the original Polynesian voyaging canoe.

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Chapter 1: Seascape

Introduction

Polynesia was settled in two major phases, separated by approximately two thousand years. West Polynesia, consisting primarily of the Samoan and Tongan archipelagos, was settled between ca. 1,000-800 BCE,¹ followed by the settlement of East Polynesia between approximately 1,000-1,200 CE.² One probable explanation for the long pause between colonization phases, followed by the rapid colonization of East Polynesia, was the innovation of new maritime technologies.³ In this paper, I will analyze the historic descriptions of vessels used by traditional cultures in Polynesia to try to derive some of the traits of a common ancestor, focusing on its five major regions: the Hawai`ian island chain, the New Zealand archipelago, the outlying island of Rapa Nui, and finally the Western and Central archipelagos, which constitute by far the largest local cultural variation, as well as the largest overall area. These regions are primarily determined based on remoteness, as each was a cultural sphere of influence into which very little communication existed after the first several centuries post-settlement.⁴

A complex craft capable of navigating large stretches of ocean under variable conditions precisely and relatively quickly would have been the only feasible transport between islands; if they did not function to the level required for long distance transport to be a feasible option, the dispersal into East Polynesia would have lasted far longer.

¹ Burley and Addison, 2014

² Willmshurst, et al., 2011

³ Anderson 2003, 79, Irwin 2008, 15-17, Montenegro, Á., et al. 2014, 2016

⁴ Rehg, K.L., 1995, Rolett 2002

Once that assumption is in place, it is only the specifics that need examining; ascertaining how the historic vessels of Polynesia relate to their ancestors. The ways in which the natural and cultural environment effected the changes seen in the historic record is crucial in understanding what an original predecessor of their canoes would have been designed.

Geography

Despite Polynesia being set in an area roughly the same as that of North America, only 300,000 square kilometers of its vast expanse is located above the water line, with 270,000 of those comprising New Zealand alone. Nearly half of the remainder is found in the Hawai`ian island chain, leaving the scant 15,000 square kilometers to be lost in the 22 million square kilometers of ocean that comprise the region. Located on the eastern expanse of the Pacific Islands inside the bounds of Hawai`i, New Zealand, and Rapa Nui, which are approximately equidistant (figure 1), it is unsurprising that this region was not settled until relatively recently.

The vast majority of the region is comprised of small islands, separated by large spans of ocean. Even within island chains or archipelagos, it is not unusual to be out of sight of most, if not all, other traces of land. There are approximately a dozen major archipelagos in the region, besides Hawai`i and New Zealand, including Tonga and Samoa in West Polynesia, and the Society Islands, the Marquesas, the Tuamotus, and Mangareva that make up most of Central-East Polynesia (figure 1). They vary in geography from island to island, mostly in relation to their age, being comprised of tall jagged mountains, before weathering all the way down to atolls, islands comprised entirely of the coral reef that once circled sunken peaks.

The region now called Polynesia is part of a much larger series of island groups that make up much of the Pacific Islands, starting in Island South East Asia (ISEA), and continuing through Near and Remote Oceania. These can also be divided into the Micronesian, Melanesian, and Polynesian regions on cultural grounds, although in that case the borders can be very vague and overlap significantly.

The abundance of islands in such close proximity in this region of the world is somewhat accidental, as their origins are varied to some degree. ISEA owes its existence to the rising sea levels over the past few tens of thousands of years, as during the last glacial maximum the region was almost entirely part of the Sunda Peninsula with any islands being much larger and closer in proximity than they are now.⁵ As such, it is characterized by many islands, some of which are quite large and in close proximity to each other. The remnants of Sahul, the landmass once comprised primarily of Australia and New Guinea, also follow similar lines.

Other island groups located farther east are the result of continental upwelling, such as in the Tongan Archipelago or New Zealand. Others are volcanic, either resulting from plate activity near the so-called Ring of Fire bordering the Pacific tectonic plate, or hot spots under the plate.

Those in the last category then vary in form based on their age, from the new islands sporting jagged cliff faces surrounded by turbulent seas, such as in the Marquesas, to the atolls made up of the coral reefs of long sunken and eroded isles such as those in the Tuamotus. Nearly every one of the over 1,000 islands that make up Polynesia, barring the exceptions already stated, are in the last category.

⁵ Clark, G., et al. (eds.), 2008, Ch. 2, O'Connell, Allen, and Hawk, 2008

What is remarkable is that all but a handful of these diverse lands were settled by humans, well before the introduction of precise navigation aids, and almost certainly exclusively on large canoes,⁶ rather than the giant hulled vessels that allowed for the European and East Asian expansions into distant maritime regions.

Map of Polynesia and Surrounding Island Groups

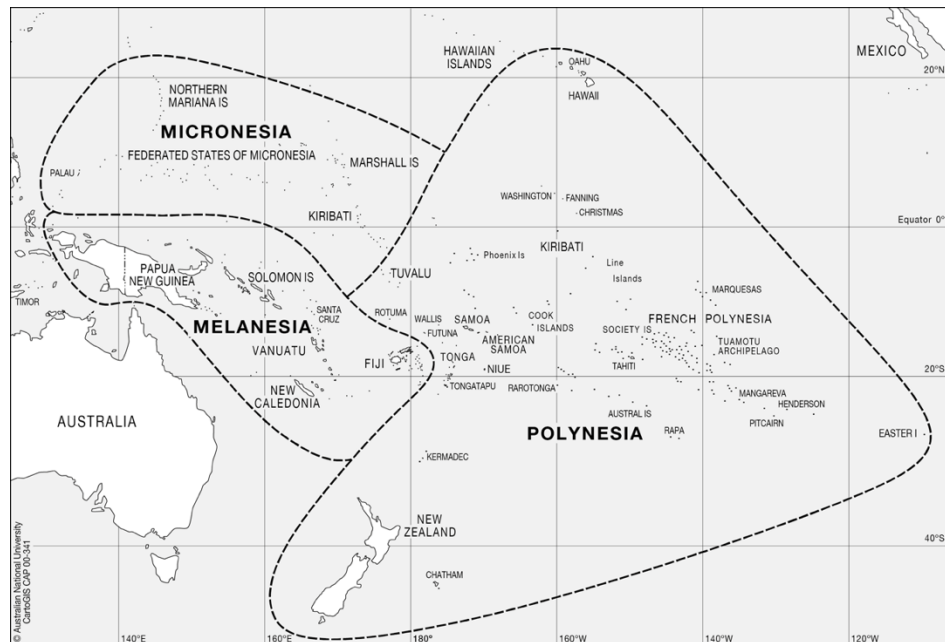


Figure 1: Map delineating the classic borders between the Polynesian, Micronesian, and Melanesian regions. (Micronesia, Melanesia, Polynesia. Australian National University, CartoGIS CAP 00-341. <http://asiapacific.anu.edu.au/mapsonline/base-maps/micronesia-melanesia-polynesia>. (Accessed Feb. 2, 2018))

⁶ Irwin, G., 2008

Chapter 2: Polynesian Dispersal Technologies

Introduction

Voyaging is a central aspect of the Polynesian culture, being the most recent of hundreds of generations of seafarers⁷. The fact that a Neolithic culture was the first to reach the heart of the Pacific, before the industrializing Europeans or even the more local East Asian Empires, is a narrative that was used in the past as an impetus to those who fought back against the philosophies of superiority that marked European colonialism.⁸ Understanding any given subject is never as simple as reading the prescribed textbook, as first one must know the context of its writing. This chapter will explore the literature surrounding human population dispersal into the Pacific, as well as some of the broader narratives circulated outside scholarly circles. The context this work provides is important in understanding how later vessel development transpired.

Early Scholarship on Human Population dispersal in the Pacific

There is not an extensive amount of details given by early European explorers as to the specific design of indigenous Polynesian vessels. The most important and influential explorer was the English captain, James Cook, who made three expeditions into the Pacific, including the one during which he was killed. After making landfall on numerous islands throughout the region, including Easter Island (Rapa Nui), The Sandwich Islands (Hawai`i), and New Zealand, he wrote, “In consequence of this and our former voyage, warrants our pronouncing it to be, though perhaps not the most numerous, certainly, by far, the most extensive nation upon earth,” (Cook, J., 1821, Vol.

⁷ Anderson 2003, Clark, G., et al., 2008, Irwin, G., 2008

⁸ Finney, B.R., 1994b, Finney, B.R., 1999, Finney, B.R., 2003

VI, 231). The idea did not stagnate with Cook, as the idea of a navigator people who sailed across the Pacific and back quickly became the popular image of the Polynesians up through the 19th and early 20th centuries.⁹ Others noted various aspects of indigenous vessel design, but made no real effort to understand the connections between population groups, let alone specifics like shared technology until the mid-19th century. The theory of an interconnected Polynesia was developed throughout this period through investigation into oral traditions and voyaging technology. This idea consisted of a varying level of intentional movement between island groups, mostly dependent on large time intervals and some chance.¹⁰ Its basic structure involved a slow expansion of Polynesians into the Pacific through the development of the lateen or spritsail and the capability of sailing into and across the wind.¹¹

Early research on human interaction in Polynesia was primarily focused on determining their relationships with other human 'families', as was popular throughout the academic world at the time.¹² It was thought that such research would create a map of relationships, both regarding ethnicity and cultural diffusion. These studies almost always linked the origin of Polynesians to Southeast Asia, although the specifics varied considerably based on which features were seen to take precedence. Perhaps the most important field in studying the early dispersal of Polynesians was linguistics, as it allowed for a basic chronology to be made of the entire language family, showing

⁹ Best, E., 1918, Fornander, A., 1878

¹⁰ Best, E., 1918

¹¹ Irwin, G., 2008

¹² Best, E., 1918, 1927, Gregory, H.E., 1922, Heine-Geldern, R., 1950, Heyerdahl, T., 1950b, 1979, Holton, G.E.L., 2004, Linton, R., 1926, Smith, C.H., and Kneeland, S., 1855, Wake, C.S., 1883

which islands were settled by whom.¹³ It was largely through this body of research that a west to east settlement of Polynesia was originally conceived.

Not everyone immediately supported this early research, as many questioned how these supposedly related populations came to be in such distant locations. There were also some who credited the region's population as a spontaneous happening, in which case different island populations would have no relation outside of a common creator. Others thought to explain the phenomenon as a result of a sunken continent, where only the highest peaks were left.¹⁴ These ideas were quickly discredited, but the seemingly incredible scattering of a people demonstrated to have limited oceanic voyaging capabilities at best, railed at attempts at explanation. A number of competing theories developed over the next half-century, and although they agreed in many ways, no satisfactory consensus was reached.

Although widely accepted initially, the region spanning inter-connected nation theory eventually faced criticism because of the general lack of historical examples of inter-island traffic after contact, particularly in the outer reaches of East Polynesia. Some researchers believed that the vessels described in early accounts could not have been capable of intentional transit across large bodies of an ocean, especially without instruments to aid in navigation.¹⁵ Throughout much of the mid 20th century, many researchers studying the Pacific Islands believed that human colonization happened at least partly by chance. Andrew Sharp was the public face of this argument, proposing the chance marooning of fishermen or other users of small vessels, causing a slow,

¹³ Best, E., 1918, Churchill, W., and Roussel, H., 1912, Gray, R.D., et al., 2009, Heyerdahl, T., 1950a, Holmes, L.D., 1958, Leverd, A., 1922, Rehg, K.L., 1995, Walworth, M., 2014

¹⁴ Brown, J.M., 1924

¹⁵ Sharp, A., 1964, Vayda, A.P., 1959

haphazard, seeding of the Pacific Islands over the course of several centuries. This theory never gained much headway in the broader academic community. The prevailing winds and currents around the equatorial Pacific flow westward made it far more likely that any such castaways would be swept in that direction, but it remained part of the layman communities' view of the subject for decades.

Another possibility considered was that Polynesia was settled not from Asia, but rather from the Americas because of the prevailing westerly winds. In 1830, missionary William Ellis first proposed this hypothesis, but it remained untested until the famous Kon Tiki expedition set out in 1947. Thor Heyerdahl, who was the architect of the demonstration, set out from Peru on a balsa wood raft in order to demonstrate that such a method was a viable theory of human population dispersal.¹⁶ The theory was based largely on the cosmetic similarities between the architectural designs of Polynesian and a few South American cultures. These included some stonework on Rapa Nui that used very similar architectural ascetics¹⁷, and iconography found in the Marquesas Islands that resemble alpaca¹⁸. One of his keystone arguments focused on the South American rafts for which he modeled Kon Tiki, which shared many features with the double-hulled canoes used in Polynesia. He also used the existence of raft technology in much of the less accessible islands of Polynesia, and some uses of the word for raft in place of canoe in some areas, as additional evidence.

