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A CULTURAL ODYSSEY

THROUGH POLYNESIA

REDISCOVERY

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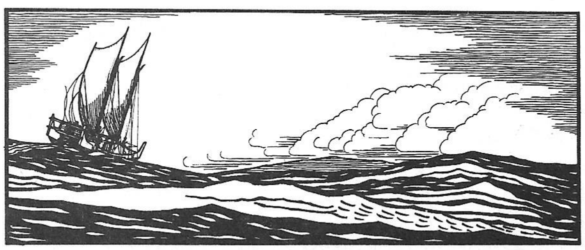
ILLUSTRATIONS BY RICHARD RHODES



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MORE THAN HALFWAY AROUND THE WORLD

Hōkūle'a sailed from Hawai'i on 10 July 1985 and returned home on 23 May 1987, completing the long voyage through Polynesian waters in just six weeks short of two years. In order to be able to construct an accurate track of the canoe over the entire route of the voyage, *Hōkūle'a* was tracked by the ARGOS satellite system described in the previous chapter, and by frequent position fixes made with the satellite navigation receiver aboard the yacht *Dorcas*, which followed the canoe as an escort vessel throughout the entire voyage.[1] Totaling the distances between satellite position fixes yields a minimum measure of the distance sailed by the canoe: 11,511 nautical miles from the fishing village of Miloli'i on the southwestern coast of the island of Hawai'i through Polynesia and back to the port of Hilo on the northeastern coast of that island. If one allows for extra miles sailed during twists and turns of the canoe's track between position fixes, those side trips taken at some island stops which were not tracked, and the crossing from the canoe's home island, O'ahu, to the island of Hawai'i to position the canoe for the departure for Tahiti, it can be said that *Hōkūle'a* sailed well over 12,000 nautical miles during the Voyage of Rediscovery, a distance equivalent to traveling more than half-way around the world at the equator.

Hōkūle'a sails comfortably at 6 or 7 knots in brisk, steady trade winds and can accelerate up to 10 to 12 knots or more when broad reaching across strong winds coming from just slightly abaft the beam. But on long crossings, the inevitable calms and spells of light winds plus the squally, stormy conditions when sails have to be lowered brings the average down to around 4 knots. In fact, the satellite fixes indicate that the canoe averaged slightly over 4 knots, or about 100 nautical miles a day during the 118 days at sea on the way from the island of Hawai'i to Aotearoa and return.

If *Hōkūle'a* can sail an average of almost 100 miles a day, why did it take almost two years to complete the voyage? Actually, for most of that period the canoe was tied up alongside a wharf, or beached on dry land, at the numerous island stops along the way. Some of the days spent in port can be accounted for by the need for those crew members making all or most of the entire voyage to return to Hawai'i between legs in order to take care of work or family obligations. In addition, there were inevitable delays involved in flying in new crew members from Hawai'i to replace those who had only enough time off from their jobs to sail on one leg of the voyage. Still more days at each island stop were devoted to welcoming ceremonies and other cultural events, as well as to the repair and maintenance of the canoe. Even, however, if we had tried to restrict the time spent in welcoming ceremonies, crew rest and changes, and repairs and maintenance to just a week or so at each island stop, the voyage would still have taken much more time than the nearly four months actually spent at sea.

This is because at key points along the route it was necessary to wait for seasonal wind shifts in order to continue on to the next island landfall. No sailor, whether in a Polynesian canoe or a modern yacht, wants to force his vessel against wind and sea when it is possible to wait for more favorable winds to make the same passage. Because the route crossed so many different wind zones, it was inevitable that the canoe would be faced by contrary winds along some segments of the voyage. Rather than attempting to tack against these winds, the strategy was to wait, at times for many months, for the season when we could expect favorable wind shifts that would allow the canoe to set sail for the next island destination. For example, it would have been foolish to push directly on to Aotearoa after arriving at

Tahiti in August, for that would mean sailing into temperate latitudes during the Southern Hemisphere winter when cold and often stormy westerlies frequently blow along the approaches to Aotearoa. Since easterlies usually begin blowing in these temperate latitudes late in the spring, we took our time sailing from Tahiti to Rarotonga and then delayed our departure from there to Aotearoa to catch these favorable winds.

The Winds of Polynesia

To understand the nature of the wind field through which the canoe sailed during the voyage and why we waited for favorable wind shifts to complete those legs of the voyage made against the direction of the prevailing winds, consider an idealized model of the winds that sweep across the Pacific (fig. 19). The Polynesian triangle straddles the easterly trade wind zone and in the Southern Hemisphere extends into the midlatitude zone of westerlies. Except for the doldrums region just north of the equator, easterly trade winds prevail in the tropics (i.e., between the Tropic of Cancer at 23° 27′ North latitude and the Tropic of Capricorn at 23° 27′ South latitude) and typically extend to around 28° north and south of the equator. Except for Aotearoa, all the Polynesian islands and archipelagos are within the trade wind zone, although Rapa, the southernmost of the Austral Islands, and Rapa Nui at the very southeastern corner of the triangle lie on the edge of that zone. North and south of the trade wind zone are belts known for strong westerly winds. Extending from 34° to 47° South latitude, the islands of Aotearoa comprise the only part of Polynesia that lies wholly in latitudes where such westerly winds blow for much of the year.

