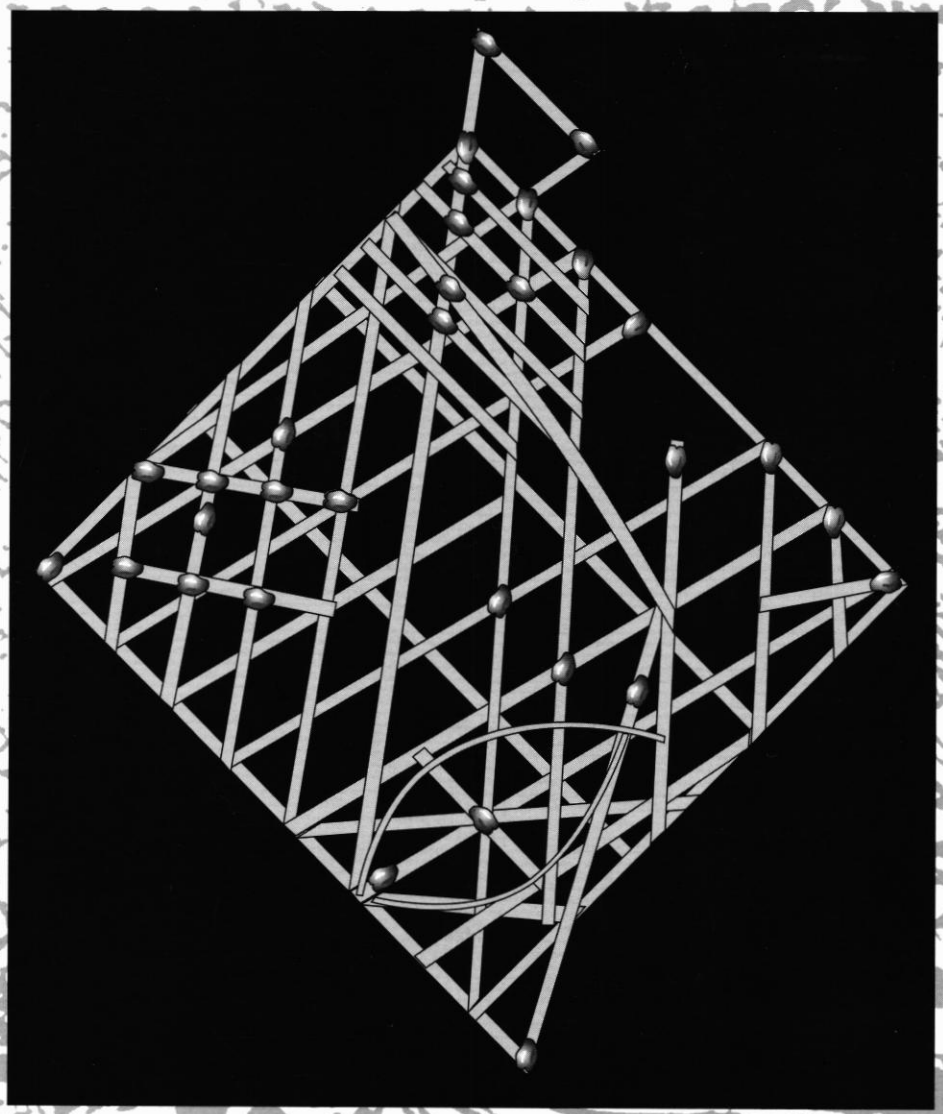
NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION MONOGRAPH 21:
Marshall I. Weisler (ed.), ***Prehistoric Long-Distance Interaction in Oceania: An Interdisciplinary Approach***



PREHISTORIC LONG-DISTANCE INTERACTION IN OCEANIA: AN INTERDISCIPLINARY APPROACH

Edited by Marshall I. Weisler

21

NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION
MONOGRAPH

EXPERIMENTAL VOYAGING, ORAL TRADITIONS AND LONG-DISTANCE INTERACTION IN POLYNESIA

Ben Finney

To what extent did the Polynesians sail back and forth between the islands of their oceanic realm? After having settled the many islands and archipelagos within the vast Polynesian triangle did they mostly stay put, confining their voyaging activities primarily to short trips within their respective archipelagos or between islands of closely-spaced archipelagos? Or, did they travel more widely, undertaking voyages back and forth between distantly-separated islands and archipelagos? Answers to these questions are crucial to understanding how individual Polynesian societies developed. If, for example, the people on each island or group of closely-spaced islands largely stayed put after settlement, then their societies could be thought of as isolates, and the explanation for how they developed over the centuries would be sought in processes solely internal to each society and the immediate island environment. If, however, post-settlement voyaging was widespread, then the effects of the diffusion of artefacts, ideas and institutions, and of the impact of arrival of new settlers, whether peaceful or bent upon conquest, would have to be taken into account.

From the late nineteenth century until the middle of this one, most scholars sought to explain the development of Polynesian societies in terms of external factors. In particular, they focused on the role of migration, invasion and diffusion in the development of social stratification. For example, in the 1870s and 1880s Abraham Fornander concluded from his study of Hawaiian oral traditions that the coming high-status chiefs and priests from 'Kahiki' (which, arguably, refers either to Tahiti or more generally islands far to the south of Hawaii) and their imposition on the original settlers of new political and religious institutions transformed Hawaii into a highly-stratified society dominated by an endogamous chiefly class (Fornander 1969, vol. 2:58-63). Similarly, in 1930, E. S. C. Handy, one of the first professional anthropologists to work in Polynesia, proposed that the division of Tahitian society into a commoner class and a ruling class was a direct result of the invasion and conquest of the original tribal society by aristocratic warriors (Handy 1930).

By the 1950s, however, this focus on external factors as the prime drivers for sociocultural change began to be replaced by an emphasis on processes of change internal to each society. For example, in their respective studies of Polynesian social stratification, cultural anthropologists Marshall Sahlins and Irving Goldman argued that stratification developed through such social processes as the growth of redistribution networks (Sahlins 1958) and status rivalry (Goldman 1955). At about the same time, archaeologists working in Polynesia began to reject the old ideas that individual Polynesian societies had been shaped primarily by migration, conquest and diffusion, and to seek to understand how each society developed in terms of how immigrants adapted to the environment of their island, the effects of natural population increase, the flow of random cultural drift and other processes internal to each society.

Basic to this paradigm shift was the assumption of isolation: once an island was settled by a single canoe, or at the most a few, because of the great difficulty of voyaging, the resultant society developed in relative, if not absolute, isolation from all but its nearest neighbours. However, faith in this assumption, and the studies based upon it, began to be shaken when in the early 1970s archaeologists working in eastern Melanesia began to discover evidence of the transport of artefacts back and forth between widely separated settlements of the Lapita people thought to be ancestral to the Polynesians. Further telling were archaeological studies of Polynesian outliers in Melanesia indicating how island societies had been massively impacted by the arrival of newcomers (Garanger 1972a, b; Kirch and Yen 1982).

Searching for hard evidence of inter-island and inter-archipelago links is now becoming one of the most exciting fields in Pacific island archaeology. For example, four recent Ph.D. dissertations - Walter (1990) on the Cook Islands, Rolett (in press) on the Marquesas, Weisler (1993a) on Samoa, the Cook Islands, and Mangareva and its outliers, and Hunt (1989) on a Lapita culture in the Bismarck Archipelago off New Guinea - have focused on the analysis

of archaeological evidence for the transport of pottery, stone tools, volcanic glass, oven stones and other artefacts and materials that can be traced to their geological source. In particular, much attention is now being directed toward determining the provenance and interisland transport of adze blades and other tools made from basalt, as witness the papers in this volume as well as such recently published studies of Best *et al.* (1992), Weisler (1993b, 1994) and Walter and Sheppard (1996).

All these efforts, past and present, to determine the extent of long-range interaction in Polynesia, and whether or not the various individual societies developed in isolation or in communication with one another, beg the question of whether or not the Polynesians had the means to undertake long voyages back and forth between the islands and archipelagos where they had spread. Experimental voyages made during the last two decades with reconstructed Polynesian canoes sailed throughout Polynesia have begun to play a role in removing this question from sheer speculation and assertion by providing data and insights on the canoe performance, navigational accuracy and seamanship needed to make long, navigated crossings. This chapter outlines this experimental research, setting the principal findings within the context of the centuries-long debate about the sailing capability of the Polynesians as well as the issue of employing oral traditions to trace Polynesian movements.

MODELS OF POLYNESIAN VOYAGING

From the time the first European ships sailed into Polynesian seas, the nautical capabilities of the Polynesians have been subject to debate. Those first Atlantic seamen to sail into Polynesian waters were greatly surprised to find that the islands they chanced upon were already inhabited by people who lacked ships, the compass or any of the other devices so crucial to European overseas expansion. Most could not accept that people who had only slim canoes hewn by stone adzes, lashed together with coconut fibre line and powered by mat sails, and apparently lacked any navigational instruments whatsoever, could have sailed so far into the Pacific. When, for example, Mendaña's expedition visited the Marquesas Islands in 1595, the navigator Quiros had to imagine a land bridge or a long chain of closely spaced islands leading all the way from Asia to within easy sailing range of the Marquesas to account for how these mid-ocean islands had come to be inhabited by people whom he judged to be "without skill or the possibility of sailing to distant parts" (Quiros 1904, vol. 2:152; Kelly 1966, vol. 2:309). Similarly, when on Easter Sunday of 1722 the Dutch navigator Roggeveen happened across a lone island in the eastern South Pacific which he thereby christened Easter Island (but which is now known by its inhabitants as Rapa Nui) he was at a complete loss to explain how people with only small outrigger canoes and no apparent means of navigation had come to be living on such an isolated island. After considering and then rejecting the possibility that the Spanish might have transported the people to the island, he could think of only one other explanation: they must have been set on the island by God (Rongeveen 1970: 101, 153-154). Then, fifty years later the French navigator Crozet conjured up a sunken continent to explain how linguistically related but seemingly nautically primitive peoples came to be living on islands strewn across the South Pacific from New Zealand to Tahiti. They must be the survivors of a race, he hypothesised, which once had been spread over a vast continent that subsequently had broken up and sank in a tremendous volcanic cataclysm which spared only those living on mountains high enough to remain above sea level and become islands (Crozet 1783:48, 253-254).