When [I] arrived in the Tuamotu archipelago on a replica of the Peruvian sailing raft it created much excitement among the elders of the Raroia tribe, who inform him that this was a very ancient type of boat used by

¹⁶ Heyerdahl, T., 1950a, Heyerdahl, T., 1950b,

¹⁷ Golson, J., 1965

¹⁸ Heyerdahl, T., 1965

their ancestors and described in the traditions generally as paepae, but in still older legends rongo-rongo. (Heyerdahl, T., 1950, 23).

This similarity ultimately proved to be coincidental in origin, as the Polynesian canoe has been shown to have had an entirely different source.¹⁹

While the expedition itself was a success, Heyerdahl's ideas have since been broadly refuted, primarily through linguistic, cultural, genetic, and archeological studies that all support a west to east population dispersal.²⁰ Even at the time, many anthropologists criticized his cherry-picked evidence. "Heyerdahl's claim that attempts to relate the Polynesians to the Old World have failed was no doubt news to the majority of anthropologists who believe that the evidence is so conclusive that Old World origin is a premise from which one may work without question," (Holmes 1958, 127). Both theories of drift voyaging were eventually dismissed in favor of the older model of intentional two-way navigation, but there were still numerous questions left to be answered.

Modern Debate

In recent decades, the scholarship surrounding the study of East Polynesia has undergone significant revision, namely in the basic chronology of its initial colonization. Most older models of Polynesian colonization relied on the 'Long Chronology', which suggested that East Polynesia was colonized in a period between 200 BCE and 1000 CE.²¹ These dates were determined through a variety of sources, including linguistics, pollen sediment cores, and later, radiocarbon dating. Scholars

¹⁹ Clark, G., et al., 2008, Irwin, G., 2008

²⁰ Golson, J., 1965, Heine-Geldern, R., 1950, Holton, G.E.L., 2004, Holmes, L.D., 1958

²¹ Anderson, A., 1995, Best, E., 1918

from across the field of linguistics sought to study the formation of the language family, as it was seen as a way to determine how languages developed out of one another without the worry of outside influence.²² Unfortunately, early research did not account for inter-island communication. The current understanding of how island populations interacted indicates that any island within a day's sail share much of their linguistic traits.²³ There is evidence of at least some contact occurring between remote populations. This added complication caused the extensive reevaluation of how these languages developed.

The actual dating of much of this early work was done through the study of pollen sediments in lake and swamp beds. Most water bodies have periods of greater or lesser run-off feeding into them, resulting in patterns that can be found in the deposited sediments that can be counted much like tree rings to determine the approximate age of any samples embedded within the stratigraphic record. Although the process can be made more difficult by various climate events, such as storms; by taking a core sample, it is possible to get a chronology of vegetation in the area around the water body.²⁴ In modern studies it is more convenient to date pieces within the core using carbon 14 samples as it neutralizes some of those effects.

It was common for islanders to bring crop plants with them when populating a new island, like taro, banana, and coconut.²⁵ These pollens suddenly appearing in a sample are a good indication that islanders have arrived. Ash and the decrease of native pollens are also an indication, as they signify burning of native forest to make way for

²² Clark, R., 1979

²³ Di Piazza, A.D., et al., 2006, Pawley, A., 2015, Rehg, K.L., 1995, Walworth, M., 2014

²⁴ Cañellas-Boltà, N., et al., 2012, Hunt, T., & Lipo, C., 2012, Mann, D., et al., 2008

²⁵ Addison, D.J., 2008, Lepofsky, D., 2016, Wilmshurst, J.M., et al., 2011

fields. While these tests were quite sound in their assessment, their chronology was consistently overestimated because it was assumed the very earliest settlers would not leave a noticeable impact.²⁶ This was also the problem in estimating the chronology on archeological evidence alone. Based on what we now know of how populations grow in these conditions, this kind of evidence should have been visible within a couple of generations, rather than the centuries originally assumed, as the initial seed population tends to grow exponentially until capacity is reached.²⁷

Firm dates enter into the picture with the development of radiocarbon dating in the mid-20th century. Early radiocarbon dates supported the long chronology, as they showed a varying timescale to the exact times in which similarly placed islands were populated. These dates all tended to be quite old and spread out, ranging from 1000 CE on some islands to 200 BCE on others.²⁸ The problem arises when it is considered that the carbon being dated does not show when the sample was used in the target event, such as a log being burned in a cooking fire. It corresponds to the sample being removed from the carbon cycle, when carbon 14 was first incorporated into the structure of the tree. Therefore, any samples taken from long-lived trees can give dates hundreds of years before the event being measured. This is called the ‘old wood’ problem within the field of archeology.²⁹ When unreliable data points are removed, far more consistent dates appear all across eastern Polynesia, all corresponding to approximately 1100 to

²⁶ Athens, J.S., et al., 2014, Lipo, C., & Hunt, T., 2016, Wilmshurst, J.M. et al., 2011

²⁷ Hunt, T.L., & Lipo, C.P., 2017

²⁸ Anderson, A., 1995, Best, E., 1918, Finney, B.R., 1996, Kirch, P.V, 2000, 230-238

²⁹ Hunt, T.L. & Lipo C.P., 2008, Schiffer, M.B., 1986, Wilmshurst, J.M., et al., 2011

1200 CE.³⁰ The chronology of all of the theories so far discussed played a major role in their perception. The drift theory, in particular, was dependent on a slow, random colonization. With the new, tighter time frame, many of the old models of the culture surrounding voyaging and colonization had to be reevaluated. Many of the preconceptions of Polynesian population dispersal, such as successive generations of voyagers, were questioned.

³⁰ Allen, M.S., and Wallace, R., 2007, Hunt, T.L., and Lipo, C.P., 2006, Kennett, D., et al., 2006, Matisoo-Smith, E., 2012, McGlone, M.S., & Wilmshurst, J.M., 1999, Rieth, T., & Cochrane, E., 2015, Wilmshurst, J.M., et al., 2008, Wilmshurst, et al., 2011

Models of Human Dispersal

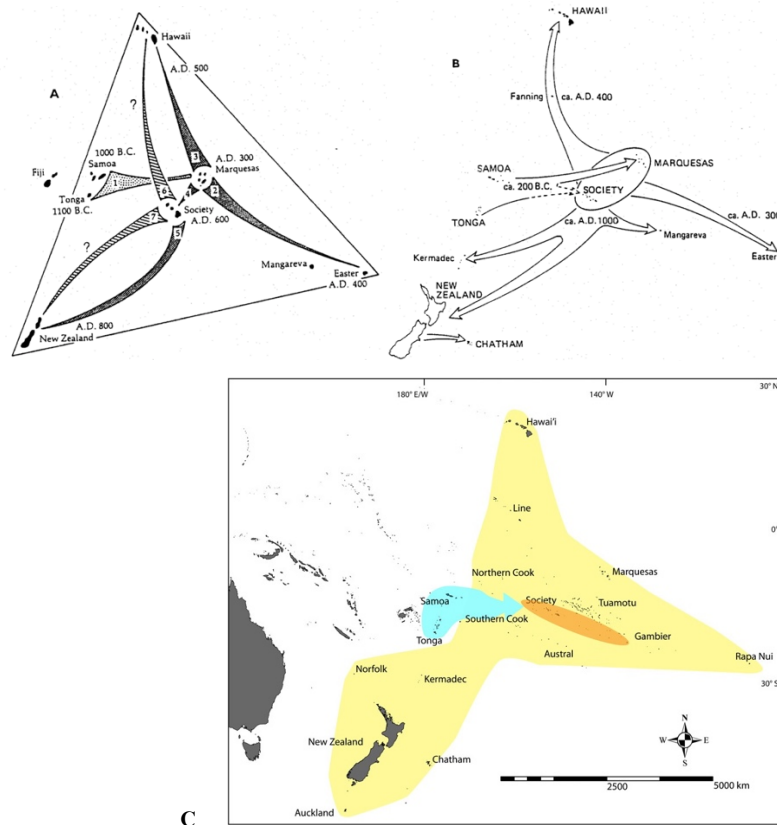


Figure 2: Three models of human dispersal in Polynesia derived from Radio Carbon tests under different levels of scrutiny, (A) Emory & Sinoto 1965, (B) Kirch 1984 (Kirch, P.V., 2000, 231), (C) speculates that the Society Islands, with the possible inclusion of Gambier Island was settled between 1025 and 1121 CE, while the more remote and marginal islands were settled in a wave between 1200 and 1290 CE. The most recent models indicate that the early dates found in the Societies may be inaccurate. (Wilmshurst, J.M., et al., 2011)

The initial catalyst for colonization of East Polynesia is still somewhat of a mystery. There is substantial speculation as to why such an endeavor was undertaken, ranging from warfare or famine-induced refugees, exploration for its own sake, or a simple land grab spurred on by advances in maritime technology.³¹ We may never know why, but we are increasingly close to a better understanding. As of the writing of

³¹ Burley, D.V., and Addison, D.J., 2014, Burley, D., et al., 2015, Clark, G., et al. (eds.), 2008, 87-93, Di Piazza, A., et al., 2006, Rongo, T., et al., 2009, Wilmshurst, J.M., et al., 2011

this paper, estimations for the settlement of Eastern Polynesia are split into two parts. There is the early settlement from Samoa into the Society Islands and Gambier between ca. 1025 CE and 1121 CE,³² and the rest of East Polynesia in the thirteenth century (figure 3). There is some evidence to support that the earlier dates in the first wave are inaccurate, allowing for rapid colonization of the entirety of Eastern Polynesia within a few hundred years, possibly as short as a single century.³³ The implications of the theory would be astonishing in the sheer scope of the endeavor, especially for a people unaware of that scope from the beginning.

Research into the actual function and manner of use with which the vessels used to undergo these proposed migrations have also evolved significantly. The modern scholarship on human population dispersal in East Polynesia is primarily focused on the debate of the extent of intentional traffic between island groups. It is now well accepted that such travel did exist at this point;³⁴ but it is one thing to say that voyagers set out with the intent of finding new islands to inhabit, and quite another to say that voyagers set out to go to islands long settled. The two major contributors to this debate are Ben Finney, who actively supported the interconnection narrative since the late 1950s until his death in 2017, and Atholl Anderson, who advocates the narrative of limited two-way voyaging.

Each of these theories is in large part based on the variability in the sophistication of sail plans used at the time of heightened contact after initial colonization. Finney's model relies on the strategic use of winds to navigate between

³²Wilmshurst, J.M., et al., 2011

³³ Wilmshurst, J.M, et al., 2011

³⁴ Collerson, K.D., and Weisler, M.I., 2007, Couper, A.D., 2009, Lewis, D., 1972, Weisler, M.I., and Kirch, P.V., 1996

island groups, as local differentials to global norms allow for travel between islands in mostly downwind or crosswind trajectories, while sailing against the global prevailing winds.³⁵ The possibility of significantly more complex vessel designs than those found historically is also considered. Finney is not as concerned with providing a history of colonization, as much as mapping prehistoric trade routes as a more the central facet of his studies, but other researchers have concluded that aspects of his basic model make sense regarding safety in navigating. It allows for the slow advance of sailors into the prevailing wind during brief reversals, leaving them with a fair amount of certainty of being able to return home.³⁶ Unfortunately, while they are often drawn from oral history alongside wind pattern data, archeological evidence for substantial contact is often far less abundant. In his work, he has lamented this lack of a clear ‘smoking gun’.