The easterly wind flow of tropical and subtropical Polynesia, and the westerlies that sweep over Aotearoa, are part of the global circulation of wind generated by the differential solar heating of the planet.[2] Maximum solar heating occurs at the equatorial bulge where surface winds are typically light and variable, or absent altogether. There the heated surface air rises high above the ocean's surface and splits into two upper air streams, one flowing northward, the other southward. As these air streams travel toward the poles they cool, and some of the cooled and thereby heavier air descends to the surface in a band generally centered at around 30° North latitude and 30° South latitude

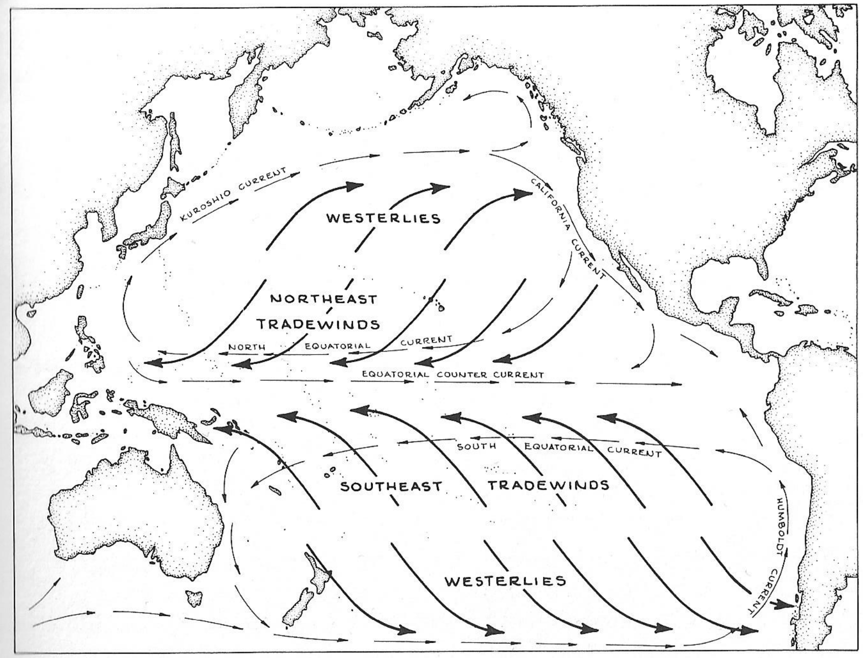


Figure 19. Idealized model of the prevailing winds and ocean currents in the Pacific.

(fig. 20). This region of high pressure, called the "horse latitudes" by British sailors, is known for its prolonged calms.

After having been cooled by its journey northward, and dried by its descent to the surface, some of the air in the horse latitudes then returns to the tropics. It does not flow directly south or north, however, because of the Coriolis Force. The earth's rotation to the east and the increasing circumference of the globe toward the equator makes the southward-flowing winds appear to twist to the west in relation to the earth's surface, so that in the Northern Hemisphere they blow from the northeast quadrant, and in the Southern Hemisphere from the southeast quadrant. These northeasterlies and southeasterlies are the famous "trade winds," so named, some say, from the crucial role they played in enabling sailing ships to carry trade around the world before the days of steam propulsion.[3]

Some of the air descending at around 30° flows poleward rather than back to the equatorial region. As it does so the earth's rotation and the decreasing circumference of the globe gives the

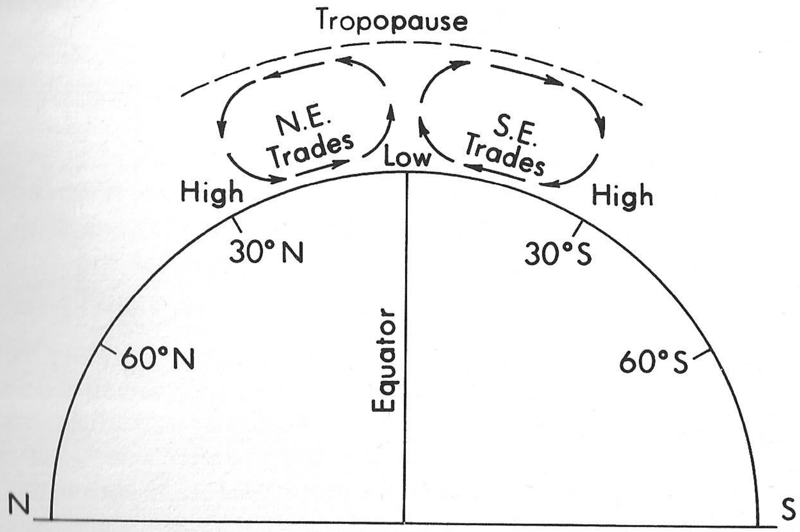


Figure 20. Schematic representation of the equatorial convection cells, the surface segments of which give rise to the northeast and southeast trade winds (Harvey 1976, 102). In the eastern Pacific the southeast trade winds regularly extend over the equator into the Northern Hemisphere.

wind an apparent twist to the east, giving rise to the midlatitude westerlies. During the days of sailing ships, vessels bound from Asia to North America or bound from the east coast of North America to Europe would sail westward before these midlatitude westerlies.

Intense cooling at the poles produces a dense surface air flow toward the equator which, skewed toward the right by the earth's rotation, generates the polar easterlies. At about 60° these polar easterlies and the midlatitude westerlies meet, causing the surface air to rise and then split at high altitudes where some flows back toward the equator and some flows back to the poles. Figure 21 shows an idealized model of these global surface winds and the air circulation cells of which they are part.