The first western navigator to give Polynesians credit for their own voyaging capabilities was Captain James Cook. In 1769 he anchored off Tahiti to undertake a scientific commission for the Royal Society. On board he carried telescopes to time the transit of Venus across the face of the sun, as part of an international project of observations to provide data needed to calculate trigonometrically the distance between earth and the sun, the so-called 'Astronomical Unit' (AU), a measuring rod for the solar system. While setting up the observatory and waiting for the transit to occur, Cook and his chief scientist, Joseph Banks learned some Tahitian and compiled a word list. When they compared their list with similar ones contained in the published accounts of those navigators who had previously touched on islands in the western Pacific, they realised that the Tahitian language was related to languages spread over the Pacific to the islands of Indonesia, or the 'East Indias' as they called them. This naturally led them to hypothesise that the ancestors of the Tahitians must have come from Indonesia.

Cook, however, was puzzled about one thing. Unlike his predecessors, Cook admired the sailing canoes he saw, and believed the Tahitians when they told him that they could navigate long distances with "the Sun serving them for a compass by day and the Moon and Stars by night" (Cook 1955:154). But he had trouble accepting that their ancestors could have worked their way thousands of miles across the Pacific from Indonesia when that feat would seemingly have required them to have sailed directly east into the face of the trade winds. A Tahitian polymath named Tupaia was able to set Cook straight. After Tupaia told the

English navigator about all the islands surrounding Tahiti, Cook then drew up a chart based upon Tupaia's testimony as to the bearing from Tahiti to each island and the number of days it took to sail to each one. Arguably, adjusting for Cook's apparent confusion about Tahitian directional terms, the resultant chart depicts a section of the South Pacific about the size of the continental United States that extends from Rotuma (near Fiji) and Samoa in the west to the Marquesas, Tahiti and the other Societies, the Tuamotus and the Australs in the east. But Cook was puzzled when Tupaia explained how his countrymen sailed back and forth between the islands scattered across this region. He accepted that the Tahitian's canoes could easily sail before the prevailing easterly trade winds, but wondered how, after sailing downwind from east to west, Tahitian sailors could then turn around and sail back to Tahiti against the easterly trade winds.

When pressed, Tupaia explained that Tahitian sailors do not try to beat into the easterly trades, but instead wait for seasonal westerly winds that are common during the Austral summer and then sail home before these. With this intelligence in hand, Cook then accepted that the Tahitians could alternately utilise the easterly trade winds and westerly wind shifts to sail back and forth across Polynesia, and that therefore their ancestors could indeed have come from Indonesia by exploiting spells of westerly wind to work their way eastward, from island to island, all the way to Tahiti (Cook 1955:154).

Over the next century or so Cook's sketchy thoughts were developed into what might be called the orthodox theory of Polynesian settlement from the western edge of the Pacific basin. Linguists followed up on the findings of Cook and Banks about language relationships across the Pacific by fleshing out the geographical spread of the great language family they called Malayo-Polynesian (now known as the Austronesian family) which stretches from Southeast Asia eastward as far as Rapa Nui and westwards across the Indian Ocean to Madagascar. Sea captains and other nautically-informed travellers confirmed that spells of westerly winds periodically swept across Polynesian waters and could have been used to migrate to the east, and, more to the point of this chapter, that the alternation of easterly trade winds and periodic westerlies made two-way canoe voyaging between islands and archipelagos eminently feasible.

Yet there were some dissenters from this orthodoxy who revived earlier scepticism about sailing capabilities of the Polynesians and denied that their ancestors could have intentionally expanded from Southeast Asia eastward to the islands of Polynesia. For example, in 1803 Joaquin Martínez de Zúñiga, a Spanish priest stationed in the Philippines, argued that because of the impossibility of sailing canoes all the way from Southeast Asia to Polynesia the islands there must have been settled from South America by people pushed westward by easterly trade winds and accompanying ocean currents (Martínez de Zúñiga 1966). Later in the nineteenth century, John Lang, a Presbyterian minister serving in Australia, hypothesised that since the Polynesians did not have the ability to make long, navigated voyages against the easterly trade winds, Polynesia must have been settled by a long series of accidental voyages that occurred when people undertaking short crossings in Indonesian or Philippine waters were blown far to the east by westerly gales, became totally lost, and then eventually landed on uninhabited islands (Lang 1834, 1877).

Such dissenting views were in the minority, however, and at the end of the nineteenth century and the beginning of this one the orthodox theory of intentional settlement from the western edge of the Pacific was further expanded by such amateur scholars as Abraham Fornander of Hawaii and S. Percy Smith and Elsdon Best of New Zealand. These European residents of Polynesia, who had became fluent in Hawaiian and Māori respectively, added a new perspective to the discussion by gathering oral traditions about Polynesian voyaging and using them to reconstruct not only the original migration to Polynesia, but also patterns of subsequent inter-archipelago voyaging within the region. However, in their enthusiasm they tried too hard to convert legends into precise historical accounts featuring migratory canoes swiftly moving from Asia to Polynesia, and, following settlement, the adventures of heroic voyagers who ranged far and wide between even the most distantly separated islands and archipelagos.

Although not all scholars of this era accepted such grandiose portraits of Polynesian migration and voyaging, the general consensus was that the Polynesians had intentionally migrated into the Pacific from Southeast Asia, and that once settled in Polynesia they voyaged widely, if episodically, between islands and archipelagos. This consensus was not seriously challenged until the middle of this century when a pair of writers revived the theories of Martínez de Zúñiga and Lang.

Following the 1947 voyage of the raft *Kon-Tiki* from South America to Polynesia, the Norwegian adventurer Thor Heyerdahl (1947, 1953) claimed that Polynesia must have been settled from the Americas not Asia because that was the only direction from which seafarers lacking modern ships could have reached the islands. Heyerdahl's reasoning was contained in a simple syllogism. Primitive seafarers could not cross the ocean against wind and current. The wind and current in the tropical Pacific always flows from the east to west. The Polynesians were primitive seafarers.

Therefore Polynesia could not have been settled from the western, Asian side of the Pacific because the early voyagers could never have forced their craft against the prevailing easterly trade winds and accompanying currents. Thus, the Polynesians must have come from the eastern side of the Pacific, from the coast of North and South America, sailing before the trade winds and drifting with the accompanying equatorial currents.

Soon thereafter the New Zealand historian Andrew Sharp (1956, 1957) mounted another attack on Polynesian orthodoxy. Unlike Heyerdahl, Sharp accepted that Polynesia must have been settled from the west, but claimed that the Polynesians' canoes were too unseaworthy and their navigational methods too inaccurate to have enabled them to mount intentional voyages of exploration and colonisation such as those featured in oral traditions. He concluded that therefore Polynesia must have been settled 'accidentally.' By that, he meant that the islands had slowly been colonised by a long series of nautical mishaps, occasioned when canoes sailing on short trips were blown off course or became lost because of the inherent inaccuracy of non-instrument navigational methods, or when people were driven from their islands by war or famine to randomly wander the seas until they died or chanced upon land.

Although few scholars took seriously Heyerdahl's thesis that Polynesia must have been settled from the Americas, Sharp's hypothesis appealed to many who thought that the nautical prowess of Polynesians had been grossly exaggerated, as well as to those prehistorians who were delighted to have a rationale for assuming that once an island had been settled by one or two canoes it remained largely if not totally isolated from all but nearby islands, so that they could study the development of an island culture as an internally generated process, not a function of outside influences.

But in the controversy that followed it became apparent that the available data on Polynesian nautical capabilities were inadequate either to confirm or to deny Sharp's hypothesis, or, for that matter, Heyerdahl's contention that canoes could never have been sailed eastward to Polynesia The voyaging canoes and their navigators were no more, and the written accounts about them were too sketchy to make firm conclusions. To make up for this lack of exact information on sailing performance, navigational accuracy and seamanship, starting in the mid-1960s my colleagues and I embarked on an experimental programme to reconstruct voyaging canoes and test how well they sailed, and how well non-instrument navigation methods worked, on long voyages throughout Polynesia in order to develop data and insights that could be employed to analyse Polynesian voyaging.

EXPERIMENTAL FINDINGS

The bulk of the documented experimental voyaging research has been undertaken aboard the *Hōkūle'a*, a double-hulled vessel which was launched in 1975. We chose to replicate a double canoe, a vessel made by joining two hulls with lashed crossbeams, rather than an outrigger canoe, a vessel made from a single hull steadied by the addition of an outrigger float, because both ethnohistorical evidence and the greater stability and carrying capacity of the double canoe suggest that the latter was the primary type of vessel employed for long voyages. *Hōkūle'a* was designed to represent a double canoe that might have been sailed between Hawaii and Tahiti some 800 years ago, an era when, according to Hawaiian legends, the two regions were linked by two-way voyaging.