Unfortunately, pottery making declined after Lapita voyagers reached the mid-Pacific, and was not spread farther east by their Polynesian descendants. Moreover, although obsidian occurs in New Zealand and Easter Island, tools made from this type of volcanic glass were apparently not widely spread from these peripheral islands. (Finney, B.R., 2007, 1873)

His data is also often reliant on the maximum performance characteristics of pre-contact canoe technology, thus drawing some criticism to his more grandiose claims.³⁷

Atholl Anderson approaches the problem from a slightly different perspective. He also assumes intentional two-way navigation but differs in one clear area. In his models of inter-island navigation, he does not allow for the ability to navigate against the wind. Instead, he more often has relied on shifts in climate patterns, associated with

³⁵ Finney, B.R., 1988, Finney, B.R., et al., 1989, Finney, B.R., 1996, Finney, B.R., 2001, Horvath, S.M., & Finney, S.M., 1969

³⁶ Irwin, G., 2008, 22

³⁷ Anderson, A., 2008

El Niño events, causing a temporary reversal of the predominant winds to facilitate upwind migration.³⁸ This approach has the benefit of providing a window of suitable winds to allow an eastward expansion closely matching the time- period of the late chronology.³⁹ Of course, there are still questions left to be asked by this model.

The downwind sailing theory makes a minimum estimation of performance, which has the virtue of not over-estimating it. El Niño is employed as a forcing agent and provides a loose chronology for colonization. However, it constrains the direction of advance and rather begs the question of why downwind Lapita voyages were not made westward to Papua New Guinea and Australia in La Niña conditions. (Irwin, G., 2008, 24)

Motivation is difficult to determine, but among populations so capable of traversing vast stretches of an ocean against the prevailing conditions, the question of why they never turned around is a relevant one.

There probably was some westward travel, if only due to sailors being blown off course, but why there is then so little evidence of westward dispersals remains a point of some study. There is almost a complete lack of linguistic and cultural exchange evident in the Western islands of Oceania. It is somewhat understandable that there might not be a noticeable movement of people; as it is a well-accepted behavior theory that given the chance populations will tend to expand into areas with less competition even if they are not as rich in resources.⁴⁰ This is called the ideal free distribution, and it seems to fit the data from the Polynesian expansion to a degree, but it is curious when the warlike and conquest prone cultures described historically would not have left more of a mark.

³⁸ Finney, B.R., 1988, Goodwin, I.D., et al., 2014, Irwin, G., 2008

³⁹ Anderson, A., 2006a

⁴⁰ Kraft, J.R., et al., 2002

An important addition to all of the theories so far discussed, both past and present that has heavily influenced the canon of Polynesian colonization is the idea of contact with the Americas. Unlike the theories of Heyerdahl and his supporters, this theory indicates that it was the Polynesians who first made contact with the Americas, rather than the reverse. There is tantalizing evidence can be found throughout both Polynesia and western South America. However, equivocal evidence for direct contacts has often proven elusive.⁴¹ The sweet potato is undoubtedly of South American origin, and yet it is a staple of the Polynesian diet, while the chicken, a bird native to Southeast Asia, possibly found its way into the culture of the Inca before European contact.⁴² This is not a new observation, and, in fact, played a role in dismantling Heyerdahl's claims.

It took Thor Heyerdahl and his crew nearly four months to drift to the Tuamotu islands, and sweet potato tubers become rotten in less time than... it is more logical to assume that it was made by a seafaring people like the Polynesians who could have made a trip from the Marquesas Islands to northern Peru in three weeks in a sailing canoe averaging seven knots. (Holmes, L.D., 1958, 129)

There is also some evidence of cultural diffusion through similarities in artifacts and words,⁴³ although it is quite scant in comparison to the botanical evidence. What remains is to find concrete evidence of human involvement, as whatever contact existed appears to have been very brief and late in time, which seemed to have left minimal impact on either region.

Outside of the questions of how and why Polynesians started and continued to navigate between islands, there is also the question of when and why they stopped. By the 14th century there is almost no evidence for new human settlements or fresh gene

⁴¹ Thomson, V.A., 2014

⁴² Fitzpatrick, S.M., & Callaghan, R., 2009, Storey, A.A., 2007, Storey, A.A., et al., 2011

⁴³ O'Connor, J.T., White, F.J., & Hunt, T.L., 2016, Walworth, M., 2014

flow, as well as the abandonment of many of the more remote or marginal islands that were inhabited.⁴⁴ One of the narratives proposed that the initial surge of colonization into East Polynesia was followed by a ‘devolution’ in vessel design after all the available land was claimed. This hypothesis is partly in response to the observations of the maritime technology on outlying Polynesian islands, made by European explorers who stated that the vessels at the islanders’ disposal were not capable of concerted efforts in exploration. It is thought that the vessels observed in Hawai`i, Rapa Nui, and New Zealand were the descendants of early voyaging canoes, made by a healthy population no longer in the throes of expansion.⁴⁵ Without the need for long oceanic voyages, large canoes were impractical, and thus discontinued even in the areas where building them was relatively easy. This hypothesis disregards trade as an incentive for travel.

The rival view sees an average advancement in vessel design across Polynesia,⁴⁶ citing such advancements as the crab-claw sail design in Hawai`i that allowed for better management of the wind, and a closer tack into the wind.⁴⁷ These advancements were not necessarily beneficial for inter-island transport, but rather a case of individual groups providing crafts best suited for their needs, given their resources.⁴⁸ For example, the giant canoes of New Zealand do not compare at all to those on Rapa Nui, and neither is capable of inter-island transport, but both were adequate to the needs of their island populations.

⁴⁴ Anderson, A., 2001, Anderson, A., 2015

⁴⁵ Anderson, A., 2008

⁴⁶ Anderson 2006b, 760

⁴⁷ Campbell 1995, 12-18

⁴⁸ Arana, P.M., 2014, Best, E., 1918, 175

There is also the possibility of a combination of these two ideas, as there is evidence of contact between Central and West Polynesia around the same time as the first European explorers ventured into the area, allowing for the advancements from either region to make it into the other.⁴⁹ This hypothesis is one of the main causes of controversy within current research, as such an influx of new maritime technologies, the possibility of spreading of European ideas ahead of their explorers,⁵⁰ all added to the changes already seen, would have distorted how the first vessels would have performed. It may never be entirely clear what the original Polynesian voyaging canoes looked like, or even if there was a standard when the original pioneers set out for seas. Regardless, the very idea of such a craft has rooted itself deep within the academic community that studies these phenomena.

A real effort has yet to be made in modeling the exact form of the Polynesian voyaging canoe, and not simply because of the lack of information. Past efforts, such as those of Finney and Anderson, have focused entirely on a limited, or even a single source off of which they modeled their vessel. As has been demonstrated, a great deal is known from the various historic records, so long as one is aware of the hyperbole that was common in early anthropological texts. A concerted project to catalog the various diagrams and descriptions available from early explorers and settlers could create the data set required to finally get a solid image of how the original Polynesian voyaging canoe was designed.

⁴⁹ Finney, B.R., 1988, Rolett, B.V., 2002, Walter, R., Sheppard, P.J., 1996

⁵⁰ Best, E., 1976, 341, Campbell, I.C., 2003, Haddon, A.C., & Hornell, J., 1936, 18, 87, Richards, R., 2008

Modeling Dispersal and Voyaging

One of the largest fields that is undergoing current expansion is that of modeling. Since the early period of research in the region it has been recognized that the distance separating islands seems to have played a major role in their sequence of habitation. Almost every pause in settlement has been due to a significant water barrier between islands. Fiji, Tonga, and Samoa have a 1200 km gap separating them from their nearest neighbor in Melanesia, whereas the distance between the archipelagos is approximately 800 km, a span that could be crossed in approximately 48 hours based on the reported characteristics of their craft at contact, as well as models of sailing performances of reconstructed craft.⁵¹

Canoe Recreation Sailing Chart

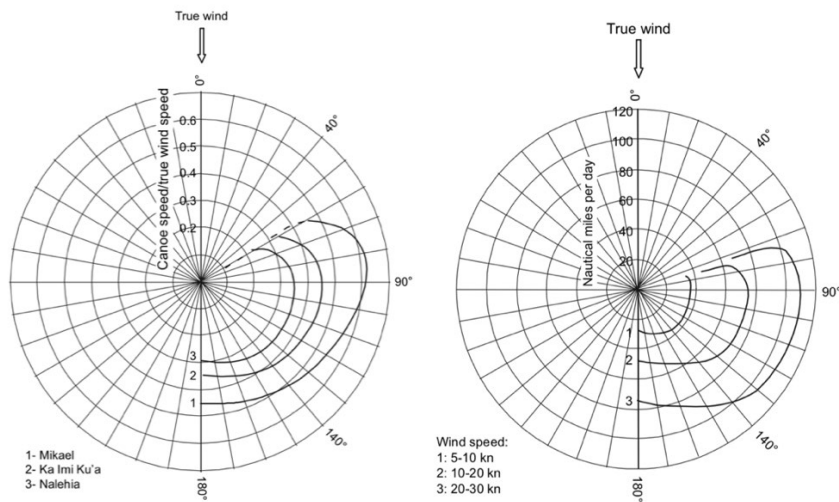


Table 1: Competitive charts of wind-speed and angel as they relate to canoe speed for three of the Hawai`ian Voyaging Societies recreation canoes (De Piazza, A.D., et al, 2006).

The person doing the most work on modeling is Geoffrey Irwin, an archeologist from New Zealand. He uses the visible horizon, that being the area in which traces of

⁵¹ Best, E, 1976, 339, Gunson, N., 2008a

the island become visible such as changes in ocean currents or seabird activity, and compares it to the distance from its neighbors to postulate probable settlement patterns.⁵² These models are very elegant and intuitive. Similar models are being used to predict settlement patterns all across the world, including speculation into the future. As of now, Irwin's work is best optimized for the settlement of the Lapita Complex. Current accepted colonization dates in East Polynesia seem to indicate an extremely rapid colonization, with only a small correlation between settlement order and remoteness.⁵³

It has been shown that El Niño Southern Oscillation events can cause unusually prolonged easterly shifts to the prevailing winds, allowing for more daring explorations in that direction,⁵⁴ possibly explaining the acceleration of the expansion. There is evidence for such an oscillation around the time of the colonization of East Polynesia,⁵⁵ and, in fact, these match up reasonably with projected dispersal and settlement dates. Given very rudimentary metrics for vessel performance under those conditions it is very possible that they would have been capable of reaching many of the island groups in East Polynesia with little trouble. From those islands the more remote regions also become viable targets under those conditions. Taking this research into account, it seems likely that a major change in vessel design was less important than climatic factors in initiating East Polynesia's settlement. These insights are why these speculative models are so useful in consort with the more physical archeology found in digs and reconstruction efforts.

⁵² Irwin, G., 2008, Irwin, G., 2015

⁵³ Wilmshurst, J.M., et al., 2011

⁵⁴ Anderson, A., et al., 2006a, Goodwin, I.D., et al., 2014, Montenegro, Á., et al., 2016

⁵⁵ Montenegro, A., et al., 2014, Montenegro, A., et al., 2016, Piazza, A.D., 2013

Layman Research and Voyaging

The drive to better understand the voyaging past of Polynesia is not exclusive to researchers, and in fact, makes up a large segment of the Neo-Traditionalism movement. In modern times, Polynesian voyages are a point of pride amongst the people that now live in the region, and a point of acclaim they hold up to the rest of the world. Starting in the mid 20th century, and fully underway by the 1970s, the Hawai`ian Renaissance had swept the islands, bringing with it a revival of native watercraft such as surfing and paddle-driven canoe racing. The movement was primarily a way in which native Hawai`ians could create a unified identity, for use in both the political and broader cultural spheres.⁵⁶ One of the most iconic symbols of this movement are the voyaging canoes built during this period. Ben Finney, one of the leading figures in this revival, was a large part of their gaining such a prominent position. He co-founded the Polynesian Voyaging Society, and in that capacity built several double canoes with which to provide proof of concept for his theories.⁵⁷ That research, as well as its active use as an object of cultural icon, cemented the idea of voyaging into the Neo-Traditionalist identity of the Polynesian people. Other Neo-Traditionalist movements were happening in concert throughout Polynesia. In 1995 replica double canoes from numerous groups met at Awarua in French Polynesia, to establish a common identity and purpose. Such movements continue to this day, raising awareness of Polynesian culture, both within and outside Polynesia.