A glance at figure 19 indicates that some segments of our voyage had to be made against the direction of the prevailing winds. In particular, the southwestward passage from Rarotonga to Aotearoa and then the subsequent eastward passage from Samoa to Tahiti look most difficult, for in both cases the course is contrary to the direction of the dominant winds: against mid-

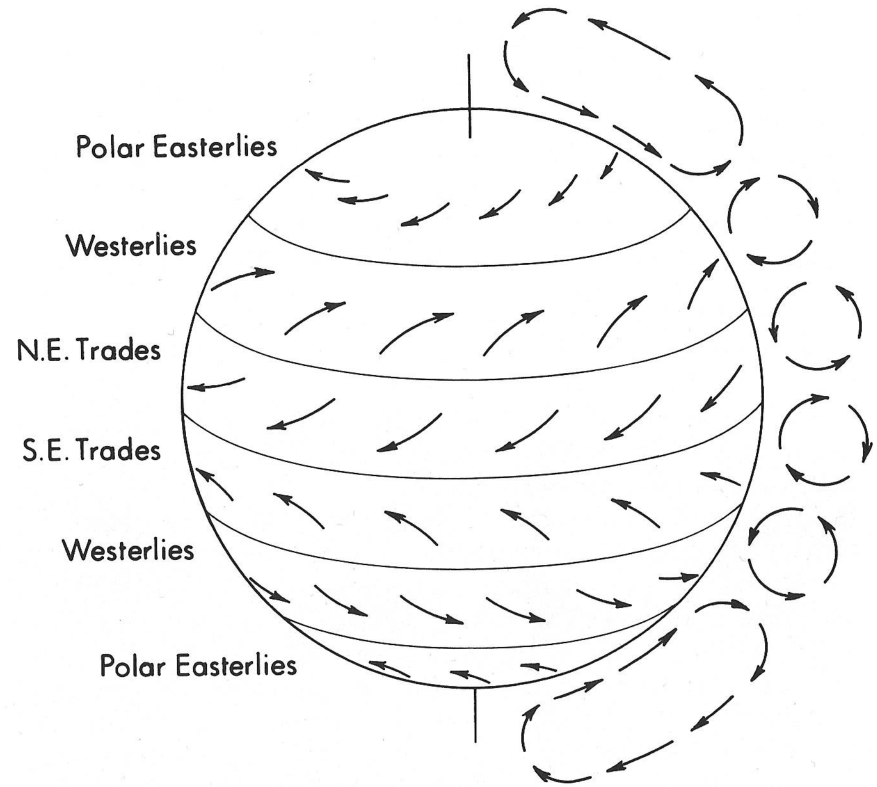


Figure 21. Schematic representation of global convection cells and surface wind belts (Brierly 1985, 17).

latitude westerlies to reach Aotearoa, and against easterly trade winds of the tropics to reach Tahiti.

Those who oppose the idea that Polynesians migrated eastward into the Pacific have focused upon the problem of sailing against the prevailing trade wind direction to buttress their theories. Heyerdahl, for example, makes his contention that the easterly trade winds would have prevented canoes from migrating eastward across the Pacific the linchpin of his theory that only voyagers from the Americas, sailing before the easterly trade winds and drifting with the accompanying currents, could have settled Polynesia. Similarly, those who think Māori legends of numerous voyages made from a homeland in tropical East Polynesia to Aotearoa must be fictions often stress the difficulty canoes would have had in sailing southwest against the cold and stormy westerly winds guarding the approaches to Aotearoa.

Although real, this problem of sailing against the direction of the prevailing winds is not at all insurmountable. Figure 19 is an idealized model that can only show the most common, or prevailing, wind flow, not seasonal variation or the more episodic disturbances in the wind field due to the passage of high and low pressure systems. The phrase "prevailing wind" refers to relative, not absolute, dominance. Even those global winds considered to be the steadiest, the trade winds, do not always blow. Periodically they falter to be replaced by calms and by spells of westerly winds that provide opportunities to sail eastward. Nor do westerlies blow unceasingly in the midlatitudes, forever preventing voyagers from sailing to the west. A drawing such as figure 19 cannot, therefore, be invoked to deny the possibility that ancient mariners could have sailed in a direction contrary to the portrayed wind flow, for the arrows are meant to illustrate average wind directions, not seasonal variation, much less wind shifts linked to passing high and low pressure systems.

Polynesian mariners, I contend, were acutely aware of these seasonal and shorter-period variations in wind direction and exploited them to sail in the direction they wished to go. As Tupaia told Cook, the Tahitians knew that westerly winds interrupted the trades during the Austral (Southern Hemisphere) summer, and they waited for their arrival before trying to sail to the east. Similarly, Māori traditions indicate that pioneering voyagers knew that the best time to head southwest from central East Polynesia to Aotearoa was in the late Austral spring when easterly winds, rather than westerlies, began to blow along the midlatitude approaches to Aotearoa. Later chapters will explain how we were able to replicate this strategy of waiting for seasonal wind shifts to sail *Hōkūle'a* from Samoa to Tahiti, and from Rarotonga to Aotearoa.

Prehistorically Significant Legs of the Voyage

We do not claim that ancient voyagers ever sailed between Hawai'i and Aotearoa just as we did. Yet the Voyage of Rediscovery did take the canoe over a number of the seaways of Polynesia that, according to our current understanding of Polynesian prehistory, were pioneered by early migrants or traveled by later