Although *Hōkūle'a* was built largely of modern materials, we attempted to replicate the shape and weight of a traditional voyaging canoe so that the results of our sailing trials could be related directly to prehistoric voyaging issues. (Recent joint trials with *Hōkūle'a* and *Hawai'iloa*, a new canoe constructed of traditional materials, indicates that the performance characteristics of the two are comparable.) *Hōkūle'a*'s hulls, each of which is 62 feet (18.9m) long overall, are joined by ten major crossbeams. Two masts are mounted on the central platform placed between the hulls and atop the crossbeams. Each mast carries a single sail of the inverted triangular shape characteristic of East Polynesian sails. Although the canoe can easily carry some three dozen people, on long voyages we usually sail with a crew of 12 to 14, plus food and water for a month or more at sea. So loaded, the canoe displaces some 12 tonnes. Although modern materials were employed in the construction of major components of the canoe (cold moulded plywood for the hulls, cotton sails and synthetic lashings), we believe that the traditional shape of the hulls and the sails, and the considerable weight of the craft, means that *Hōkūle'a* sails more or less like an archaic craft of the same overall dimensions. The use of these materials meant, of course, that our canoe is considerably more maintenance free and durable than one made with hulls in which planks are joined edge to edge and sewn together, sails made from woven pandanus leaf, and with lashings made from coconut fibre line.

All in all, *Hōkūle'a* has sailed over 75,000 nautical miles of open ocean, more then three times our planet's circumference at the equator. (In conformance with nautical usage, nautical miles and knots are employed throughout. One nautical mile equals 1.15 statute miles and 1.85 kilometres. One knot is one nautical mile per hour.) This distance has been covered in the course of undertaking five

major voyages from Hawaii to the South Pacific and return, visiting the Tuamotus, Tahiti, the Leeward Society Islands, the Cook Islands, Aotearoa (New Zealand), Tonga, Samoa and the Marquesas Islands, as well as numerous voyages up and down the Hawaiian chain. During most of these crossings, *Hōkūle'a* has been navigated without a magnetic compass, charts or other navigational aids. On her first voyage from Hawaii to Tahiti in 1976, the canoe was navigated by a traditional navigator from Satawal, a Micronesian atoll where they still practice methods closely related to Polynesian ones. Since then, she has been navigated by a Hawaiian, Nainoa Thompson, who learned to navigate without instruments in a quasi-traditional style, or has been guided by his students.

All but the most recent voyages of *Hōkūle'a* have been analysed in a series of papers (Baybayan *et al.* 1987; Finney 1977, 1979, 1993a; Finney *et al.* 1986, 1989) and a recent monograph (Finney 1994). This section abstracts from these publications those findings which are most relevant to the issue of post-settlement, inter-island voyaging. These can be conveniently grouped under three headings: canoe performance, seamanship and navigation.

Canoe performance

Hōkūle'a sails most swiftly on a broad reach, that is when the wind is coming from slightly abaft the beam (i.e., blowing at an angle of more than 90° to the longitudinal axis of the vessel). In moderate trade winds and seas she can sail steadily at 7 to 8 knots on a broad reach, and can accelerate up to 10 or 12 knots when reaching before strong winds and surfing down the accompanying seas. The two long hulls of *Hōkūle'a* are semi-V shaped, a compromise typical of voyaging canoes between a narrow-V shape which would provide maximum resistance to making leeway, and a fully rounded shape which would give maximum carrying capacity. These hulls provide enough resistance to leeway, and her sails are aerodynamically efficient enough, to enable *Hōkūle'a* to sail to windward, although not as well as a monohull racing yacht equipped with a deep keel. Sailing full and by to windward, that is as close to the wind as possible without greatly losing speed, she can sail, after accounting for leeway, at least around 75° off the true wind. Of course, the canoe moves more slowly when sailing into the wind than in reaching across the wind, its speed dropping to around the 4.5 to 5.5 knot range in moderate winds and seas.

Spells of head winds, calms and gales (when sails have to be lowered) reduce the average sailing speed on long voyages. For example, on the 12,000 nautical mile voyage from Hawaii to Aotearoa undertaken in 1985-1987 *Hōkūle'a* averaged a little over four knots, which translates to about 100 miles (185 km) a day, an average daily run that most cruising yachtsmen would be happy to maintain. The longest voyages undertaken so far by *Hōkūle'a* are between Hawaii and Tahiti. Whereas the rhumb line course between the two covers about 2250 nautical miles (4164 km), because Hawaii lies to leeward (with respect to the easterly trade winds) of Tahiti, to gain enough easting *Hōkūle'a* has to sail a curving course that can take her over almost 3000 miles (4828 km) of ocean, and require upwards of a month at sea to accomplish.

Double canoes, the ancestors of the modern catamaran, are generally seaworthy vessels that move easily through the seas. Yet, they are vulnerable to swamping, capsize and breaking apart in heavy seas and high winds. Even modern reconstructions have suffered such disasters. In 1975 a reconstructed double canoe sailing from the Marquesas to Hawaii foundered in gale force winds and high seas just north of the equator. When the crossbeams linking the two hulls gave way, the hulls had turned inward and filled with water, leaving the crew to cling to the wreckage until an accompanying yacht rescued them. Although *Hōkūle'a*'s massive crossbeams made from oak, and the lashings made from dacron line connecting the hulls and crossbeams, have never been in danger of failing, she has twice been swamped. Furthermore, during one swamping when the leeward hull filled up while the windward hull retained its buoyancy, heavy winds blew the listing craft over before the sails could be lowered. Fortunately, both these accidents took place in Hawaiian waters close enough to land so that rescue vessels could tow the disabled canoe to shore. Had they taken place far from land and any vessels that might effect a rescue it seems likely that the vessels and all aboard them would have been lost at sea.

Seamanship

In its widest sense seamanship refers to all the arts that go into sailing a vessel from one place to another. A crucial feature of seamanship for Polynesians and other voyagers in the age of sail was learning the wind patterns and how to use them to sail where they wanted to go. Heyerdahl's assertion that 'permanent trade winds' moving from east to west across the ocean would have prevented ancestral Polynesians from sailing eastward to Polynesia ignores the actual wind patterns that prevail across the tropical Pacific. The trade winds do not always blow. Particularly during the Austral summer and during periods when El Niño disturbances occur, they periodically die down and are replaced by spells of westerly winds that may last for days, and sometimes for weeks or even months. As

Tupaia told Cook, Polynesian sailors wanting to make long crossings to the east waited for these westerly spells rather than trying to tack back and forth against the easterly trade winds.

Contemporary yachtsmen avoid making long crossings to windward when they can sail under more favourable conditions. Even though they can force their craft to windward, they reckon it would not be worthwhile exposing their vessel and crew to the beating that would sustain plunging into head seas. Polynesian sailors had even more incentive to avoid long windward passages. Since a double canoe can sail to only within about 75° of the wind, forcing such a craft directly to windward requires making a long series of shallow tacks that greatly lengthen a voyage. When tacking back and forth a double canoe such as *Hōkūle'a* must sail almost four miles to make one mile directly to windward. To tack directly to windward to an island a thousand miles away would therefore require a canoe to sail almost four thousand miles, even without considering the effects of current.

When we sailed from Samoa to Tahiti in 1986 we did not try to follow a rhumb line course, for that would have meant heading east-southeast directly against the mean trade wind direction for that part of the Pacific. Instead, our navigator, Nainoa Thompson, elected to try and exploit occasional spells of westerly winds brought on by the passage of low pressure troughs through the trade wind field. The navigator first broke the voyage into two legs: from Samoa to the Southern Cooks; from the Southern Cooks to Tahiti. Since the Southern Cooks lie some 10° to the south of Samoa, he chose to head south when the trade winds were blowing in order to position the canoe for a quick run east to these islands when the next low pressure trough came through. On the third day at sea the wind began to shift to the northeast, a sign that a low pressure trough was approaching. As the trough came closer and eventually passed the canoe the wind swung to the north, then the northeast, and then the southwest, all directions that enabled *Hōkūle'a* to be sailed due east, putting her within striking distance of the Southern Cooks. When the trades returned, the canoe was close enough to the Cook Islands to reach there by making just two tacks (Fig. 3.1).

After a month's layover in the Cooks, *Hōkūle'a* again set sail to the east, only this time she left when the wind was already blowing from the northwest. Although the navigator expected that, at best, it would probably take two such episodes of westerlies, punctuated by a spell or two of trade winds, to enable the canoe to reach Tahiti, until the very end of the voyage the wind blew mostly out of the northwest, driving the canoe to the east of Tahiti before steady southeast trades returned and she could be turned around and sailed westward back to Tahiti.