⁵⁶ Finney, B.R., 1994b, Finney, B.R., 2003

⁵⁷ Finney, B.R., 2003

Chapter 3: The Evolution of Vessel Design

Introduction

The exact form of the Polynesian voyaging canoe is still a mystery in its specifics, but advances in our knowledge have been made through a combination of archeological research, historical reconstruction, and analysis of physical factors of wind and current that would have restricted the forms used in sailing. It has been demonstrated that environmental factors that occur in a specific region can have an enormous effect on how the basic Polynesian culture and architectural traditions express themselves.⁵⁸ The basic form of the Polynesian canoe is well known, based on common traits exhibited on all islands in the region up into the historic period. They were, “slim canoes hewn with stone adzes, lashed together with coconut fiber line, powered by mat sails” (Finney, B.R., 1977).

Historic Voyaging Canoe Plans

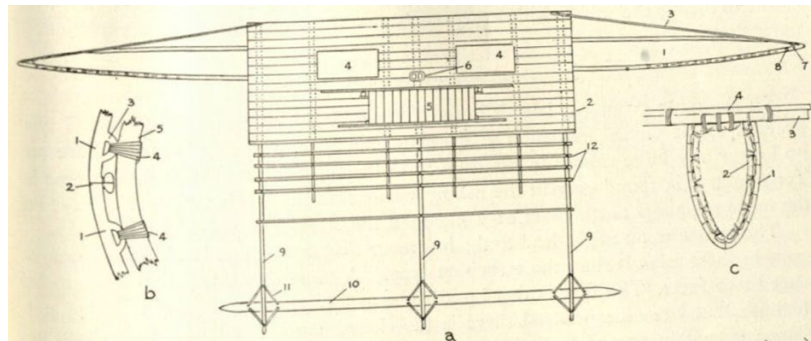


Figure 3: Plans depicting a single outrigger canoe (vaka or hamatafua) described in the Tongan Archipelago. Noteworthy are the storage compartments (a4) and the ribbed internal structure (b and c) (Haddon, A.C., & Hornell, J., 1936).

It is typical to think of ‘primitive’ canoes as dugouts, but, with a few exceptions, this is broadly untrue in Polynesia. The specifics of design varied widely between island

⁵⁸ DiNapoli, R.J., et al., 2017

groups, but most often vessels were made up of lashed planks.⁵⁹ Holes would be bored through the plank at its edges, so that rope could be fed through to stitch each side together. This allows for a much more versatile construction in both hull shape and size, as it is not dependent on the dimensions of the trunk. They are all constructed out of multiple buoyant bodies, most typically a single hull with an outrigger lashed alongside to spread out the craft's balance point; a necessary arrangement for roll stability and the use of sails on such an otherwise narrow craft. A platform would be constructed on top of this frame for living space while underway, with the hollow of the hull primarily used for storage of provisions and trade goods.⁶⁰ Often the largest craft had two semi-symmetrical hulls for added stability and storage potential. Sometimes a second outrigger was used, but such arrangements were typically only found in the more western portions of the Pacific Islands, well outside of Polynesia.⁶¹ It granted greater stability at the cost of increased drag.

One aspect of this hull configuration that has provoked some controversy is that they could have been shunted.⁶² Shunting is the process in which a vessel changes its heading across the wind by changing the location of its sails to the opposite end of the vessel, rather than tack across the wind or wearing with the wind, both of which have downsides that make them undesirable. If shunting were a common procedure, it would mean that the sail plan utilized by the Polynesians would have been incredibly mobile, and thus probably not as rigid as is called for in the Finney model. Descriptions of

⁵⁹Arana, P.M., 2014, Haddon, A.C., & Hornell, J., 1936, 8, 32, 144, 148, Johns, D.A., Irwin, G.J., & Sung, Y.K., 2014, Sinoto, H.Y., 1979

⁶⁰ Best, E., 1976, 136, Haddon, A.C., & Hornell, J., 1936, 13-15, 189

⁶¹ Irwin, G., 2008

⁶² Irwin, G., 2008

Polynesian sails seem to support the basic plan needed for this maneuver, although without much conviction of its use.⁶³ On the other hand, there is substantial evidence that the typical Polynesian canoe was built with a distinct bow and stern, as well as the sail plan mentioned above being a possible historic innovation.⁶⁴

Hōkūle‘a



Figure 4: The artist Herb Kawainui Kane’s rendition of traditional Polynesian voyaging canoes, based on the Polynesian Voyaging Societies model canoe, Hōkūle‘a (Hōkūle‘a by Herb Kawainui Kane, Courtesy Herb Kane Heritage Trust).

Canoe Lashings



Figure 5: A preserved Marquesan near-shore fishing canoe showcases the typical manner of lashing planks flush to one another with fiber rope and bread fruit caulking.

The vessels were definitely propelled by sails of some type, even if the plan used at the time is uncertain. It was likely a spare rigged design of some type, that being

⁶³ Haddon, A.C., & Hornell, J., 1936, 18, 25, 40, 94, 120-122, 167, 190, 208, 238

⁶⁴ Anderson, A., 2014, Campbell, I.C., 2003

a triangular shaped sail with some combination of mast and spare.⁶⁵ The examples still in use in the 17th century, when European explorers first documented their design, were typically 15-20 meters long and mostly double-hulled,⁶⁶ creating a large deck on which to haul people and cargo. These may have been relatively recently introduced, but carvings and oral tradition throughout the region seem to indicate that they were in use during even the earliest expeditions. The mere fact of the colonization efforts substantiate that they must have had significant hauling potential and reliability in facilitating population dispersals.⁶⁷

Biological Models

As the field of archeology has strived to become more scientific in its methodology over the past few decades, it has begun borrowing various models from other disciplines, particularly ecology. Several of these models can be employed in explaining the population dispersal into East Polynesia, namely Optimal Foraging Theory. The model dictates that a population will expand at the point at which the effort needed to compete with others becomes even slightly greater than the effort needed to move to a different environment, even one with fewer resources. This model would explain why as soon as the technology was developed, or the first new island was discovered, the drive to escape competition would have necessitated the rapid dispersal we see in the archeological record. It also explains why there is a tapering off in long

⁶⁵Anderson, A., et al., 2006a, Campbell, I.C., 1995, Feinberg, R., 1988, Haddon, A.C., & Hornell, J., 1936, 18, 25, 40, 94, 120-122, 167, 190, 208, 238, Irwin, G., 2008

⁶⁶ Finney, B.R., 1988

⁶⁷ Finney, B.R., 1994b, Johns, D.A., Irwin, G.J., & Sung, Y.K., 2014, Irwin, G.J., Flay, R.G.J., 2015, Sinoto, H.Y., 1979

distance voyaging at approximately the same time we see that most islands had fully colonized their coastlines.⁶⁸

Another model that can explain the discontinuation of voyaging is a model that disincentives voyaging. In island ecology it has been observed that similar bird species often find their way onto different islands. These birds are generally very good fliers, but after reaching an island, the species almost always evolves behavior and physiology that prevent longer flights.⁶⁹ There are a number of possible explanations for this phenomenon, such as the wasted energy needed to maintain the trait, when it is no longer a useful skill in deriving food, or the likelihood of straying too far from the island to get back is much higher for the better flyers. The same can be used to describe canoe voyaging potential, as when voyaging became less viable of an option, the design of the canoes would change to make them less capable of straying too far from their home island.

To best understand the evolution of the Polynesian canoe after dispersal, it takes every dataset that can be derived even tangentially related to the topic. Biological and ecological models can be incredibly helpful in determining what some of the most pressing environmental factors would have been. The realities of the risks that would have had to have been weighed against their possible reward across generations, would have been the primary force dictating how canoe designs changed over time. There is no real way to truly understand the dangers faced by early voyagers beyond extensive statistical analysis utilizing data that is as of yet unknown. Any direct evidence is crucial in providing a firm data point off which to base further speculations.

⁶⁸ Lepofsky, D., 2016

⁶⁹ Komdeur, J., et al., 2004

Archeology

One reason the vessels of Polynesia cannot be studied in a like manner as those found in Europe in the same respective eras has to do with the geography of the region, as well as some of the particular elements in the design. European ships relied on deep keels to navigate rough seas and strong currents, whereas the Polynesians utilized catamaran like designs to create a more stable platform. The latter requires no ballast that would drag a sinking ship to the bottom, where the anaerobic environment may preserve the wooden hull for further analysis. Most of those finds were also found not in the ocean, but in river estuaries; a phenomenon almost completely missing in Polynesia. There are few large rivers in Polynesia, nor a great need for pre-European contact Polynesians to have sailed up the few that exist. There very well might be pieces of submerged canoe in the lagoons and sand beaches that are common in the region, but it is unlikely any will be found without an extreme effort that is beyond the scope of serious archaeology in the area.

There have been canoe fragments found in the Society Islands and New Zealand,⁷⁰ dating roughly to the time-period of initial colonization, but they were predominantly found by chance. The Society Islands site, a swampy portion of Huahine called Fa'ahia, was the site of a hotel renovation that allowed the dredging of the entire site before it was irrevocably altered. Analysis of the artifacts determined that they were probably part of a double canoe approximately 24 meters (80 ft) long. This is primarily based on the configuration of two large deck plank segments that fit the design of historic contemporaries almost perfectly. The site may have been that of a construction

⁷⁰ Johns, D.A., Irwin, G.J., & Sung, Y.K., 2014, Sinoto, H.Y., 1979

or renovation attempt that was abandoned for some reason, based on several artifacts that seem to be have been undergoing construction before they were deposited, including a bailing device and the steering oar.⁷¹ The site also contained several stone tools that would have been appropriate for woodworking.

The vessel appears to have been of the same basic design as those found in historical accounts, with a few differences. The before-mentioned steering oar is far blockier than later ones found in the area, being more reminiscent of those found in the Marshall Islands,⁷² possibly indicating a point of contact. There was also a canoe brace found that does not match the shape of latter examples of spanners, of which the artifact is thought to be an example. To what extent this indicates a change in design is unknown. The site was dated at being deposited somewhere between 700 and 1200 CE. Based on new estimates of the settlement chronology of the region, that would indicate that the vessel these artifacts came to the region as part of the earliest wave of explorers given that the early dates are well outside all the currently accepted earliest settlement of the region.⁷³ Given the range of materials that were analyzed for radiocarbon dates, it is likely that they received several dates that were much older than the target event. The vessel could have originated much further west, as there were still ample signs of communication throughout this period.

The Anaweka estuary find in New Zealand consisted of a single section of hull, and was only found by extreme providence after a cut bank left it exposed after a

⁷¹ Sinoto, H.Y., 1979

⁷² Sinoto, H.Y., 1979

⁷³ Athens, J.S., et al., 2014, Wilmshurst, J.M., et al., 2011

storm.⁷⁴ While a single hull panel is not able to give a great deal of new data regarding the exact structure of prehistoric vessel design, it can be used to help shore up our understanding. This find is primarily of importance because it does not differ significantly from the basic idea of how the ancient canoes of the region were designed. As previously stated, historical accounts of vessel design across Polynesia, and the rest of the Pacific Islands, almost invariably consisted of a dugout or log-built base, with side-strike planks to build up the hull. The exact ratio between log-base and side-strikes varied based primarily on the availability of the large trees needed to build a complete dugout vessel of the size required for oceanic voyaging. The dimensions of a vessel can tell us a great deal about the priorities of its builders.