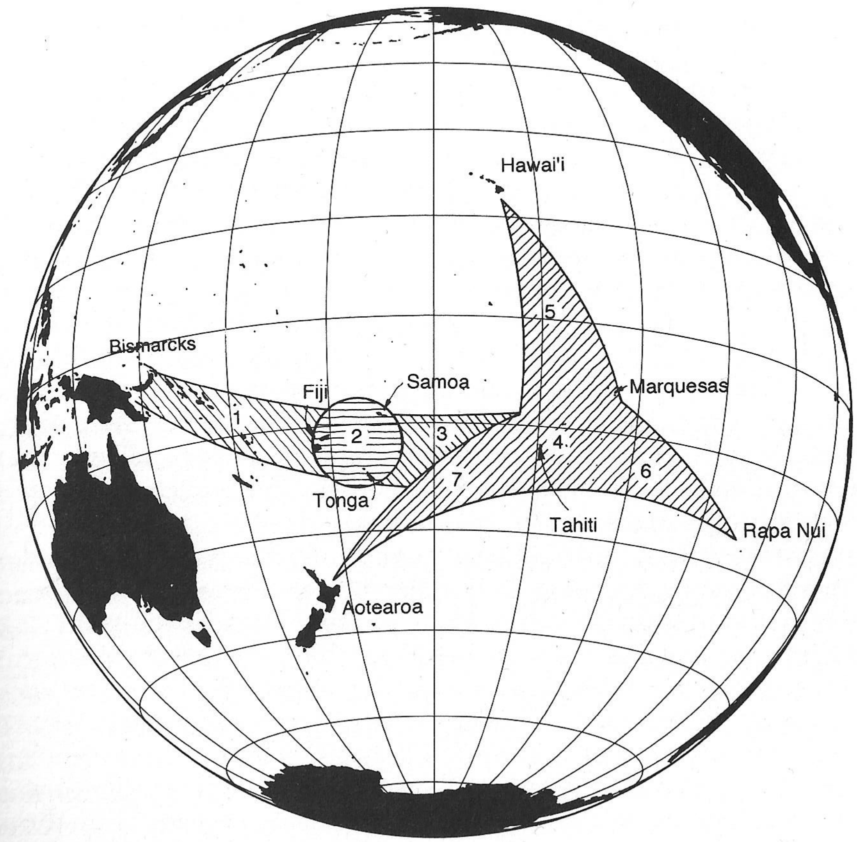


Figure 22. Main Migration Sequence: (1) from the Bismarck Archipelago to Fiji, Tonga, and Samoa (Lapita); (2) West Polynesia formative region; (3) from West to East Polynesia; (4) Central East Polynesia; (5–7) dispersion to Hawai'i, Rapa Nui, and Aotearoa.

voyagers. As such, the record of our voyage applies directly to questions concerning Polynesian migration and postsettlement voyaging over these routes, and more generally to major issues concerning the dispersion of the Polynesians and the ability of the consequently scattered populations to communicate with one another over the seaways separating them.

Figure 22 attempts to provide a visual impression of current thinking derived from linguistic, archaeological, and legendary evidence about the general trend of migration from islands offshore New Guinea to the western edge of Polynesia and then within that region. It indicates only broad directions of movement, not specific migration routes from one island to another. The reasons for this deliberate vagueness will become clear in chapter 8, where issues in reconstructing Polynesian migration and postsettlement communication between archipelagos are discussed in detail. Here only an outline of current thinking about the trend and sequence of Polynesian settlement, plus a few words about postsettlement voyaging, are given in order to provide a spatial and temporal framework for analyzing particular legs of the Voyage of Rediscovery.

Lapita voyagers appear to have moved rapidly from the Bismarcks through the archipelagos of eastern Melanesia, reaching the western edge of Polynesia at around 1500 B.C. according to the earliest radiocarbon dates, and by more conservative estimates at least by 1000 B.C. There they settled the islands in and around the archipelagos of Fiji, Tonga, and Samoa, a region that, with the exception of the main islands of Fiji and their immediate outliers, now makes up the cultural province called West Polynesia. Ancestral Polynesian culture appears to have begun evolving from its Lapita roots in these islands, and to have become archaeologically identifiable there by approximately 500 B.C. Exactly when the movement eastward to the rest of Polynesia (called East Polynesia even though one group, Aotearoa, lies to the west of West Polynesia) began is very much open to question. Some prehistorians think that the migration eastward to central East Polynesia, which is composed of the Cooks, Societies, Marquesas, Tuamotus, and Australs, did not get started until West Polynesia was thoroughly settled and ancestral Polynesian culture had emerged. Others, however, propose that the movement from the Bismarck Archipelago to central East Polynesia was a continuous process without any pause in West Polynesia. Unfortunately, the earliest radiocarbon dates available so far from East Polynesia (around 500 B.C. for agricultural disturbance in the Southern Cooks, and around 200 B.C. for occupation sites in the Northern Cooks and the Marquesas) do not settle the issue. Although these dates might seem to indicate a pause, it can also be argued that archaeologists have not yet found the evidence for the earliest movement into East Polynesia.

Although the exact sequence and dating of the initial colonization thrust to the east may be in dispute, there is a fair degree of consensus that canoes sailing from the central region of East Polynesia undertook the long voyages to Hawai‘i, Rapa Nui, and Aotearoa to settle the far corners of the Polynesian triangle. Radiocarbon dates from archaeological excavations indicate that emigrants from below the equator were established in the Hawaiian archipelago by at least 400–600 A.D., although some archaeologists point to signs of increased erosion from around 0 A.D. as evidence of agricultural activity and hence settlement at that time. On the basis of less secure archaeological work, it is thought that Rapa Nui may have been reached by around the same period of 400–600 A.D., and at least one archaeologist has cited early environmental disturbance in Aotearoa as evidence that the first colonizers of Aotearoa may have also arrived around this time. Most archaeologists, however, believe that these islands were settled centuries after Hawai‘i and Rapa Nui, perhaps even as late as between 900–1200 A.D.[4]

As can be seen in figure 22, three segments of our voyage more or less coincided with main directional trends of Polynesian migration: (1) from Samoa to Tahiti; (2) from Tahiti to Rarotonga to Aotearoa; and (3) from Tahiti to Hawai‘i. The legs from Samoa to Tahiti and from Rarotonga to Aotearoa have been chosen for separate and detailed treatments in chapters 5 and 6. These chapters are not arranged according to the order in which the legs were sailed, but according to the logic of the questions concerning Polynesian migrations that they address. Chapter 5 analyzes how we sailed from Samoa to Tahiti in order to provide some insight into how a double canoe can be sailed against the trade wind direction from West Polynesia to central East Polynesia, the crucial first step in the spread of the Polynesians throughout the triangle. Chapter 6 analyzes how we sailed from Rarotonga to Aotearoa in order to demonstrate how earlier voyagers might have moved out of the tropical heart of East Polynesia and into the temperate zone to reach this southwesternmost Polynesian outpost.