Earlier, in late 1985, we had faced a different sort of problem when crossing from Tahiti to Aotearoa, that of sailing southwest out of the trade wind zone and into temperate latitudes where cold and stormy westerly winds often blow. Although the first leg of the voyage from Tahiti to Rarotonga in the Southern Cooks was accomplished in August-September by sailing across the southeast trades, we had to wait in Rarotonga until late November before attempting the crossing to Aotearoa. Māori legends specify that a canoe bound for Aotearoa should set sail around this

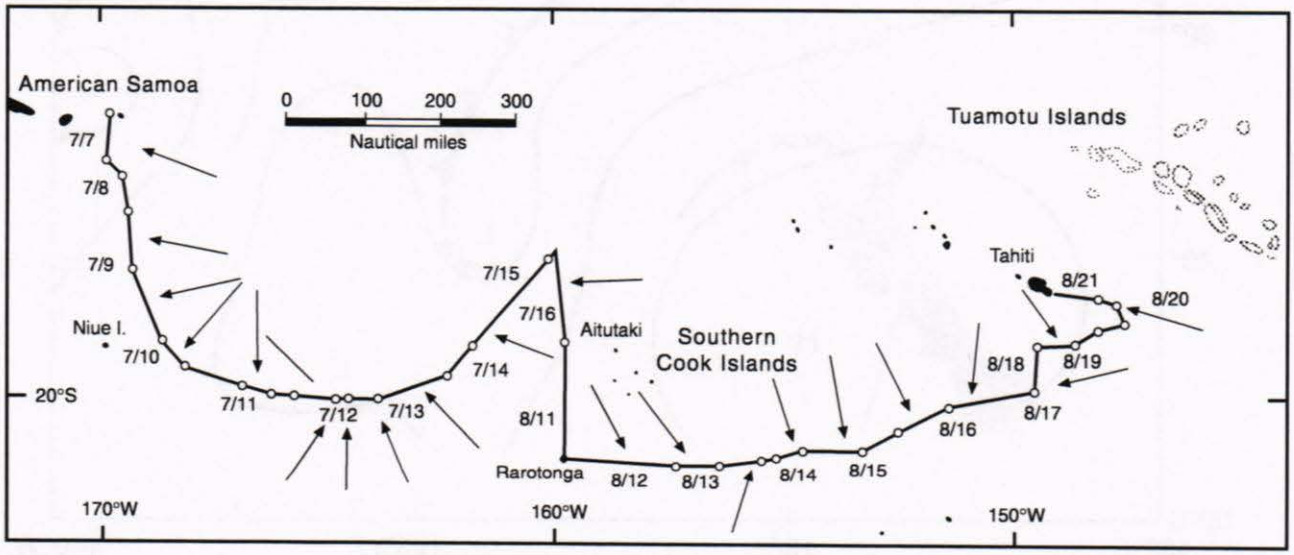


FIGURE 3.1. Sailing track of *Hōkūle'a* from Samoa to Tahiti during July-August 1986. Winds encountered along the route are indicated by arrows.

time and head directly for the setting sun. When we first read these directions we thought that the navigational information was primary, for that is the time of the year when the setting sun sets in the direction of Aotearoa. However, in studying the wind patterns in that part of the Pacific it became apparent that a late (Austral) spring sailing date was specified because that is when large, slow-moving high pressure systems begin to dominate the sea lanes to Aotearoa, bringing spells of easterly winds that would speed a canoe southwest to Aotearoa. Fortunately, practice followed theory. A few days after setting sail we passed out of the trade wind zone and then were able to catch the easterlies circulating counter-clockwise around three consecutive highs (separated by the brief passages of intervening lows) that enabled us to keep heading southwest to Aotearoa, bringing us there in just 16 days (Fig. 3.2).

Even when crossing between islands aligned north and south, sailing both ways across the easterly trade winds requires some timing to be at sea when the trades are steadiest and the incidence of storms is least. For example, in making round-trip voyages between Hawaii and Tahiti we try to leave Hawaii between late March and early May, after the stormy seasons of both the Northern and Southern Hemispheres have passed and steady trade winds normally resume along the route. Then, we do not linger long in Tahiti. After a rest, we hurry back to Hawaii in order to arrive there before the start of the hurricane season in July when tropical disturbances originating off the Central American coast start moving westward across the Pacific where they frequently intersect the route between Tahiti and Hawaii.

Waiting for favourable winds can of course lengthen the time required to make a crossing from days or weeks to months. (Even waiting for variations in the trade wind, for example for a switch from southeast to northeast trades in order to sail to the southeast, can take much time.) Furthermore, the need to wait for favourable winds can greatly lengthen multi-leg voyages when each leg requires a different wind pattern. Thus, long waits required at

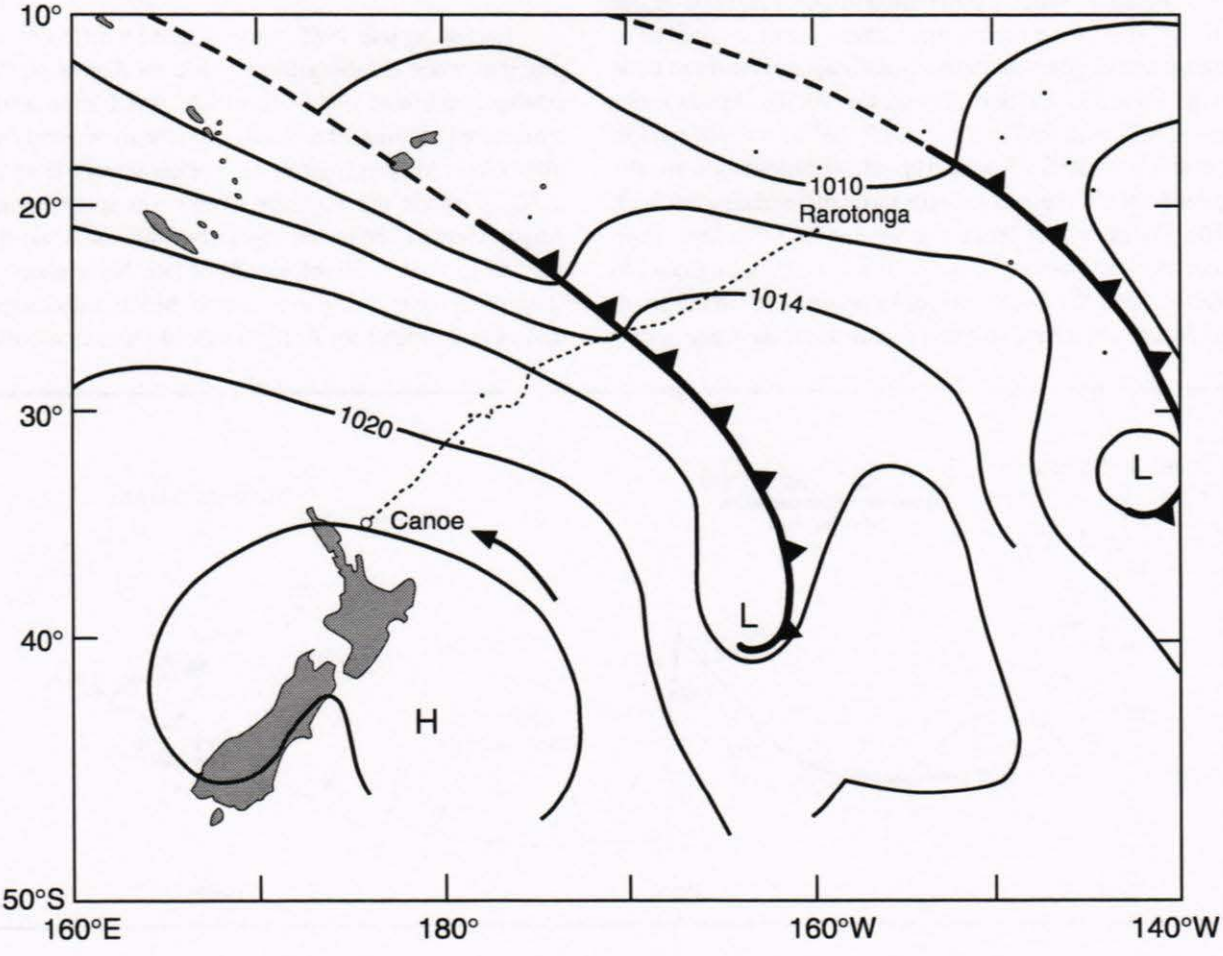


FIGURE 3.2. Sailing track of *Hōkūle'a* southwest from Rarotonga to Aotearoa in November-December 1985: position of the canoe on December 7 showing southeasterly winds circulating around a high centred on Aotearoa (from Finney 1994:193).

Rarotonga, Aotearoa, Samoa and Tahiti on the 12,000 mile (19,300 km) round-trip voyage between Hawaii and Aotearoa greatly contributed to making that voyage last two years when the canoe was actually under sail for only four months.

Navigation

Sharp was adamant in his negative assessment of Polynesian navigation. Their methods were so inaccurate, he declared, that it was impossible for them to have made intentionally navigated voyages between islands separated by more than 300 miles (483 km) of open ocean. Yet, Nainoa Thompson and his colleagues have been able to navigate *Hōkūle'a* without resort to any instruments or charts on numerous voyages longer than 300 miles, including five crossings between Hawaii and Tahiti, islands separated by over two thousand miles of open water!

To be sure, there are plenty of sources for error in Polynesian methods. To set a course the navigator takes his bearings from the rising and setting points of the stars, which, since these do not shift perceptibly in a person's lifetime, can be said to form invariant points of a stellar compass. To keep oriented during the day he employs the bearings of the rising and setting sun (periodically calibrating their shifting position to the invariable star compass). When overcast skies obscure all views of the stars, or the sun, or when the sun is too high in the sky to yield a bearing, the navigator keeps himself oriented by reference to the dominant swells, which he has previously been monitoring in relation to his stellar and solar compass for just such an eventuality.