The panel itself is just over 6 meters (20 ft) long, making the vessel it was made for at least 12 meters (40 ft), assuming it had a symmetrically curved hull. As those found historically in the region did so, it is likely that is the case.⁷⁵ It is roughly straight-edged and likely was more so if the effects of the past few centuries of neglect were to be ignored, with a tapered point curving upward on one side, indicating that it adjoined either the bow or the stern. It also includes a carved turtle on a raised section near the outside tapered end. Since turtles were not native to the region, this indicates that either the cultural significance of turtles in voyaging, as seen in much of tropical Polynesia, had been maintained up to this point, or that this particular vessel had been constructed in an area with more frequent turtle sightings. It was probably located on the stern starboard side, above the waterline, if it is to be assumed that the turtle was facing

⁷⁴ Johns, D.A., Irwin, G.J., & Sung, Y.K., 2014

⁷⁵ Johns, D.A., Haddon, A.C., & Hornell, J., 1936, 211, Irwin, G.J., & Sung, Y.K., 2014

forward and on the outside of the canoe.⁷⁶ It was built with reinforcing ribs carved out of the same timber as the panel and bore holes marking it as a central timber. The bores themselves show sign of repair and maintenance, indicating that the craft, or at least the plank, was well used before it was deposited. It had likely traveled a great deal as part of one or more different canoes before that event, originating well outside of New Zealand.⁷⁷

Given the infrequent finds from which archeologists have derived their knowledge of canoes, it is surprising how much is known. With these fragments as guides, it has been possible to verify that at least some of the vessels were of a similar design to what archeologists and historians have proposed as the standard design of the ancient Polynesian voyaging canoe. Our current understanding of human population dispersal that resulted in the peopling of Eastern Polynesia can be described as something akin to a land rush. It is unclear as to the precise sequence of events that led to the first migrants from Tonga or Samoa, the two most likely origins for colonists, to start searching out new islands, but whatever did, had them on nearly every island large enough to support agriculture within one-hundred years.⁷⁸ Even the most marginal of islands show evidence of a human presence dating to between the 12th and 14th centuries.⁷⁹ Evidence for limited trade, legalistic and cultural exchange, and the seasonal exploitation of remote islands continued throughout this period,⁸⁰ before dropping off to a far more limited contact between nearby island groups as it became

⁷⁶ Johns, D.A., Irwin, G.J., & Sung, Y.K., 2014

⁷⁷ Johns, D.A., Irwin, G.J., & Sung, Y.K., 2014

⁷⁸ Athens, J.S., et al., 2014, Wilmshurst, J.M., et al., 2011

⁷⁹ Anderson, A., 2006a, Athens, J.S., et al., 2014, Di Piazza, A., & Pearthree, E., 2001, Wilmshurst, J.M., et al., 2011

⁸⁰ Clark, G.R., et al., 2014, Collerson, K.D., and Weisler, M.I., 2007, Couper, A.D., 2009, Di Piazza, A., & Pearthree, E., 2001, Scaglione, R., 2005, Walworth, M., 2014, Weisler, M.I., and Kirch, P.V., 1996

more efficient to exploit inland territories on one's own island, rather than journey to an already populated island.

Historic Accounts

There were many people involved in the historical mapping and categorizing of the Pacific Islands, starting in the 16th century when Vasco Núñez de Balboa first sighted the Pacific Ocean from Panama in 1513. It did not take long before expeditions were sent to plumb its depths, as they searched out land, treasure, and trade. Explorers flooded the region over the next 300 years, hailing from Spain, Portugal, France, the Netherlands, and the relatively late-coming but prolific Britain.⁸¹ Some searched for new routes to known regions, while others sought out new lands. Many Europeans thought that the sheer size of the Pacific Ocean indicated the existence of a new continent somewhere in the regions of Polynesia, Melanesia, and Micronesia, or as it was then known, the South Sea.⁸² It was called Terra Australis, and its potential existence led to the discovery of many of the most remote Polynesian islands. It was also this theory that spawned the notion that Polynesia comprised a sunken continent.⁸³ Over the course of the European expeditions, nearly every island in the Pacific was documented to some degree, including some of the first anthropological analyses conducted on such expeditions.⁸⁴

The first expedition to reach the Pacific Islands was the Spanish fleet led by Ferdinand Magellan, who attempted the circumnavigation the globe in 1519. While

⁸¹ Delaney, J., 2010

⁸² Estensen, M., 2006, Hawkesworth, J., 1773, Vol. 2, 184, Henry, D., 1774, Vol. 1 471, Home, H., 1775, 18, 38, 46-47, Pringle, J., 1776, 2, Purchas, S., 1625

⁸³ Brown, J.M., 1924

⁸⁴ Harari, Y.N., 2014

passing through Polynesia, they saw only two islands in the Tuamotus where they report no interaction with any native presence, as well as Guam.⁸⁵ They make little mention of the peoples they encounter, much less the sailing vessels in the area. Álvaro de Mendaña y Neira's 1567 and 1595 expeditions were the next major forays into the South Pacific, resulting in the description of the Solomon Islands in some detail, as well as some description of the Marquesas Islands.⁸⁶ The last major Spanish expedition into the Pacific Islands, led by Pedro Fernandes de Queirós, discovered the Buen Viaje Islands in Melanesia, and probably sighted the Society and Tuamotu archipelagoes on his way west.⁸⁷

The first English venture into the Pacific was made by Sir Francis Drake in 1577, becoming the second to do so in a single mission, and the first to command the expedition throughout. His journey through Polynesia was not long, with no landfalls until he reached the Indonesian islands.⁸⁸ Englishmen would not return to the region for over a century when William Dampier circumnavigated the globe in 1679. Although he accomplished this feat three times, ending in his death as a result of the last expedition in 1710, he spent a majority of his time in Indonesia and Australia.⁸⁹ He was followed by Samuel Wallis, who in 1766 set sail with orders to explore the region. He mapped much of the Society Islands, as well as the Tuamotus,⁹⁰ before proceeding onward to the Marshall Islands in Micronesia. He was meant to travel in company with Philip Carteret but was separated while traveling through the straits of Magellan. Carteret went

⁸⁵ Beaglehole, J. C., 1966, Ch. II, Purchas, Samuel, 1625

⁸⁶ Beaglehole, J. C., 1966, Ch. III, Purchas, Samuel, 1625

⁸⁷ Beaglehole, J. C., 1966, Ch. IV

⁸⁸ Beaglehole, J. C., 1966, 60-63, Trusler, J., 1778, ii

⁸⁹ Beaglehole, J. C., 1966, 170-174, Trusler, J., 1778, 228

⁹⁰ Beaglehole, J. C., 1966, 200-206, Trusler, J., 1778, 2-56

on to describe the Pitcairn and the Carteret Islands.⁹¹ The last major British voyages of discovery was those of James Cook starting in 1768. Perhaps the most prolific of any explorer in history, he was the first European to traverse much of the Pacific, including the Hawai`ian Island chain on his third voyage.⁹² Although his mapping of Hawai`i granted his ascendancy into the halls of the European discoverers, it was his, and his crew's, descriptions of the people they came across that set his voyages apart.⁹³ Even the islands already thoroughly traversed can trace most of their anthropological history back to Cook's expeditions.

Throughout this period, the Indonesian islands were traversed almost continually by Portuguese, Spanish, Dutch, and English shipping, with a heavy emphasis on the Dutch. The Dutch East India Company, which was founded in 1602, was responsible for much of the region's maritime traffic, including expeditions to discover new islands and shipping routes. The voyage of Abel Janszoon Tasman in 1642 was perhaps their most successful exploratory venture, during which his fleet became the first Europeans to land on both Tasmania and New Zealand.⁹⁴ They also traveled through the Tongan archipelago and Fuji. Other Dutch enterprises, funded by rival companies, also contributed to discoveries in the region. In 1615 Jacques Le Maire and Willem Corneliszoon Schouten explored the Tongan archipelago as part of their circumnavigation of the globe,⁹⁵ and in 1722 Jacob Roggeveen, who sailed for the

⁹¹ Beaglehole, J. C., 1966, 200-213, Trusler, J., 1778, 160-170

⁹² Beaglehole, J. C., 1966, Ch. X, XI, XII, Cook, J. 1777, Vol. 1 and 2, Trusler, J., 1778, 186-227

⁹³ Harari, Y.N., 2014, 276-278

⁹⁴ Beaglehole, J. C., 1966, Ch. VII

⁹⁵ Beaglehole, J. C., 1966, 127-184

Dutch West India Company, was the first European to sight Rapa Nui.⁹⁶ He also mapped much of the Society Islands, including Bora Bora, parts of the Tuamotu archipelago, as well as Samoa.⁹⁷

The last dominant world power to send an expedition to explore Polynesia was the French. In 1766 Louis Antoine de Bougainville was tasked with the journey to circumnavigate the globe. Although being primarily politically motivated, as it was meant mostly as a gesture to indicate French ability after their defeat in the Seven Years War with Britain, the voyage is vital due to it being the first to bring dedicated naturalists as part of its crew. They stopped on the island of Otaheite in the Societies, as well as in Samoa,⁹⁸ and although they did not discover any new lands, theirs were the more descriptive accounts. France would come to have cultural dominion over the region in the subsequent centuries, in part due to the precedent set by this voyage.

These expeditions were undertaken with the express purpose of expanding territory and trade routes of the European powers that sponsored them. Developments in their cultural prerogatives, particularly science and knowledge generation in general, made it paramount for such expeditions to not only describe the lands and peoples they saw in terms of potential conquest, but also speculate as to their origins and the reason for their state of being.⁹⁹ This unique set of priorities are what let future historians and cultural anthropologists receive a snapshot view of many hundreds of cultures, before increased interconnection to far-flung regions altered them from traditional practice. In the case of artifact design, such as with maritime vessels, this can be crucial in

⁹⁶ Beaglehole, J. C., 1966, 181-182, Roggeveen, J., 1722, 93 - 115

⁹⁷ Beaglehole, J. C., 1966, 180-197

⁹⁸ Beaglehole, J. C., 1966, Ch. IX, Bougainville, L.A., 1831, Henry, D., 1774, Dunmore, J., 1965, 57-113

⁹⁹ Harari, Y.N., 2015

understanding what attributes were native to the culture at the time of contact with the explorers in question, and what was introduced later.

A relatively significant amount of time was dedicated to describing Polynesian boats, for a variety of reasons, the most straightforward of which is that these were primarily naval expeditions, headed by boating people who would quite naturally first analyze the maritime capabilities of the people they came across. In describing the vessels of the Maori of New Zealand, Dr. Savage wrote, "These will contain upwards of thirty warriors, and they sometimes lash two of them together. Ten or 15 of these double canoes must form a powerful fleet and would prove formidable to a European merchant ship," (Savage, J., 1807, 62). From a military mindset, assessing a potential enemy's mobility over a primarily aquatic environment is crucial, and scientifically the question of human origins on the islands has everything to do with that same capability. Cook was entirely convinced of an interconnected Polynesian culture, based on oral traditions describing ancient voyages, as well as an understanding of the geography of the islands that allowed Cook to traverse thousands of miles through central Polynesia with confidence of finding whichever island he directed himself toward.¹⁰⁰ Boats were among the most prevalent drawing made throughout the European expeditions. It is unclear what the specific vessel design was during the colonization phase, but their general form is not a complete mystery, as there are numerous historical accounts of the vessels found in the area in the 17th and 18th centuries.

In the next few sections I will analyze the historic vessels of Polynesia as they were described by these and latter expeditions. It is likely that many of the accounts are

¹⁰⁰ Cook, J., 1777

faulty in some way, whether it be from imprecise recollection or observation, or straight exaggeration. It is very likely that many of the lengths that will be mentioned will be over estimating the true scale. Regardless, it is possible to determine many of the characteristics associated to various craft, if not the specific hull plan. Through this analysis it should be possible to gain insight on their common ancestors that were capable of feats of long distance navigation and transport across Oceania.

Central Polynesia

Current models of the settlement history of Eastern Polynesia indicate that, after the original rapid expansion, contact tapered off until almost no long-distance voyaging occurred after approximately the 14th century.¹⁰¹ The exception to that rule was in Central Polynesia, where islands and island groups were close enough together so that water gaps larger than the distance one could sail in a day were uncommon, thus allowing for continued contact across a vast distance, while mainly engaging in only short-range expeditions.¹⁰² In this context I am defining Central Polynesia as including the islands from the Society group all the way to Mangareva, than north to the Marqueses and South to the Australs. This is a decreasing sphere of influence model that allowed for a great deal of cultural transmission long after the outer rim regions of Polynesia had been cut off from contact. Even if that contact was almost never direct outside of ones' closest neighbors, the technologies used in maritime transport remained

¹⁰¹ Wilmshurst, J.M., et al., 2011.

¹⁰² Rolett, B.V., 2002, Walworth, M., 2014

relatively standard across most of this region,¹⁰³ quite probably staying the most faithful to the original design.

Central Polynesia seems to have retained the most inter-island contact in East Polynesia after this initial period of extreme mobility, although this is not to say that contact was frequent or uniformly spaced.¹⁰⁴ The extent is not known, but it is likely that many regions remained entirely insular for decades or even centuries. As has been previously discussed, rescue voyaging was one of the only viable rationales behind voyaging after the 14th century according to current models. The outlying islands, such as the Line Islands or Rapa Iti had water gaps greater than 1000 km. Those that were capable of supporting their populations would have had no reason to engage in voyaging, and being out of the way of exchange routs between larger islands, it is entirely possible they remained completely out of contact.