The third chapter devoted to a particular leg of the voyage, chapter 7, departs from this pattern of focusing on pioneering migration routes to look at the question of intentional voyaging back and forth between already settled archipelagos. On the basis of language comparisons, studies of characteristic artifacts, and analyses of Hawaiian oral traditions to be discussed in chapters 8 and 9, the Marquesas Islands have come to be considered by many as the most likely jumping-off point for the first settlers to reach Hawai'i, whereas Hawai'i and Tahiti are thought to have been connected during a period of two-way voyaging that occurred well after Hawai'i had originally been colonized. Accordingly, chapter 7 examines the round-trip voyage from Hawai'i to Tahiti and return composed of the first and last legs of the Voyage of Rediscovery in order to shed light on the problems of maintaining two-way communication between widely separated archipelagos, rather than on the issue of from exactly where and how Hawai'i was settled.[5]

Voyage Summary

Before plunging into the chapter-length analyses of these crucial segments of our voyage, an outline of the entire journey is presented below. In this outline, the two segments of the voyage not covered in chapters 5 through 7, the legs from Tahiti to Rarotonga and Aotearoa to Samoa, are described in more detail. The crew members who sailed on each leg are listed in appendix A.

Hawai'i to Tahiti: 10 July–12 August 1985 (fig. 23)

During the late spring and the first few weeks of summer, storm-free, trade wind conditions can generally be expected along the Hawai'i to Tahiti route. The crossings in 1976 and 1980 had been undertaken during the spring in order to be able to have enough time, after resting in Tahiti, to return to Hawai'i before midsummer when the tropical storms generated well to the east of Hawai'i spin westward and often pass just to the south of the islands. In 1985, because the canoe did not have to be immediately sailed back to Hawai'i, there was no pressing need to leave for Tahiti so early. Accordingly, the crossing was scheduled for June in order to take advantage of the steady winds that can generally be expected then. But problems in getting the canoe and the escort vessel ready delayed departure until July, putting the canoe at sea months later than the previous two crossings. In retrospect at least, it should not therefore be surprising that conditions encountered on this third crossing turned out to be significantly different from those met on the previous two.

Instead of reasonably steady trades, interrupted only by the predictable appearance of doldrum calms between the northeast

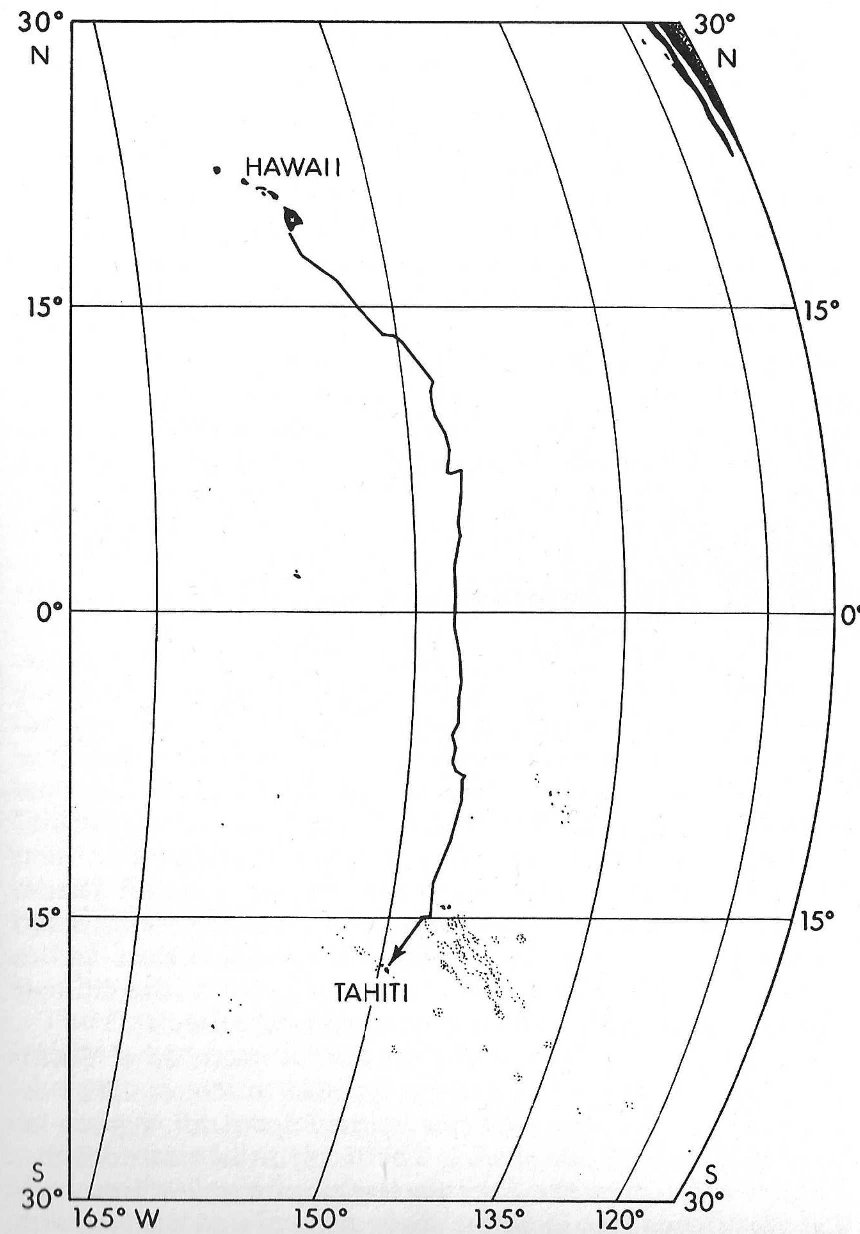


Figure 23. Hawai'i to Tahiti, 10 July–12 August 1985.