But none of these tasks can be accomplished exactly. First, the horizon is often too cloudy or hazy to take a precise bearing. Second, even when the horizon is clear, key navigational stars are seldom right on the horizon when needed. If they are well above the horizon, the navigator must estimate where they were when they rose or where they will be when they set. If they are overhead, or below the horizon, he has to try to estimate his bearings from other stars close to the horizon which he knows follow more or less the same path across the sky (i.e., have the same declination) as his key stars. Third, keeping oriented on the sun as it climbs high overhead, or on shifting ocean swells when all celestial referents are obscured, leaves even more room for error. Finally, the difficulty of estimating the course and speed of a canoe, as well as the impact on these of unseen current flow, might seem to make dead reckoning and making course adjustments on the basis of this estimation process a seemingly impossible task.

How then, given so many sources for error, can Nainoa and his colleagues successfully make landfall after landfall, as, allegedly, did their ancestors? If you assume, as did Sharp, that navigators had to sail unerringly from one small island to another, and that the inevitable errors, large and small, made in each step of the navigational process must add up to throw a canoe hopeless off course after several days of sailing, the question cannot be answered. However, when you realise that most Polynesian islands are not alone in the ocean but exist within archipelagos, and that navigational errors are more likely to cancel one another out than accumulate in one direction, the apparent paradox is resolved.

This can be illustrated by reference to the five round-trip voyages *Hōkūle'a* has made between Hawaii and Tahiti. If Tahiti was alone in the ocean, and O'ahu (the home base of *Hōkūle'a*), was equally isolated, sailing back and forth between the two would indeed be challenging. However, O'ahu and Tahiti exist within large archipelagos, the Hawaiian chain, and the Society Islands, respectively. The navigator's job is therefore lightened because he knows that he does not necessarily have to find his island target directly. If he can make landfall on any island within the archipelago in question, he can then reorient himself and sail directly to the target island.

Actually, the navigator typically aims for an island or islands on the windward (with respect to the prevailing winds) side of the archipelago in question, so that after initial landfall he can freely sail downwind to his final destination. Thus, when sailing from Tahiti to Hawaii, we try to reach the latitude of Hawaii just slightly to windward (east) of the easternmost island of the chain, the 'Big Island' of Hawai'i, and then turn downwind until we sight the island. Once we have so established our position, we sail with the trade winds directly for O'ahu. Since, however, Tahiti is at the windward end of the Society chain, we try to make our landfall on one of the atolls at the western end of the Tuamotu chain which lie one day's sail north of Tahiti and slightly to windward of the island. In fact, on all five crossings to Tahiti we have made landfall on one of the three westernmost islands of the Tuamotu chain - Mataiva, Tikehau and Rangiroa, from whence our navigators have always been able to reorient themselves and sail directly on to Tahiti.

However, on two of the five crossings to Tahiti, a comparison of the actual track of the canoe with where the navigator thought the canoe was sailing indicates that major navigational errors were made, but that they made no difference to the outcome. We establish the actual track of the canoe remotely through the ARGOS satellite tracking system in which signals from a sealed transmitter on board

the canoe are received by passing satellites, then relayed to a ground station in Toulouse. After the ground station calculates the position of the canoe at the time each signal is received, the information is sent to the University of Hawaii where it is archived. While *Hōkūle'a* is being remotely tracked in this manner, at each sunrise and sunset the navigator records on a tape recorder his dead reckoning estimate of where the canoe is at the time. After the voyage the actual track of the canoe based on the satellite data, and the navigator's twice daily position estimates (converted from his directional system into latitude-longitude fixes), are plotted.

Figure 3.3 shows *Hōkūle'a*'s track from Hawaii to Tahiti in 1980, and navigator Nainoa Thompson's twice-daily dead reckoning estimates during that crossing. A comparison of the two indicates how opposing errors in estimating current cancelled each other out so that by the end of the voyage his dead reckoning estimates were virtually right on the canoe's actual track. On March 31st, just after leaving the doldrums, the zone of calms and light winds between the northeast and southeast trade wind belts, Nainoa's perception of where the canoe was and its actual position were only a dozen or so miles apart. However, soon thereafter *Hōkūle'a* apparently crossed, unperceived, through one of those swift, narrow current jets that periodically appear near the equator. Without a land referent, Nainoa failed to detect that this current jet had quickly pushed the canoe some 90 miles (145 km) to the west of where he thought it was sailing. Therefore, as the canoe headed south over the next ten days his position estimates paralleled the canoe's actual track, but were 90 miles to the east of it. However, on April the 11th Nainoa revised his thinking. Because he reasoned that the slow progress of the canoe below the equator was exposing it to more of the westward-flowing South Equatorial Current than allowed for in his calculations, he factored in a greater current set to the west, which placed his dead reckoning positions some 90 miles to the west, almost directly onto *Hōkūle'a*'s actual track. However, contemporaneous tracking of the current south of the equator by radio buoys dropped by a U.S. Navy aircraft indicated that the current was extraordinarily weak at this time and that Nainoa's revision was therefore based on an overestimate of current strength. Nonetheless, that overestimate offset his earlier failure to notice and factor in the current jet north of the equator, thereby bringing his mental picture of where the canoe was sailing almost directly onto the actual track.

On the 1985 crossing to Tahiti, however, no such cancelling out occurred, and the gap at the end of the voyage between where Nainoa thought the canoe was, and its actual position, was considerable. Nainoa had reckoned that strong currents and headwinds had driven the canoe to the west of Tahiti where it would make landfall on one of the leeward islands of the Society group, when in fact the canoe made a landfall on the Tuamotuan atoll of Rangiroa. In this case, although Nainoa had faultlessly carried out the navigational strategy of making initial landfall in the western Tuamotus, he somehow had overestimated how far the canoe had been set westward by wind and current. But that made no difference to the outcome of the voyage. The next day, after identifying the atoll (by its size; Rangiroa is many times bigger than the other atolls in the western Tuamotus and those of the neighbouring Society Islands) Nainoa was able to guide *Hōkūle'a* to Tahiti without difficulty.

ORAL TRADITIONS AND INTER-ISLAND VOYAGING

In 1925 the New Zealand ethnographer Elsdon Best (1925:14) published a chart on which he had plotted "some recorded voyages of the Polynesians in olden days" derived from oral traditions (Fig. 3.4). His chart, which indicated that Polynesians had voyaged widely across the length and breadth of Polynesia, as well as into eastern Melanesia and even into frigid Antarctic waters, graphically summed up the prevailing opinion at the time. However, since the middle of this century hardly anyone interested in Polynesian prehistory has paid attention to this chart, or to the compilations by Best and others of Polynesian traditions featuring accounts of long-range voyaging.

Starting in the mid-1950s, it became popular to label voyaging traditions as 'mythical' constructs of the imagination, not verbal narratives based upon or reflecting voyages actually undertaken. At first, voyaging traditions were characterised in Malinowskian terms as 'mythical charters' invented to justify claims to land and social status. For example, in 1956, Ralph Piddington, then the influential head of Auckland University's anthropology department, denounced earlier researchers who had written about Māori traditions of canoes arriving periodically at Aotearoa, and claimed that these were in no sense historical accounts of actual migrations, but, instead, were myths composed to bolster claims for land and status derived by descent from the settlers arriving on these canoes (Piddington 1956). More recently, the term mythical has been applied to voyaging traditions in the post-modern antirealism sense (Searle 1995). For example, in 1985 Margaret Orbell devoted a volume to 'a new approach to Māori tradition', in which she claimed that the legendary Māori homeland of Hawaiki did not refer to a geographical place, but to a mythical paradise, and that tales of canoes sailing from Hawaiki to Aotearoa recorded voyages made in the mind, not at sea (Orbell 1985).