In this paper, I have concentrated primarily on cultural distinctions separating construction techniques, but it is often dictated less on these terms than by the materials present on the island, as well as the unique climate of the region. Numerous factors of environment played into the exact model of canoe and sail plan used on different island groups, such as average distance traversed, average wind speed, variable distance and, wind speed, variable wind vector, and average wind vector in relation to the average destination vector. For these reasons, it is likely that the places where these vessels were first designed in Central and Western Polynesia retained the most significant amount of continuity in design. While function altered significantly across time as they morphed to

¹⁰³ Haddon, A.C., & Hornell, J., 1936, 26-96, 103-194

¹⁰⁴ Rolett, B.V., 2002, Kahn, J.G. 2014

fit a more localized need for sailing vessels, the physical conditions of the regions seascape remained mostly constant.

Early descriptions tend to point out the skill of central Polynesian canoe construction. “[The] little fleet consisted of vessels like galeots, not of one tree-trunk, but very subtly contrived. Better could not have been made in Castille, with their mat sails very curious.” (Quiros, P.F., & Markham, C. (Tran.), 1904, 336) Unlike in Hawai‘i and New Zealand, typical hull construction consisted of many lashed together planks, with a breadfruit caulking, rather than a single dugout log serving as the main body and keel.¹⁰⁵ This is not an uncommon way of constructing such a vessel without rivets or nails, but their apparent skill in the method does set them apart.

Tahitian Canoe

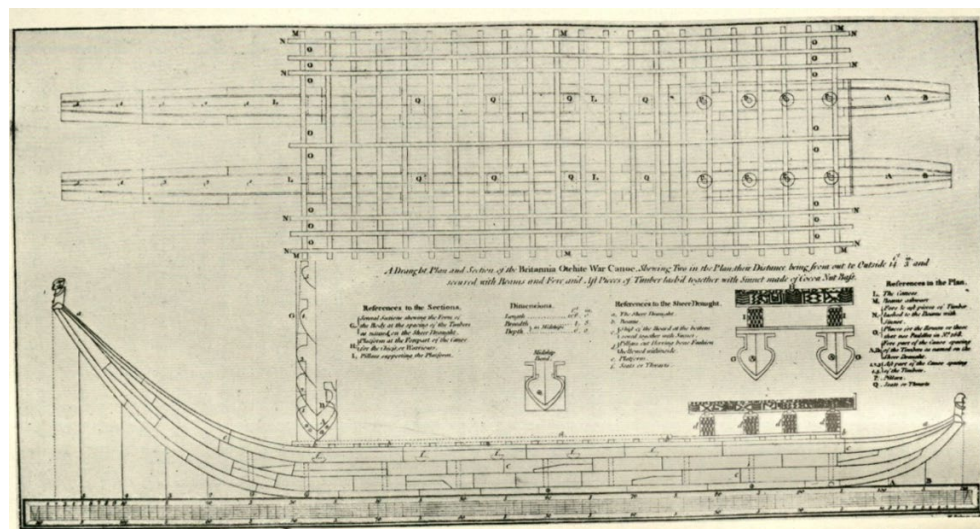


Figure 6: Diagram made of a Tahitian War Canoe (Britannia) made during Captain Cook’s visit to the Island (Haddon, A.C., & Hornell, J., 1936).

The Society Islands are the most populous of the central Polynesian Islands, and according to the oral history were the starting place of many of the expeditions of

¹⁰⁵ Best, E., 1976

discovery and long distance contact.¹⁰⁶ The island of Ra’iātea especially tends to be named as the original home of many of Polynesia’s peoples in their histories.¹⁰⁷ There is some evidence supporting the region being colonized approximately a century before the rest of East Polynesia.¹⁰⁸ As physical and cultural center to the region, the island group had cultural dominance over the region in historical times, likely spanning back into the prehistoric period as well.¹⁰⁹

The Society Islands, like much of the region, are lush with tropical flora, but are somewhat lacking in large timbered trees. Their canoes tended to have a keel shaped into an arch out of a single trunk, but the hull of the vessel was completely of a lashed plank construction.¹¹⁰ According to Sir Joseph Banks, the naturalist of the first Cook expedition, there were two primary styles of craft built on the islands. The large oceanic double canoes, called *pahi*, were of a very similar overall design to that of the standard Australasian vessel.

[The *pahi*] extreme length from stem to stern, not reckoning the bending-up of both those parts, 51 ft.; breadth in the clear at the top, forward 14 in., amidships 18, aft 15; in the bilge, forward 32 in. amidships 35, aft 33; depth amidships, 3ft. 4 in.; height above ground, 3 ft. 6 in.; her head raised, without the figure, 11 in.; her stern, 8 ft. 9 in.; the figure, 2 ft. Alongside of her was lashed another like her in all respects, but smaller in proportion, being only 33 ft. in her extreme length. (Banks, J., 1968-71)

The nearshore *waka* was built with a squared bow and stern, with a flat bottom. Many early accounts made by European explorer’s emphasis the large fleets found in the area.

This would indicate that there was a substantially larger demand for vessels where the

¹⁰⁶ Evans, J., 2009

¹⁰⁷ Couper, A.D., 2009, Kirch, P.V., and Green, R.C., 2001

¹⁰⁸ Wilmshurst, J.M., et al., 2011

¹⁰⁹ Rolett, B.V., 2002

¹¹⁰ Trusler, J., 1778, 25-27

islands would have retained greater contact with surrounding island groups than those of the outer rim of East Polynesia.

West Polynesia

Although Central Polynesia most probably retained the form of voyaging canoe in East Polynesia through the function of long distance trade and seafaring, the Samoan and Tongan archipelagos are almost certainly the true origin of the technology and quite possibly retained a greater degree of continuity. Their craft were certainly reportedly more seaworthy and participated in more frequent long distance expeditions at the time of European contact.¹¹¹ Called Western Polynesia, it remained interconnected with central Polynesia,¹¹² to a greater or lesser extent, but probably remained in greater contact with the island groups of Melanesia. Humans reached the islands at or shortly after the end of the Lapita Complex, which was another period of increased mobility across island groups, this time in Near Oceania characterized by the spreading of a distinctive pottery style. For an unknown reason pottery in its entirety was abandoned as a concept by the early settlers of West Polynesia, but it is still very likely that Lapita descendent voyagers were their predators.¹¹³

The canoes found in Samoa were typical of the double style, but were constructed out of an almost completely dugout hull, or possibly out of non-uniform wooden slabs sewn together.¹¹⁴ There is conflicting information as to their speed, but at the least they were capable of around 7 knots, possibly much faster. Double canoes

¹¹¹ Best, E., 1976, 333

¹¹² Di Piazza, A., & Pearthree, E., 2001, Lan Hogbin, H., 1940, Walter, R., and Sheppard, P.J., 1996

¹¹³ Anderson, A., 2014, Irwin, G., 2008

¹¹⁴ Best, E., 1976, 342

measuring between 10 and 15 m were reportedly used in transferring smaller vessels to distant fishing grounds. Outrigger canoes are described on less favorable terms.

Having both a prow and stern, these canoes cannot be manoeuvred without tacking; consequently the outrigger that constitutes their safety is, in using their sail, alternately to leeward and windward, and does not, when to leeward, add much to the stability of the canoe. They carry less sail than the canoes of the other natives of Polynesia, and, to guard against the danger of upsetting, the natives rig a sprit or boom (suati) projecting from the opposite side to that on which the outrigger is fitted. This boom is secured with guys to the top of the mast. When the wind blows fresh some of the men go out upon it, and thus balance or counteract the force of the wind. (Wilkes, C., 1849, 214)

All of Samoa's oceanic canoes are shrouded in contradictions to some extent.

Conflicting early accounts, followed by a near complete abandonment of the style, to be latter filled by Fijian and Tongan designs leaves very little on which to base a reconstruction.

Unlike the large oceanic canoes, many of the smaller vessels were constructed of tightfitting lash plank constructions. The Va'a alo, a craft generally less than 7 m in length used in bonito fishing, especially deserves mention for the skilled woodworking required in its construction.¹¹⁵ Each craft was lashed in such a way as to have no exposed lashings on the exterior hull,¹¹⁶ on planks less than 1.25 cm thick. The existence of lash plank constructed vessels in an area where their development has been deemed unlikely may indicate a point of contact with other regions, perhaps in Central Polynesia. Beyond that, the large vessels earlier described exemplify remarkably similar designs to those found in the Society Islands, far more so than displayed in other regions.

¹¹⁵ Armstrong, K., et al., 2011, Smith, S.P., 1920

¹¹⁶ Best, E., 1976, 339-340

The Tongan Archipelago is notable for being actively documented traversing island groups at the time of European contact, being able to exert a degree of economic and political control over Samoa, Fiji, and possibly others including Vanuatu and Tahiti, up to the 15th century.¹¹⁷ Their canoes were reportedly able to reach speeds in excess of 11 kt and were very well crafted out of lashed planks.¹¹⁸ Double Canoes were measured between 9 and 28 m, with differing rigging plans based on length. The smaller vessels were designed to shunt while the larger craft held more stout masts designed to tack. They are the home of perhaps the most quintessential Australasian canoe, being on, and in some ways within, the border between Near and Remote Oceania.

There is also some evidence of interspersed contact with the Melanesian and Micronesian regions influencing their designs,¹¹⁹ opening the possibility of influences coming into broader Polynesian design not originally found in their construction. They share a history in that all three regions underwent dispersal periods at around the same time, the time of initial colonization of West Polynesia also being the time when Fiji and much of central and eastern Micronesia was settled.¹²⁰ One key shared technology is the double hulled canoe; found in Polynesia and the eastern portions of Melanesia, but not in the rest of Remote Oceania.¹²¹ Movement was possible between other Pacific peoples especially during the period of increased mobility in the 11th to 14th centuries. The island of Fiji appears especially often throughout the oral history of western

¹¹⁷ Aswani, S., & Graves, M.W., 1998, Burley, D.V., 1998, Clark, G.R., et al., 2014. Geraghty, P., 1994, Gunson, N., 2008a, Gunson, N., 2008b, Petersen, G., 2010

¹¹⁸ Best, E., 1976, 339

¹¹⁹ Finney, B., 1996, Lan Hogbin, H., 1940, Kirch, P.V., 2000

¹²⁰ Fitzpatrick, S.M., 2008, Intoh, M., 1997

¹²¹ Anderson, A., 2014, Haddon, A.C., & Hornell, J., 1936

Polynesia as a source of exchange for marital partners, particularly in royalty. It is unknown as to the extent of this contact, although the lack of significant swap of technology or other cultural vectors speaks to a fairly limited connection.

Hawai`i

Hawai`ian canoes differ from those found in the central region of Polynesia in many ways. This is not surprising, as the island chain was likely completely out of contact with the region since at least the 14th century.¹²² Hawai`i remained in contact with central Polynesia for the prior three centuries after the initial settlement of the islands, although to what extent is unknown.¹²³ Located at the furthest northern range of Polynesia, Hawai`i has a unique culture, related to but distinct from that of central Polynesia. It is among the most thoroughly studied island groups in the Pacific, being the key place of study of many of the field's greatest researchers. In recent years, it has also played host to much of the Polynesian cultural revival movement. Seeing just how these canoes differ can shed some light on to what extent it is an independent entity from the rest of Polynesia.

One of the key differences in hull design is that Hawai`ian canoes almost always had a dug-out base with lashed plank tops to increase the hull's surface area, and thus the hulling potential.¹²⁴ This was far more expedient than lashing the whole structure. This convenience was in large part thanks to the abundance of large native trees in the

¹²² Kane, H.K., 1998

¹²³ Collerson, K.D., and Weisler, M.I., 2007, Couper, A.D., 2009, Lewis, D., 1972, Weisler, M.I., and Kirch, P.V., 1996

¹²⁴ Haddon, A.C., & Hornell, J., 1936, 8-10, Holmes, T., 1981, 64

highlands of the islands.¹²⁵ Eighteen meter trunks (60 feet) before the first branches were not uncommon. Large timber could also be found as driftwood, originating from the American Pacific Northwest from trees such as spruce, fir, or redwood, all of which could have reached the desired proportions before being swept by the Pacific currents to Hawai`i.¹²⁶ It is conceivable that it was also used on occasion. These opportunities for expedients allowed these canoes to remain at their massive proportions, even after there was no longer a great need for them.