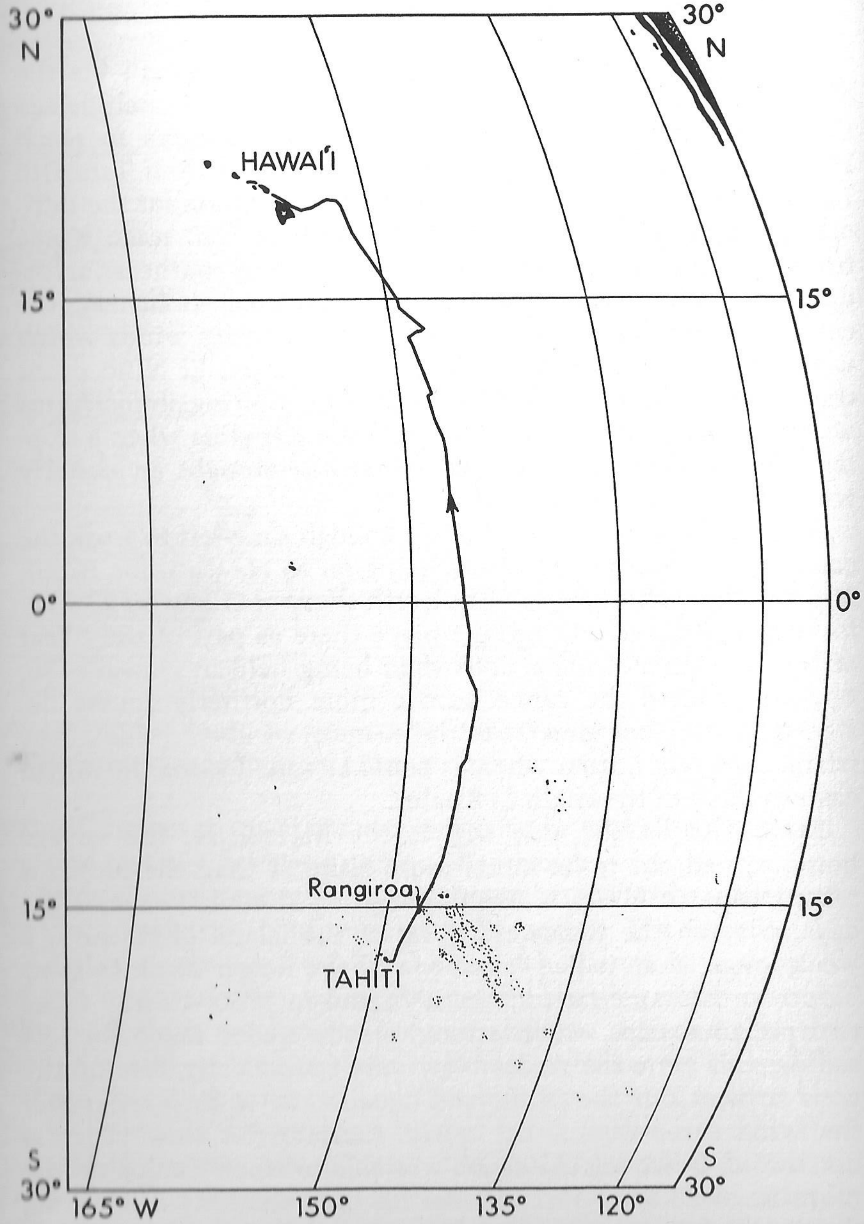


Figure 28. Tahiti to Rangiroa, Tuamotu Islands, 2–4 April 1987; Rangiroa to Hawai'i, 24 April–23 May 1987.

5

WAIT FOR THE WEST WIND

Why were the islands of Polynesia settled by a lineage of seafarers that stemmed ultimately from the faraway Asian side of the Pacific and not by people from the much closer shores of the Americas? The answer to this question may lie in the way islands are distributed across the Pacific. Starting with Taiwan, the Philippines, and Indonesia, a virtually continuous series of archipelagos extends far out into the Pacific to the eastern edge of Polynesia. In contrast, except for a few island clusters and lone islands relatively close offshore, thousands of miles of open ocean lie between the Pacific coast of the Americas and the easternmost islands of Polynesia: Hawai'i, the Marquesas, and Rapa Nui. Whereas the spread of islands from Southeast Asian shores eastward seems to have encouraged successive generations to sail farther and farther out into the ocean by rewarding them with island after island on which they could settle, the great stretches of open ocean between the western shores of the Americas and Polynesia apparently provided little opportunity or incentive for Native Americans to expand across the Pacific.[1]

Yet, however inviting to oceanic expansion the spread of islands from Southeast Asia to Polynesia may have been, the immense distances of the open Pacific and the westward flow of the dominant winds and currents must have greatly tested the ability of these seafarers to keep pushing eastward across the

*With Paul Frost, Richard Rhodes, and Nainoa Thompson ocean. Indeed, the challenges posed to would-be migrants from the west become progressively greater the farther east one sails. Whereas at the western edge of the Pacific most islands can be seen from one another, interisland distances increase to hundreds of miles in the central Pacific, then to thousands of miles in the eastern Pacific. Furthermore, as the island gaps grow larger, so does the problem of sailing eastward against the increasingly dominant trade winds and accompanying currents.

These challenges brought forth a vigorous maritime response. Fundamental was the development of the double canoe as a stable and seaworthy vessel adapted to carrying all the people, their provisions, and their breeding stock of plants and animals needed to establish colonies on the increasingly distant and species-poor islands. Similarly crucial was the evolution of ways of systematically searching unknown seas and of locating islands there. Yet, however basic large, stable watercraft and blue water navigational skills were to this oceanic expansion, in order to penetrate so far and so fast across the Pacific these seafarers also needed to learn how to use variations in the flow of oceanic winds to sail eastward against the direction of the dominant trade winds and ocean currents. This chapter addresses this third basic adaptation for oceanic expansion by analyzing how in 1986 we sailed *Hōkūle'a* eastward across Polynesia from Samoa to Tahiti by utilizing westerly wind shifts.