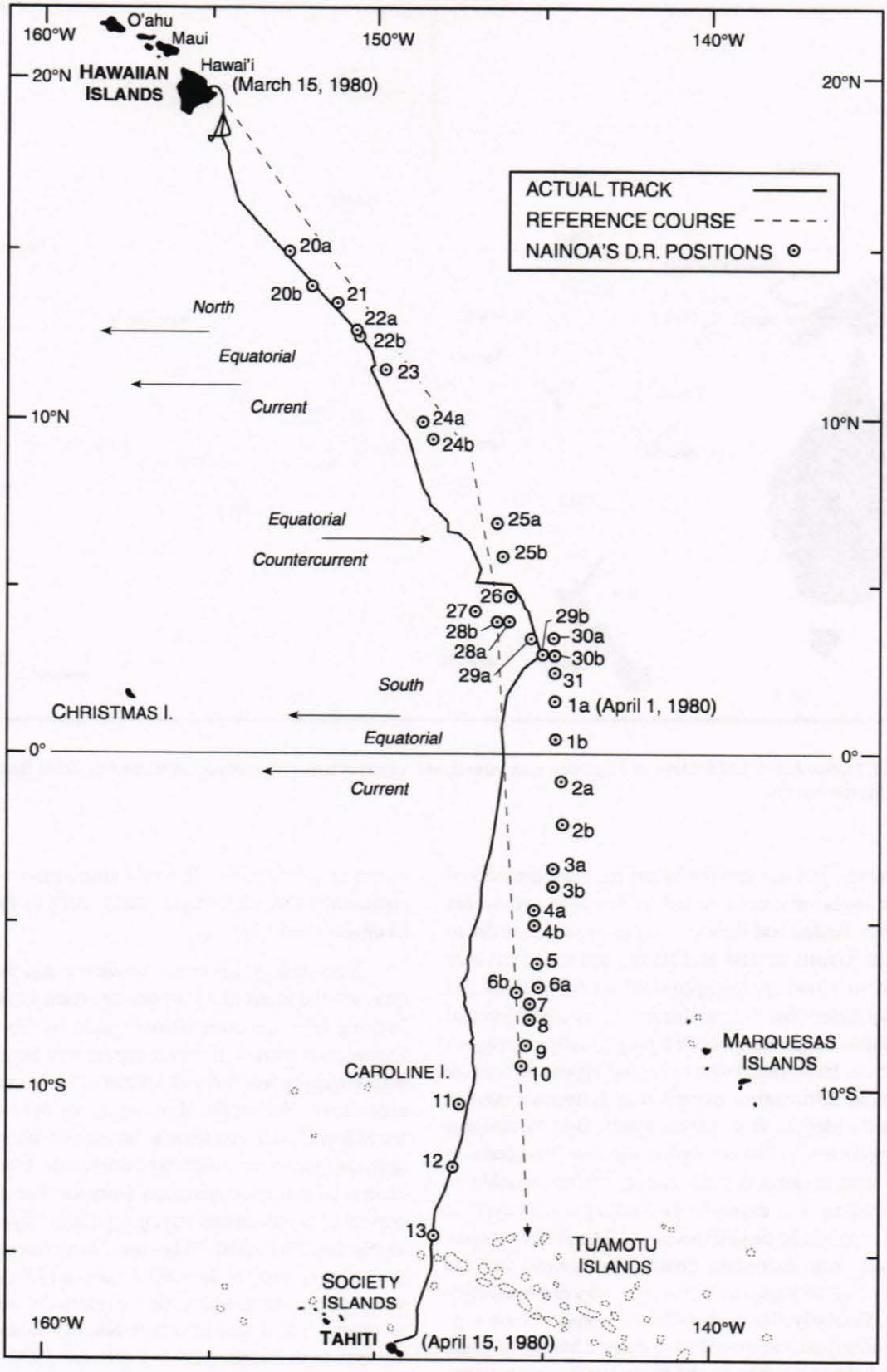


FIGURE 3.3. Hawai'i to Tahiti March-April 1980, showing actual track of *Hōkūle'a* derived from satellite fixes, the reference course used for navigation, and the navigator's dead reckoning (D.R.) positions estimated at sunrise (marked by 'a' following the date) and at sunset (marked by 'b') (from Finney 1994:91).

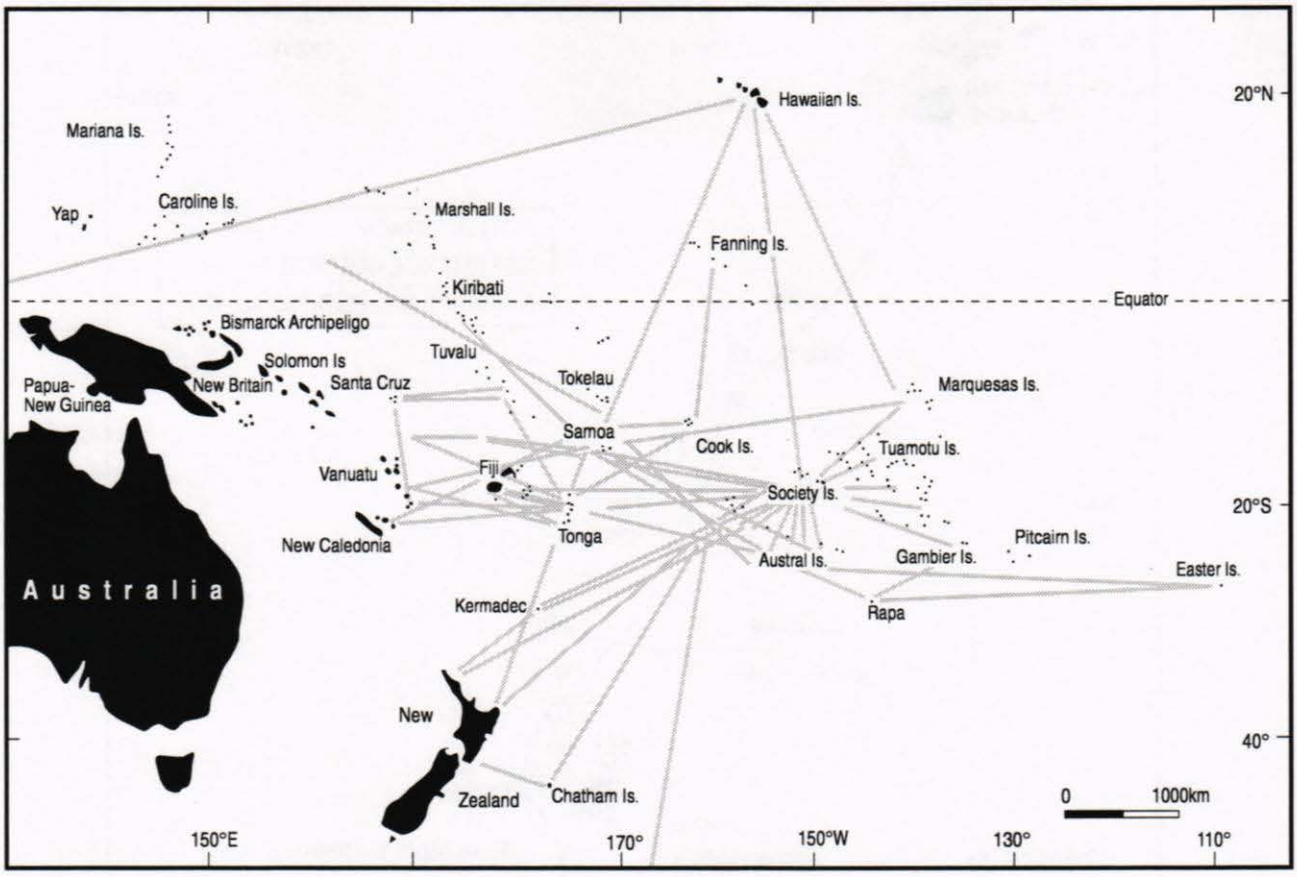


FIGURE 3.4. Elsdon Best's 1925 Chart of migration and inter-island voyages taken from voyaging traditions (from Best 1925:14; redrawn by Martin Fisher).

However, just because the Māori recited narratives of how their ancestral canoes sailed to Aotearoa and where exactly they landed and their occupants settled in order to justify their claims to land and status, and spoke of their homeland in glowing, metaphysical terms, it does not necessarily follow that their traditions were purely fictional constructions. To be sure, when trying to judge voyaging patterns from traditions, those tales that appear to contain geographical information gained after European contact should be avoided, as should those synthesised by amateur scholars who arbitrarily combined separate traditions to come up with a chronological history understandable in European terms. For example, two voyages portrayed in Best's chart might be candidates for exclusion: the journey of Irapanga from Indonesia directly to Hawaii, and the journey of Hui Te Rangiora to the ice packs off Antarctica and back. Similarly, those tales of the involved wanderings and marvellous adventures of such culture heroes as Maui and Hiro should probably also be treated with great caution. However, there are simply too many voyaging tales involving actual routes, sailing directions, places and persons to dismiss all such traditions as mythical representations of voyages made only in the mind (cf. Cachola-Abad 1993).

Nonetheless, historical evidence has been cited to question the thesis that Polynesians once voyaged widely. Judging from the observations made by Cook and other European explorers, it would appear that long-range, two-way voyaging was not widespread in Polynesia during the contact era. Neither the Hawaiians, nor the Rapa Nui, nor the Māori of Aotearoa seem to have been in regular contact with the more central islands of Polynesia. Even from these central islands documentation from the European contact period of wide-spread voyaging links beyond adjacent archipelagos is limited. To be sure, Marquesans were raiding the Tuamotu atolls to the south (Audran 1927; Quiros 1904, vol. 2:152), while in turn the Tuamotuans were voyaging to nearby Tahiti and the other Society Islands to obtain various high island products (Oliver 1974 vol. 1:214). Similarly, atoll-dwellers of Pukapuka in the northern Cooks sailed to Samoa and other high islands to obtain basalt stones to make tools (Beaglehole and Beaglehole 1938:351-353,

410-412). A Tahitian inscription on Tupaia's chart indicates that not all transport of adzes was from volcanic to coralline islands; it refers to fine adzes coming to Ra'iatea in the Societies from Ra'ivavae in the Australs (Skelton 1955, viii, chart 11). But these and most other documented routes from this period were between adjacent archipelagos, and were within Sharp's 300 mile (483 km) limit on intentional voyaging, or not much above it. Only from Tonga is there clear evidence of major long-distance voyaging at the time of contact. The Tongans were then sailing their large and fast double canoes throughout West Polynesia, far into Melanesian waters to the west and may also have been making forays to Micronesia (Dillon 1829:112; Kirch 1984:237-242).

Yet oral traditions from throughout Polynesia are filled with references about canoes sailing to and from distant islands for a variety of purposes. These voyaging traditions include, for example, tales about: the widespread rovings around Polynesia of the Samoan chief Karika (Crocombe and Crocombe 1968:140-142; Williams 1838:64, 165-169); chiefs and priests making long voyages back and forth between Hawaii and 'Kahiki' (Emerson 1893; Finney 1991); periodic pilgrimages made by islanders from as far away as Aotearoa and Rotuma to the great Tahitian temple of Taputapuātea on the island of Ra'iatea (Henry 1928:121-127); Māori voyagers sailing back and forth between Aotearoa and their legendary homeland of Hawaiki (Best 1925:385-421); Marquesan voyages made to Rarotonga to obtain supplies of precious red feathers (Von Den Steinen 1988:11-31).