Hawai`ian Canoe



Figure 7: A rendition of Hawai`ian canoes during first contact with Captain James Cook, made by John Webber in 1779 shortly after the events depicted (Cook, J., 1777).

Captain James Cook's expedition arrived in the islands in January of 1778, marking the first contact with the outside world in several centuries. The need for long distance oceanic voyages had long since passed, but large vessels could still be seen, if for no better reason than ceremony. Compare for instance, "...[on] the 25th the

¹²⁵ Haddon, A.C., & Hornell, J., 1936, 8, Holmes, T., 1981, 15-24

¹²⁶ Finney, B.R., 2003, Holmes, T., 1981, 24

Kireeaboo came. He was attended by a number of double canoes, the largest we had ever seen, being between 60 and 70 feet in length..." (Ledyard, J., 1783, 111), to "Their canoes were long and narrow; not more than two feet wide in the middle, from whence they tapered to both ends. They were strengthened by cross bars, which served both for seats and stretchers, and had small out-riggers, to prevent over-setting" (Rickmen, J., 1785, 204). The use of these large craft for the arrival of the local aristocracy, when most vessels were more modestly suited to the environment, might indicate that such vessels were still constructed so as to indicate status, rather than the purer utility of their original purpose.

There is some evidence of some form of trade across the region, as basalt tools that seem to have been quarried in Hawai`i have been found in the Tuamotu Archipelago.¹²⁷ If such trade did exist, it would indicate that the oceanic travel required to fulfil it was not overly challenging, or at least that the difficulty was regularly overcome. This does not provide absolute proof, even if it could be known for certain that the basalt adzes did originate in Hawai`i, because of the chance that they were transported after European contact. There are also records in the oral tradition of voyages back and forth, mostly focused on the movement of important and influential people. One such figure, Pa`ao, probably came from either Tahiti or Samoa to popularize the worship of the god Kū as well as human sacrifice.¹²⁸ Research into the linguistics throughout Polynesia,¹²⁹ as well as clear signs of additional lineages indicating dispersal of rat and other organisms, dependent on humans to facilitate

¹²⁷ Collerson, K.D., and Weisler, M.I., 2007

¹²⁸ Malo, D., & Emerson, N.B. (tran.), 1903, 24-25, 206, 324-325, 327, 332-334

¹²⁹ Walworth, M., 2014

spreading to different islands,¹³⁰ also points toward at least a few centuries of contact. Once contact was ended, large canoes were still required to some extent in transport between islands in Hawai`i. The large craft of the original colonization phase would not have been required, because of the sharply decreased storage requirements, as well as the decreased likelihood of encountering a storm on the shorter journey.

New Zealand

The vessels of New Zealand, as they were at the time of European contact, were also constructed out of a dugout log base, but often discarded the outrigger, double hull, and sails found in most other regions.¹³¹ It is possible that the islands' extreme abundance made such things redundant in most cases, especially in nearshore transportation. New Zealand is entirely unlike the other islands of Polynesia. It is comprised of two large islands originating from tectonic uplift, rather than volcanic activity. They are also located well outside the tropical zone, meaning that most of the traditional Polynesian crops, such as breadfruit and banana will not grow anywhere on the islands. Sweet Potato grows to some extent on the North Island, but for the most part, the inhabitants of New Zealand were hunter/gatherers.¹³² Nonetheless, the population of the islands was able to surge due to the abundance of wild foodstuffs.

The Maori canoes likely deviated significantly more from the original voyaging model than those found on Hawai`i, partly as a result of the substantially different environment located in New Zealand. Unlike in other regions of Polynesia, the Double Canoe appears to have been widely out of use by the time Europeans arrived on the

¹³⁰ Matisoo-Smith, E., et al., 1998

¹³¹ Best, E., 1976, 23-64 Haddon, A.C., & Hornell, J., 1936, 194

¹³² Green, R.C., 1975

scene.¹³³ They are evident in the historical record but are most often identified as two single hulled canoes that have been temporarily lashed together with a relatively small gap between the two hulls. "Sometimes they fasten two [canoes] together with rafters, which we call a double canoe," (Best, E., 1976, 30). There is some evidence, especially on the South Island, that double canoes were more widely used into historic times for their superior stability in rough weather but such practice evidently didn't last into the European colonization period of the island's history. Single-hulled paddle driven canoes seem to have been the more popular model.¹³⁴

Construction of canoes on New Zealand was much like that on other Polynesian islands, although the trees were exceptionally well suited for the use.

We were now no longer at a loss to know of what trees they make their canoes, as they can be no other than these pines. On this little isle were some which measured twenty inches diameter, and between sixty and seventy feet in length, and would have done very well for a foremast to the Resolution, had one been wanting. (Cook, J., 1777)

An account made by Dr. Savage, after a visit to the islands in 1805, describe the process still in practice at the time.

Their canoes are formed of the trunk of a fir-tree, hollowed out by the adze, and usually raised upon by a plank of a foot broad on each side: they are of various dimensions, from thirty to sixty feet in length and upwards, and from two feet six inches to more than five feet broad; sharp at each extremity, and about three feet deep, including the plank before mentioned. This plank is united to the body of the canoe by ligatures, and a quantity of rush or flax placed in the seam, so as to answer the purpose of caulking. Their war-canoes are ornamented with carving and painting, and many of them are really very handsome.... The common canoes are seldom more than about thirty feet in length... They are also provided with nets, hooks, and lines, as an almost inseparable part of their equipment. Paddles are universally made use of, and, from the great strength and activity of the natives, the canoe is impelled forward with

¹³³ Best, E., 1976, 24, Haddon, A.C., & Hornell, J., 1936, 194-215

¹³⁴ Best, E., 1976, 46, Haddon, A.C., & Hornell, J., 1936, 194

uncommon velocity. A large stone supplies the place of an anchor.
(Savage, J., 1807)

War Speech



Figure 8: "A party of warriors had collected at the Bay of Islands for the purpose of making a hostile visit to a Hauraki tribe. They were detained by contrary winds; and for several days were constantly engaged in listening to speeches from their chiefs, who addressed them from a canoe hauled on shore ... one [canoe], which I measured, was 70 feet long, and carried one hundred fighting men," (Earle, Augustus, 1793-1838).

There is also a great deal known about the felling and moving of the logs that were made into the canoes, thanks to historical accounts given by early European settlers in the region.¹³⁵ It is impossible to know the specifics of how the method described above differs from that used in the centuries before European contact, but it is likely that the broad ideas are similar, at the least.

Sails were used in New Zealand but to a much lesser extent than most other regions of Polynesia.¹³⁶ This absence is perhaps the most exciting aspect of the islands'

¹³⁵ Best, E., 1976, 84-89, Haddon, A.C., & Hornell, J., 1936, 194

¹³⁶ Best, E., 1976, 251-269, Haddon, A.C., & Hornell, J., 1936, 208-209

canoes, as on face value the dismissal of such an efficient labor-saving device seems unusual from a culture that had used it to such effect for so many generations. The more widely verified weather conditions found in the region, as compared with tropical Polynesia, may partly explain its fall from favor. The effort in constructing sail and tackle, as well as the broader hulls needed to support them, may have proven too costly for standard vessels, as it was never clear when they might be used. If a crew had to include enough paddlers to move the vessel efficiently, it could very well have been decided that hauling around the extra weight and drag was not worth the benefit of the chance of natural transport.

Despite this general paring down of the original Polynesian design, the New Zealand canoes were more than adequate in dealing with most needs the peoples of the islands contrived for themselves. The various types of Maori vessels have traditionally been split into three categories. They are typically only account for single hulled craft, as those were by far the most popular design. The waka taua is the most famous of the Maori canoe designs, being the largest and most meticulously crafted. Its base could consist of multiple segments, lashed together, or be dug out of a single log.¹³⁷ They were generally grandly decorated, with the high bow and stern pieces found throughout many of the Pacific island cultures. They are often called ‘war canoes’ in European sources,¹³⁸ as one of their more ostentatious uses was the transport of warriors to battle. They were capable of hauling large crews long distances, making them ideal for circumventing New Zealand’s rugged terrain.

¹³⁷ Best, E., 1976, 65-175

¹³⁸ Best, E., 1976, 48, 65, Haddon, A.C., & Hornell, J., 1936, 200-212

Other vessels were used for more mundane uses, such as fishing and general transport between habitation sites. Waka tete was basically a slightly scaled down version of waka taua, with less emphasis on the artistry and polish, and more on the practical use of the craft.¹³⁹ It was the primary deep-sea fishing vessel on the islands by the time of European contact. Waka tiwai were significantly smaller and characteristically did not include any modifications over the dugout hull. They were reportedly used for a variety of activities, such as the transport of small groups over calm water bodies.¹⁴⁰ There does not seem to be any tradition of lashed together small craft, outside of a few early accounts of questionable reliability. The rich variety of canoe found on the islands is a testament to the importance the ocean had on the lives of the people living on New Zealand, while their apparent divergence from their progenitors marks their vast difference in purpose. The next island that is to be examined is even more dissimilar to those of tropical Polynesia.

Rapa Nui

Much of eastern Polynesia shared a comparatively extended period of contact, as well as substantial resources to dedicate to shipbuilding. Rapa Nui was colonized during the expansion of the Polynesians into the Eastern Pacific after contact was made with South America,¹⁴¹ but likely remained completely isolated afterward.¹⁴² The island was most likely colonized around 1250 CE, but earlier dates going back as far as 300 CE

¹³⁹ Best, E., 1976, 24

¹⁴⁰ Best, E., 1976, 24

¹⁴¹ Lipo, C.P. & Hunt, T.L., 2016

¹⁴² Barnes, S.S., et al. 2006

have also been reported but are not widely trusted for accuracy.¹⁴³ The former date is by far the most probable, as it corresponds to the most reliable radiocarbon dates found in association with human activity on the island,¹⁴⁴ as well as the dates found on many other islands throughout Eastern Polynesia, strongly indicating a common event spurring their colonization. Even more debate has raged around the origin of the Rapanui people, going back to wild theories of sunken continents,¹⁴⁵ and displaced Egyptians.¹⁴⁶ If a 1250 CE colonization event is accurate, it is likely that their ultimate origin was Samoa, or the Society Islands.¹⁴⁷ In particular to Rapa Nui, Mangareva was a likely waypoint.¹⁴⁸ After the island was settled, it is likely there was little to no contact with any external population. Analysis of the genetics of Polynesian rat bones found in excavations indicate that only a single line was ever present on the island, strongly suggesting that there was never a second voyage to contribute to the admixture.¹⁴⁹ There has yet to be a discovery linking the island to any trading circles. Rapa Nui was well outside the envelope of even the most generous estimates of inter-island contact post colonization phase, and was thus left to develop into a completely unique branch of the Polynesian cultural tree.¹⁵⁰

The vessels found on Rapa Nui were not nearly so grand as those found in the rest of Polynesia, as the island was relatively poor in resources, both terrestrial and

¹⁴³ Kirch, P.V, 2000, 234

¹⁴⁴ Anderson, A., 1995, Lipo, C.P. & Hunt, T.L., 2016, Mulrooney, M.A. et al., 2011, Rieth, T., & Cochrane, E., 2015, Walworth, M., 2014, West, K., et al., 2017, Wilmshurst, J.M., et al., 2011

¹⁴⁵ Brown, J.M., 1924

¹⁴⁶ Heyerdahl, T., 1950b

¹⁴⁷ Athens, J.S., et al., 2014, Hunt, T.L. and Lipo C.P., 2008, Wilmshurst, J.M., et al., 2011

¹⁴⁸ Green, R.C., 1998

¹⁴⁹ Barnes, S.S., et al., 2006

¹⁵⁰ DiNapoli, R.J., et al., 2017, Walworth, M., 2014

maritime.¹⁵¹ There have not been any archaeological examples found, but a significant effort was put into describing them by early European explorers, particularly by the Cook expedition in 1774.¹⁵² They were constructed on similar lines as the outrigger canoes found elsewhere in Polynesia, having a raised bow and lashed plank hull construction, but were far smaller and didn't have the log base typical of that craft. Instead, they were constructed entirely out of short timber planks that were the only reliable source of timber on the island, as the only large trees found on the island were giant palm, which are drastically unsuited for shipbuilding.¹⁵³ They are reported to have leaked considerably due to the absence of any caulking material produced on the island.¹⁵⁴ It also appears as though they were entirely paddle driven, rather than relying on sails. All told, they were far from the oceanic transit capable craft from which they descended.