The Impermanent Trade Winds

In making his case for the American origin of the Polynesians, Heyerdahl claimed that the islands of Polynesia could not have been colonized directly from the west because "the permanent trade winds and forceful companion currents of the enormous Southern Hemisphere" would have prevented canoe sailors from the Asian side of the ocean from sailing through tropical latitudes to the east. As late as 1981, in a review of *Hōkūle'a, the Way to Tahiti*, my book on the first voyage to Tahiti, Heyerdahl was still flatly asserting that "until the days of Captain Cook and modern sailing ships, no vessel, not even the Spanish caravels, were able to enter the Pacific triangle except from the American side."[2]

If the trade winds of the Pacific were, in fact, permanent, it would indeed have been most difficult for the ancestral Polynesians to have sailed a canoe directly eastward over long distances. To be sure, Polynesian double canoes are excellent sailing vessels. When sailing on a beam reach (with the wind blowing at right angles to the hulls) or a broad reach (with the wind blowing abaft the beam, or greater than 90° to the hulls) they move easily and swiftly through the water (fig. 29). However, although double canoes can sail to windward, they cannot do so as well as a racing yacht equipped with a deep keel or centerboard. To attempt to sail a double canoe as close into the wind as a racing yacht would be self-defeating. As she points closer and closer into the wind, a double canoe slows noticeably and begins to make so much leeway that little progress can be made directly into the wind, particularly when sailing against a strong current.

Instrumented sailing trials with the Hawaiian double canoe *Nālehia*, and the long slant across and slightly into the trade winds made by *Hōkūle'a* when sailing from Hawai'i to Tahiti in 1976, indicate that a double canoe progresses most efficiently to windward when she is sailed "full and by," that is, sailing as close to the wind as possible without making too much leeway or losing the full drive of the sails. Sailing full and by against a 15- to 20-knot wind a double canoe can do around 5 or 6 knots and "make good" a course of around 75° off the wind (calculated by measuring heading against the true direction of the wind, then subtracting leeway). Because a double canoe cannot point much closer to the wind without greatly losing efficiency, when sailing to windward it is necessary to make long, shallow tacks first to one side and then to the other of a straight line course to an upwind goal, which means the canoe must be sailed over almost 4 miles of ocean for every mile made directly to windward (fig. 30).[3] A 500-mile voyage made tacking directly to windward would therefore be almost 2,000 miles long in actual sailing distance, and a 1,000-mile voyage would be almost 4,000 miles long. Struggling against a current accompanying the wind would, in effect, increase these sailing distances even more.

Certainly Polynesians were able to tack their canoes over moderate distances to windward without great difficulty and could sail them on long slants across and angling across and moderately into the wind as we have done between Hawai'i and Tahiti. But the slow forward progress to windward of their vessels when tacking back and forth makes it seem unlikely that Poly-