If we accept these and other such tales as indicative of a period when Polynesians sailed widely throughout the region, we are forced to ask why the Polynesians were evidently not voyaging so widely at the time of European contact? Certainly, our experimental voyages, as well as the documented maritime adventures of the Tongans, demonstrate that Polynesian canoes, ways of navigating and seamanship were up to the task of making long, navigated voyages. But the availability of technology hardly means that it will always be used, or at least employed at the same level. Ming Dynasty China once had the largest navy in the world equipped with huge ships that incorporated such Chinese innovations as the stern rudder, compartmentalised hull construction and the magnetic compass. Early in the 15th century the Emperor sent fleets of these vessels through the South China Sea and into the Indian Ocean where they called on ports in Sri Lanka, South India, Persia, Arabia and East Africa. Yet, following the death of the expansionist Yongle Emperor and his famous eunuch Admiral Zheng He, the last voyage conducted in 1433 ended this era of naval expansion. The Confucian bureaucrats opposed to what they considered to be wasteful expenditures for overseas voyaging reasserted their authority. The great ships never sailed again, and China withdrew from the sea and turned inward (Finney 1985a; Levathes 1994).

Sheer necessity must have played some role in motivating inter-island voyaging, particularly in the years immediately after settlement. Archaeologists discussing the establishment of Lapita settlements have proposed that sailing back and forth between a newly settled island and the home island would have given a struggling colony an edge for survival in that planting materials, tools and healthy, marriageable youths could be obtained through such continuing links (Hunt 1989; Kirch 1988). Furthermore, there are many traditions from Polynesian proper that feature voyages made for such practical ends as fetching the breadfruit, sweet potato or some other cultigen needed by a struggling colonial outpost. Furthermore, it seems clear that atoll societies such as those in the Tuamotus and Northern Cooks needed to keep in contact with high islands in order to obtain stone tools and other high islands products not available on islands composed only of coral and sand (see, Chapter 4, this volume).

But such utilitarian reasoning cannot explain all inter-island voyaging, whether documented in the historical record or featured in legend. The Tongans, for example, voyaged much farther and wider than any trade imperatives. In fact, during the late prehistoric period extending into post contact times they seem to have been reinventing Polynesian voyaging on an imperial model, establishing exchange links and military-political overlordship with islands throughout the Lau group of Fiji and as far away as Rotuma, as well as venturing far into Melanesian waters on raiding voyages.

Traditions from throughout Polynesia are also filled with tales about how chiefs, priests, and other high-ranking people sailing the seas to visit far off lands for a variety of 'adventurous' purposes: to make a pilgrimage to a sacred centre, to bring new religious ideas and institutions to a 'backward' island, to wreak revenge on a mortal enemy, to marry a fabled beauty, to get over a disappointment in love, to seek symbolically valuable items, and so on. Given the nature of Polynesian culture, as well as Mary Helms' intriguing analysis of the importance of such motivations for travel in the ancient world (Helms 1988), voyaging for such purposes cannot be dismissed as so much wishful thinking on the part of story tellers.

If, however, long range voyaging was once so useful and fulfilling, why would it have declined? In a few cases environmental degradation may have been at work. For example, once the Rapa Nui had denuded their island of trees they were left with only scraps of wood out of which

they could build only the tiny fishing canoes seen by the first Europeans to visit their lonely island (Bahn and Flenley 1992; Finney 1985b). Weisler (1994, Chapter 9) has suggested that the deforestation of Mangareva may also have been critical in the decline in voyaging between Mangareva and surrounding islands to the point where the dependent settlements at Pitcairn and Henderson had to be abandoned. But such reasoning would not appear to apply to islands such as Hawaii, Tahiti, Samoa and Aotearoa where there were still ample timber supplies for building large canoes.

Why would Polynesians living on such well-timbered high islands have given up overseas voyaging? One explanation that came to mind as we laboured to build *Hōkūle'a*, and then to sail her over legendary sea routes, hinges upon the economists' concept of 'opportunity cost'. As we learned, building, sailing and maintaining a large voyaging canoe is costly. Months or even years of labour go into building these craft. Great trees have to be sacrificed to make the hulls and other components, many thousands of fathoms of coconut fibre line have to be made to lash these together and fabricate the rigging and large crews must be trained and dispatched on the voyages, taking needed labour from the local community. Furthermore, each voyage risked the loss of considerable capital, material and human, through maritime disaster or landfall on an unfriendly island. Early in Polynesian prehistory it must have been judged worthwhile to freely invest valuable resources in voyaging. Once, however, the islands were settled with a full complement of domesticated plants and animals and other resources, and populations had become sizable, there was less material need for voyaging, and, particularly for the chiefs, competing activities evidently came to be considered as much more exciting or pressing than adventurous voyaging. At the time of contact, for example, the leaders of the mature chiefdoms of Hawaii and Tahiti were not concentrating their energy and resources on mounting overseas expeditions, but rather on intensifying agricultural production, expanding their chiefdom's boundaries at the expense of others, promoting their favoured gods, and other local projects.

DISCUSSION

Our voyaging experiments, and a reading of the voyaging traditions might seem to indicate that Polynesians must have had the capability to sail back and forth between islands distributed throughout Polynesia and to and from at least the neighbouring islands of Melanesia and Micronesia. Such a blanket conclusion would be misleading, however. Whereas it is fairly easy to sail over some inter-island routes, other routes are much more difficult to negotiate to the point where it may have taken extraordinary dedication to make a crossing. Sheer distance is of course a factor, but not necessarily more important than whether or not the winds are favourable along a route, and how wide a navigational target is presented by an island destination, or archipelago in which it is imbedded.

Routes in tropical Polynesia between islands which are aligned north and south or roughly so, and which therefore lie athwart the easterly trade winds, would generally provide the best conditions for back and forth sailing. For example, the alignment of the Tongan chain at right angles to the prevailing southeast trade winds must have facilitated interisland voyaging within that archipelago, a situation which might go a long ways toward explaining the long Tongan history of rule by one chiefly dynasty. Similarly, to cite an example where the islands distributed on a north-south axis are much farther separated, it may take a long time to sail back and forth between Tahiti and Hawaii, but the crossings are not as difficult as the distance involved might imply, a situation that lends some credibility to traditions about voyaging back and forth between the two centres.

Sailing back and forth between archipelagos within West Polynesia and the central core of East Polynesia would not seem to have presented any insurmountable problems, although it would have been easier to sail back and forth between islands aligned north and south than those aligned east and west, since voyagers on the eastward leg would either have to tack against the trades or wait for westerly winds. In some situations, however, an island does not have to lie due east of its neighbours to make it difficult to reach. Even though the Marquesas Islands lie only 750 miles (1207 km) northeast of Tahiti, our two attempts to sail from there to the Marquesas were unsuccessful because of long spells of unfavourable northerly winds and tight schedules that would not permit us to wait until the desired wind, a *mara'amu* from the south-southeast, started blowing. Similarly, we have never been able to sail to the Marquesas directly from Hawaii. Although when reaching across the northeast trade wind belt of the Northern Hemisphere *Hōkūle'a* is often headed directly for the Marquesas, as soon as we enter the southeast trade wind zone (which begins around 5° north of the equator) our track starts curving to the south-southwest away from the group.

The marked distinctiveness of Rapa Nui culture, usually classed as the most aberrant within the family of East Polynesian cultures, may well stem from the difficulty of maintaining two-way communication between the central core of East Polynesia and this easternmost outpost of Polynesia, rather than to direct settlement from West Polynesia or to cultural intrusions from South America as some have proposed (Finney 1993b, 1994:270-273, 305-

306). Rapa Nui lies between around 1500 miles (2414 km) and 2000 miles (3219 km) east, to windward with respect to the trades, from the islands at the eastern edge of central East Polynesia from which the island is most likely to have been settled: the Marquesas, Mangareva and the Australs. This means that a canoe would probably have to work its way eastward using wind shifts. Even taking the shortest route, from Mangareva to Pitcairn and then on to Rapa Nui would not be easy, particularly given the narrow target that Rapa Nui presents to a navigator. Unlike virtually every other Polynesian island, Rapa Nui is a lone target without surrounding islands to expand its width. Surely, a navigated voyage to Rapa Nui must have been one of the most difficult challenges among the possible voyaging routes of Polynesia. Further complicating the situation was that the deforestation of Rapa Nui following colonisation meant that after some centuries the people there would not have had sufficient timber to build large voyaging canoes of their own.

Moving back and forth between West and East Polynesia would probably not have presented insoluble challenges for the Polynesians, although the west to east crossings must have required considerable effort. In steady trade wind weather canoes from the Northern and Southern Cooks could easily have reached Samoa or Tonga in a week or so, and those sailing from Tahiti or the other Societies would probably have required no more than an additional week of sailing. Voyages from Samoa and Tonga to the west have required waiting for and exploiting just the right wind conditions, particularly if Tahiti or other more easterly islands were the destination. But as *Hōkūle'a*'s 1986 voyage from Samoa to Tahiti demonstrated, exploiting spells of westerly winds to move east works. It therefore seems likely that when Tupaia told Cook about sailing to "plenty of islands" lying west, taking "10 to 12 days in going thither and 30 or more in coming back", the Tahitian sage was referring to round-trip canoe voyages between the Societies and West Polynesia made by exploiting easterly trade winds to sail westwards and westerly winds shifts to return to their home islands (Cook 1955:156-157; Lewis 1972:196-198).