Despite the need for frequent bailing, the boats were used for nearshore fishing. The absence of extensive coral reefs or other marine habitats suitable for supporting fish populations severely constrained the abundance of maritime resources available to a people so limited in the scope of their enterprise. Large fish, such as tuna, do frequent the waters around the island, but not in any great numbers.¹⁵⁵ Far more abundant are the small fish native to the coastal waters, including 44 endemic species.¹⁵⁶ The unique aquatic environment most assuredly had an enormous impact on how its use was developed. Unlike other Polynesian islands, fishing on Rapa Nui was never meant to be

¹⁵¹ Arana, P.M., 2014, Hunt, T.L. and Lipo C.P., 2006, Ladefoged, T.N., et al., 2010

¹⁵² Cook, J., 1777, Ch. 2, VIII

¹⁵³ Haddon, A.C., & Hornell, J., 1936, 99-100

¹⁵⁴ Arana, P.M., 2014

¹⁵⁵ Arana, P.M., 2014

¹⁵⁶ Randall, J.E.

a mainstay of their diet, as the island lacked the vast coral reefs known to harbor large aquatic communities elsewhere. There just was never the quantity of marine resources to sustain the population on the island.¹⁵⁷ Excavation of middens and dental analysis show that comparatively little of the protein consumed by the Rapanui came from the sea.¹⁵⁸

Rapa Nui Canoe



Figure 9: A depiction of a Rapa Nui canoe made during the La Perouse expedition, which departed France in 1785 on an extensive survey of the Pacific. It is notable that the people depicted appear very Caucasian in appearance. (La Perouse, J.F.G., 1797)

What we know of prehistoric fishing on the island is that the Rapanui were very creative in exploiting a great many niches to harvest marine resources.¹⁵⁹ Bait fishing with hooks was the predominant method used, with women primarily fishing on shore, while men fished the deep water farther out.¹⁶⁰ The fishhooks themselves had a similar shape to others found throughout Polynesia, particularly those from Tubuai in the Austral Islands,¹⁶¹ except that they were usually made from stone or human bone, rather than the bones of large terrestrial animals or wood. Nets and rope made from hauhau

¹⁵⁷ Castilla, J.C., et al., 2014

¹⁵⁸ Commendador, A.S., et al., 2013

¹⁵⁹ Arana, P.M., 2014

¹⁶⁰ Arana, P.M., 2014

¹⁶¹ O'Connor, J.T., White, F.J., & Hunt, T.L., 2016

bark fiber were also used on occasion, both from boats and on shore.¹⁶² Fishing was not the only use for boats on Rapa Nui, although perhaps the most obvious. While not directly documented, they were presumably also used in harvesting obsidian from the Motu Iti quarry, a small outlying island off Rapa Nui's west coast. Obsidian itself is not typical in Polynesia, so it was once speculated that it could have solicited long-distance trade with other islands. This does not appear to be the case, as no obsidian tool found elsewhere in Polynesia has been traced to the Rapa Nui sites.

¹⁶² Arana, P.M., 2014

Chapter 4: Reconstruction and Conclusion

The evolution of vessel design after initial inhabitation of East Polynesia can be linked primarily with the changing needs for watercraft exhibited by the region's population, molded through the specific environment of the island or archipelago in question. There have been substantial efforts in the past to better understand the function and utility of the Polynesian voyaging canoe, particularly in the last 40 years. Until that point, there was no clear consensus as to whether such vessels had even existed, as many believed that the prospect of crossing the large water barriers of Polynesia was beyond the capability of the islanders themselves, and any population dispersal must have occurred over a long period of time by chance drifting.

What would have happened to the prehistoric discoverers of Hawaii and New Zealand if they had tried to get back to their home islands? The mean effect of the Pacific currents on the outward journeys of discovery would probably have been to set the voyagers to the west of their imagined course. On their hypothetical return journeys, the set would probably have been in the same direction. The navigators would thus have had a good chance of a reunion in the New Hebrides or Micronesia rather than anywhere in Eastern Polynesia. (Sharp, A., 1963, 389)

It was not until Finney's conclusive demonstrations of purposeful oceanic crossings reliably made using approximately recreated Polynesian canoes and navigation techniques that the idea started to receive more universal acceptance.¹⁶³ The 1976 expedition, in which the Hōkūle'a, a double canoe with modern crab claw sails, navigated from Hawai'i to Tahiti using nothing but traditional navigation techniques still in use on Satawal Island in Micronesia, conclusively demonstrated at least the potential of such technologies and techniques being used in Polynesia during the distant

¹⁶³ Babayan, C., et al., 1987, Finney, B.R., 1994b

past.¹⁶⁴ The Polynesian Voyaging Society, as well as similar organizations found throughout the region, have continued to build similar craft, exhibiting them across Polynesia and the world as part of the Neo-Traditionalism movement earlier examined.

The voyaging canoes used in the various modern cultural societies across Polynesia all far more resemble those of Western Polynesian designs than those native to the east, and are predominantly made using modern materials. The sail plan is much larger than even the most generous estimates of what the native technology was capable of producing.¹⁶⁵ Even the navigation methods essential to the use of the vessels in proving that they could be sailed between island groups had long since died out in Polynesia, hence the necessity of importing the art from a Malaysian navigator. It is hard to see the benefit of such artifacts when viewed as pure reconstructions, but as celebrations of Polynesian voyaging, they are exquisitely designed craft.

While purposeful navigation between island groups is now widely accepted, Finney's model is not without detractors. Atholl Anderson has broadly criticized the Traditionalist movement in general because of its somewhat nationalistic tendency toward overestimating any past technology or enterprise when given a chance.

The seafaring manifestation of the colonization-continuity hypothesis is the neo-traditionalist proposal that stellar navigation and large, fast, weatherly double-hulled canoes existed prior to the discovery of Remote Oceania and were used during dispersal. Like the traditionalist model, mauled by Andrew Sharp, it appeals to the 'principle of degeneration,' in this case, the idea that maritime technology had been more highly developed during Remote Oceanic colonization than was observed at the period of European contact. The assumed competence of the early technology, exemplified in the design, construction, and sailing of so-called 'replica' vessels, together, with computer simulation studies using

¹⁶⁴ Lewis, D., 1970

¹⁶⁵ Anderson, A., 2008

the experimentally-derived parameters, enjoined the conclusion that as no part of Oceania lay beyond reach of such vessels, no substantial hiatus could be expected in the discovery sequence. (Anderson, A., 2003, 78)

Anderson has broadly theorized that the maritime technologies imagined in its models are simply too optimistic in terms of their capabilities in speed and their ability to sail to windward.¹⁶⁶ He instead makes the key assumption that the vessels utilized by Polynesians at the time of European contact were not significantly less seaworthy than their oceanic predecessors. Rather, they were more specialized to their environment, that being a near coastal environment. While the idea of deliberate voyages of discovery was no longer an issue, Anderson is not convinced that it was efficient or reliable enough to facilitate any interisland trade. "...some central East Polynesian material reached Hawai'i, Easter Island, or New Zealand but no convincing instances of return have been documented." (Anderson, A., 2014, 2). He and others have also pointed out the futility in demonstrating that efficiency using recreated models made in whole or in part with modern materials, not as susceptible to some of the forces exerted by extended use at sea.¹⁶⁷

The sails used in Polynesian varied greatly between island groups and are one of the most studied aspects of the area's maritime technology. The reason for that popularity is the implications for sustained long-distance travel. Hull design is important in understanding how seaworthy their vessels could have been, but if their sails were not capable of transporting them in the direction needed, all else is largely immaterial as any advantage gained through more efficient hydrodynamics would be

¹⁶⁶ Anderson, A., 2014

¹⁶⁷ Anderson, A., 2008, Irwin, G., 2008

hard pressed to make up for the increased distance needed to be traversed while tacking. Throughout the entire prehistoric settlement of the Pacific Islands humans have spread eastward; but if they used sails to accomplish those feats, scholars are met with the conundrum of the prevailing winds throughout the region. Any sailor would have either needed to sail against the wind, which requires more complex sails,¹⁶⁸ wait for the winds to shift for a reliable period in which they can conduct their voyage which requires both luck and an understanding of long term weather patterns and a way to reliably record them,¹⁶⁹ or rely on orally communicated maps of a region's constantly changing wind patterns. All three possibilities have been examined with considerable scrutiny, but there is still no solid consensus. It is likely that some combination holds the answer, but at what ratio is yet undecided.

Sail Designs on Historical Polynesian Canoes

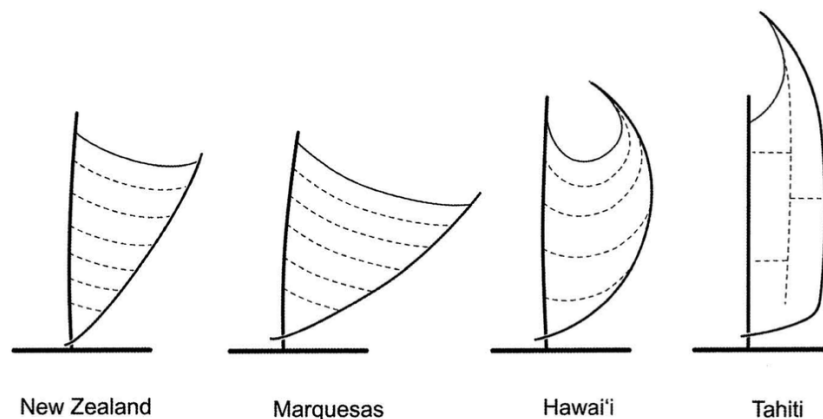


Figure 10: Comparative diagram of the four most common and diverse sail plans used in Polynesia (Irwin, G., 2008, 16).

The vessels of Polynesia are essential because of how they were utilized in the colonization of the region. We do not know exactly what they looked like, or precisely

¹⁶⁸ Anderson, A., 2008

¹⁶⁹ Anderson, A., et al., 2006a

what they were capable of regarding sailing characteristics. All that we do know is that they allowed the people of West Polynesia to traverse thousands of kilometers of open ocean, to nearly every destination, reliably enough to make it worth the chance of settling those islands. All we have left are remnants of memories; a few shards of wood and the journals of men who often only knew part of what they saw. To fully recreate these vessels will probably prove impossible, but any effort to better understand them must be worthwhile. Through an understanding of this lost technology it might be possible to better understand their builders, those that made the last great push in the colonization of our planet.

It is evident that the research on Polynesia's history has undergone substantial revision over the past few centuries. What we know of the region's maritime past has changed based on social acceptability, ideals of conceivable reality, and on the amount of raw information that is known. The changes in the understanding of how Polynesia was colonized has had far more of an impact on the contemporary ideas of vessel design than any direct evidence. As the evidence of a rapid dispersal through East Polynesia mounted, coupled with revised linguistic and genetic studies that indicated more prolonged contact, the accepted sophistication of the canoes had to be increased to meet the demand of the new models. The vessels proposed by various researchers over the past few decades generally emphasize the need to account for the speed and scale these voyages would have had to meet in order for the events we see in the archeological record to take place.

In compiling my image of the historic vessels of Polynesia I relied heavily on extant data, although a few manuscripts of interest have only recently been rediscovered

by diligent historians. I merely described the findings of the earliest historical visitors to the islands and matched their descriptions to our ever-changing image of the most likely realities. Current theories indicate a rapid exploration and colonization period, followed by a drop off in communications, which fundamentally alters the status and utility of every vessel described in the historical period. The evolution of the form and function of the Polynesian vessel were incredibly numerous, even as they did fall into certain generalizations. Although probably not the only factor in the retention of the more traditional style of Polynesian voyaging canoe, the island of tropical Polynesia seems to have had some advantage. This is most likely primarily due to the simple fact that the vessels were originally designed in that environment, and as such required minor alterations as their function changed, as opposed to those of New Zealand which were far more radically altered. There is also significant cause for believing that the canoes of Central and Western Polynesia still retained some amount of long-distance voyaging capability and purpose into the historical period. The distance separating islands, the lagoons filled with fish, the wind patterns, the fact that the canoe was built for that environment, the retention of some contact influencing ideas, all affected how the vessels of the islands evolved. A more systematic study of Polynesian vessel design over time and across space would be needed to ratify this hypothesis.

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