In summary, archaeologists should not be greatly surprised to find adzes or other cutting tools made of fine grained basalt or volcanic glass that can be traced back to a distant source, or be shy about looking for such material evidence of connections between widely-spaced islands and archipelagos. Yet, they should also realise that the alignment of islands with respect to the dominant winds, the width of the navigational targets in question, and to some degree distance between islands, must have affected the degree of inter-island communication.

REFERENCES

Audran, R.P.H. 1927. Les Hiva. *Bulletin de la Société des Etudes Océaniennes* 22:317-8.

Bahn, P. and J.L. Flenley. 1992. *Easter Island, Earth Island*. London, Thames and Hudson.

Baybayan, C., B. Finney, B. Kilonsky and N. Thompson. 1987. Voyage to Aotearoa. *Journal of the Polynesian Society* 96:161-200.

Beaglehole, E. and P. Beaglehole. 1938. Ethnology of Pukapuka. *Bernice P. Bishop Museum Bulletin* 150. Honolulu.

Best, E. 1925. The Maori Canoe. *Dominion Museum Bulletin* No. 7. Wellington.

Best, S., P. Sheppard, R. Green and R. Parker. 1992. Necromancing the stone: archaeologists and adzes in Samoa. *Journal of the Polynesian Society* 101:45-85.

Cachola-Abad, C.K. 1993. Evaluating the orthodox dual settlement model for the Hawaiian Islands: an analysis of artefact distributions and Hawaiian oral traditions. In M. Graves and R. Green (eds), The Evolution and Organisation of Prehistoric Social Systems in Polynesia, pp. 13-32. *New Zealand Archaeological Association Monograph* 19. Auckland.

Cook, J.. 1955. *The Voyage of the Endeavour, 1768-1771*. J.C. Beaglehole, Cambridge, Hakluyt Society.

Crocombe, R.G. and M. Crocombe. 1968. *The Works of Ta'unga*. Canberra, Australian National University Press.

Crozet, J. 1783. *Nouveau Voyage à la Mer Du Sud*. A.M. Rochon (ed.). Paris: Barrois

Dillon, P. 1829. *Narrative of a Voyage in the South Seas . . . to Ascertain the Actual Fate of the La Perouse Expedition*. London, Hurst, Chance & Co.

Emerson, N.B. 1893. The Long Voyages of the Ancient Hawaiians. *Papers of the Hawaiian Historical Society* No.5. Honolulu, Hawaiian Historical Society.

Finney, B. 1977. Voyaging canoes and the settlement of Polynesia. *Science* 196:1277-1285.

Finney, B. 1979. Voyaging. In J. Jennings (ed.), *The Prehistory of Polynesia*, pp. 323-351. Cambridge, Mass., Harvard University Press.

Finney, B. 1985a. Voyagers into ocean space. In B. Finney and E. Jones (eds). *Interstellar Migration and the Human Experience*, pp. 164-179. Berkeley, University of California Press.

Finney, B. 1985b. The prince and the eunuch. In B. Finney and E. Jones (eds), *Interstellar Migration and the Human Experience*, pp. 196-208. Berkeley, University of California Press.

Finney, B. 1991. Myth, experiment and the re-invention of Polynesian voyaging. *American Anthropologist* 92:383-404.

Finney, B. 1993a. Rediscovering Polynesian navigation through experimental voyaging. *The Journal of Navigation* 46:385-394.

Finney, B. 1993b. Voyaging and isolation in Rapa Nui prehistory. *Rapa Nui Journal* 7:1-6.

Finney, B. 1994. *Voyage of Rediscovery*. Berkeley, University of California Press.

Finney, B., B.J. Kilonsky, S. Somsen and E.D. Stroup. 1986. Re-learning a vanishing art. *Journal of the Polynesian Society* 95:41-90.

Finney, B., P. Frost, R. Rhodes and N. Thompson. 1989. Wait for the west wind. *Journal of the Polynesian Society* 98:261-302.

Fornander, A. 1969. *An Account of the Polynesian Race its Origin and Migrations*. Rutland, Vermont, Tuttle. (Originally published in 3 vols. all under the same title in 1878, 1880 and 1885, London, Trübner).

Garanger, J. 1972a. Mythes et archaéologie en Océanie. *La Recherche* 3:233-242.

Garanger, J. 1972b. Archéologie des Nouvelles-Hébrides: contribution à la connaissance des Iles du centre. *Publication de la Société des Océanistes* No. 30. Paris.

Goldman, I. 1955. Status rivalry and cultural evolution in Polynesia. *American Anthropologist* 57:680-697.

Handy, E.S.C. 1930. History and Culture in the Society Islands. *Bernice P. Bishop Museum Bulletin* 79. Honolulu.

Helms, M.V. 1988. *Ulysses' Sail*. Princeton, New Jersey, Princeton University Press.

Henry, T. 1928. Ancient Tahiti. *Bernice P. Bishop Museum Bulletin* 48. Honolulu.

Heyerdahl, T. 1947. Le "Kon-Tiki" à Papeete. *Bulletin de la Société d'Etudes Océaniennes* 7:345-355.

Heyerdahl, T. 1953. *American Indians in the Pacific*. Chicago, Rand McNally.

Hunt, T.L. 1989. Lapita Ceramic Exchange in the Mussau Islands, Papua New Guinea. Ph.D. thesis. Ann Arbor, Michigan, University Microfilms.

Kelly, C. 1966. *La Australia del Expiritu Santo*. 2 vols. Cambridge, Hakluyt Society.

Kirch, P.V. 1984. *The Evolution of Polynesian Chiefdoms*. Cambridge, Cambridge University Press.

Kirch, P.V. 1988. Long distance exchange and island colonisation. *Norwegian Archaeological Review* 21:103-117.

Kirch P.V. and D.E. Yen. 1982. Tikopia: The Prehistory and Ecology of a Polynesian Outlier. *Bernice P. Bishop Museum Bulletin* 238. Honolulu.

Lang, J.D. 1834. *View of the Origin and Migrations of the Polynesian Nation; Demonstrating their Ancient Discovery and Progressive Settlement of the Continent of America*. London, James Cochrane.

Lang, J.D. 1877 *View of the Origin and Migrations of the Polynesian Nation*. Revised ed. London, Sampson Low, Marston, Low and Searle.

Levathes, L. 1994. *When China Ruled the Seas*. New York, Simon and Shuster.

Lewis, D. 1972. *We the Navigators*. Honolulu, University of Hawaii Press.

Martínez de Zúñiga, J. 1966. *An Historical View of the Philippine Islands*. Trans. by J. Maver from *Historia de las Islas Philipinas*. Sampaloc, Philippines, Fr. Pedro Argüellos, 1803. Manila: Filipiniana Book Guild.

Oliver, D. 1974. *Ancient Tahiti*. 3 vols. Honolulu, University of Hawaii Press.

Orbell, M. 1985. *Hawaiki: A New Approach to Maori Tradition*. Christchurch, New Zealand, University of Canterbury.

Piddington, R. 1956. A note on the validity and significance of oral traditions. *Journal of the Polynesian Society* 65:200-204.

Quiros, P.F de. 1904. *The Voyages of Pedro Fernandez de Quiros, 1595-1606*. 2 vols. Trans. and ed. by C. Markham. London, Hakluyt Society.

Rolett, B. in press. *Hanamiai: Prehistoric Colonisation and Cultural Change in the Marquesas Islands, East Polynesia*. New Haven, Connecticut, Yale University Publications in Anthropology.

Roggeveen, J. 1970. *The Journal of Jacob Roggeveen*. A. Sharp (ed.). Oxford, Clarendon Press.

Sahlins, M. 1958. *Social Stratification in Polynesia*. Seattle, University of Washington Press.

Searle, J. 1995. *The Construction of Social Reality*. New York, Free Press.

Sharp, A. 1956. Ancient Voyagers in the Pacific. *Polynesian Society Memoir* No. 32. Wellington, The Polynesian Society.

Sharp, A. 1957. *Ancient Voyagers in the Pacific*. 2nd. ed. Harmondsworth, Middlesex, Great Britain, Penguin.

Skelton, R. A. 1955. *Charts & Views Drawn by Cook and his Officers and Reproduced from the Original Manuscripts*. Cambridge, Cambridge University Press.

Von Den Steinen, K. 1988. *Von Den Steinen's Marquesan Myths*. Trans. by M. Langridge. Ed. by Jennifer Terrell. Canberra, Target Oceania and the Journal of Pacific History.

Walter, R. 1990. The Southern Cook Islands in Eastern Polynesia Prehistory. Ph.D. thesis, University of Auckland.

Walter, R. and P. Sheppard. 1996. The Ngati Tiare adze cache: further evidence of prehistoric contact between West Polynesia and the Southern Cook Islands. *Archaeology in Oceania* 31:33-39.

Weisler, M.I. 1993a. Long-distance Interaction in Prehistoric Polynesia: Three Case Studies. Ph.D. thesis, University of California, Berkeley.

Weisler, M. I. 1993b. Provenance studies of Polynesian basalt adze material: a review and suggestions for improving regional data bases. *Asian Perspectives* 32:61-83.

Weisler, M. I. 1994. The settlement of marginal Polynesia: new evidence from Henderson Island. *Journal of Field Archaeology* 21:83-102.

Williams, J. 1838. *A Narrative of Missionary Enterprises in the South Sea Islands*. London, John Snow.