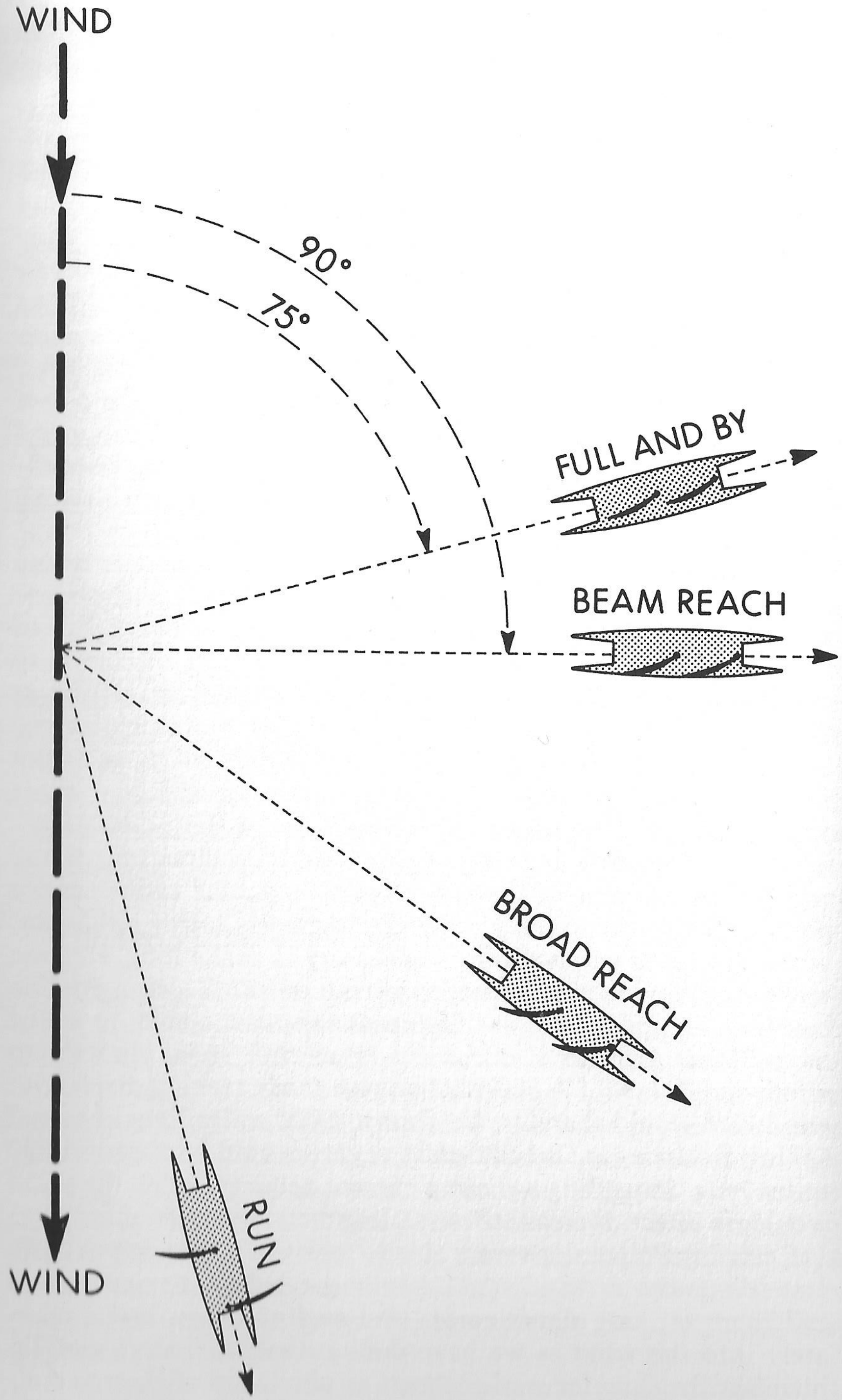


Figure 29. Best points of sail for Hōkūle'a.

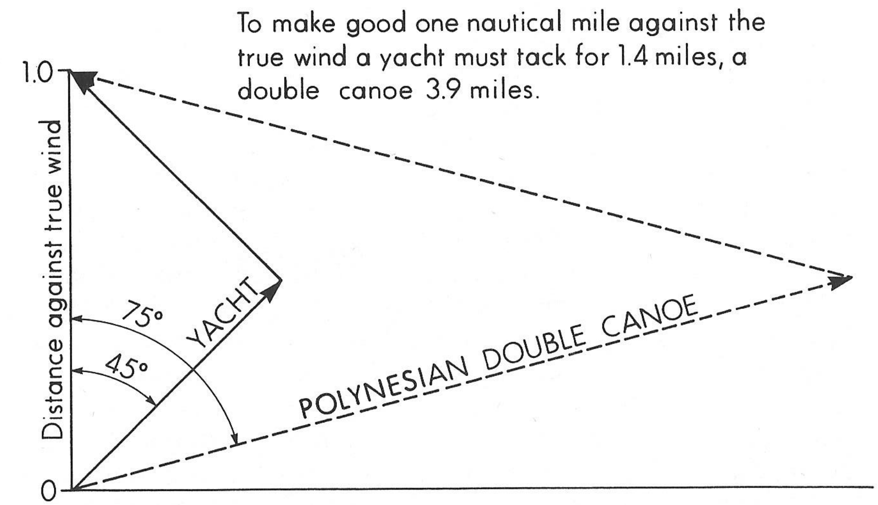


Figure 30. Distance a yacht and a double canoe must travel tacking against the wind.

nesian sailors would ever have sailed directly upwind to distant islands. Particularly for migrating canoes heavily loaded with men, women, and children, as well as their supplies, plants, and animals, such voyages would have become impossibly long as well as highly dangerous because of the stress of pushing against pounding head seas. In 1975 Jim Siers, a New Zealand photographer, had canoe builders from Tarawa atoll in the Micronesian nation of Kiribati (formerly the Gilbert Islands) build a big outrigger sailing canoe for an attempt to sail south-southeast from there to Fiji, and then due east to Tahiti. Despite the V-shaped hull of his canoe, called *Taratai*, she sailed no better to windward than *Hōkūle'a* and, leaking badly from working to windward, just barely made it to Fiji. Siers then consigned the canoe to a museum and constructed a second Micronesian-style outrigger canoe with a very deep, V-shaped hull made from plywood which he christened *Taratai II*. While working to windward east of Tonga, however, the *Taratai II* broke up when the booms holding the outrigger float snapped in the heavy seas, dumping Siers and his crew in the ocean.[4]

Actually, the main issue is not the exact degree to which Polynesian craft could sail to windward, or their ability to stand up against pounding head seas. Even sailors with modern yachts of superlative windward characteristics do not relish tacking ong distances directly into the wind and bucking the accompanying seas. Instead, they prefer to seek out zones of favorable winds for crossing the oceans. For example, after sailing their Manila Galleons before the trade winds from Mexico to the Philippines, the Spanish did not try to return east by sailing directly into the trades. Instead, they headed north from the Philippines in order to get out of the trade wind zone and into the belt of westerlies found in higher latitudes. Then they turned east to sail before these westerlies until sighting land somewhere along the North American coast, after which they turned south to reach Acapulco or one of the other Mexican ports. Polynesians and their immediate ancestors searching for islands to the east could also have tried to sail north (or south) out of the tropics to catch the midlatitude westerlies. But, given their open canoes and lack of warm clothing, they would probably have found it difficult to survive for long in the cold seas of these latitudes. Besides, those pioneering voyagers who discovered and settled the islands strung across the South Pacific from Southeast Asia eastward into the Polynesian triangle had a shorter, warm-weather alternative to lengthy, roundabout voyages made via the higher and colder latitudes: they could stay in the tropics and wait for the west wind.

Not only did Heyerdahl have the direction of settlement wrong, but he also attributed a permanence to the Pacific trade winds that does not exist. This error is not uncommon. Indeed, it is encouraged by the way these winds are usually described and graphically illustrated. Saying that trade winds prevail in the tropical Pacific does not mean they blow for 365 days of the year. The word "prevailing" really only refers to a statistical dominance over the year, but not during every season, month, or week. Similarly, whereas a chart showing trade wind patterns, such as figure 19 in chapter 4, may usefully picture the dominant direction of the wind flow over the entire year, it tells us nothing about the many times during the year in which the wind does not blow steadily out of the east. In reality, although the Pacific trades are among the steadiest and most regular of global winds, they nonetheless wax and wane and are periodically replaced by westerlies for days, weeks, or sometimes even months at a time.

The wind flow on the western side of the tropical South Pacific exhibits a marked monsoonal pattern with two distinct

wind seasons: the Austral (Southern Hemisphere) winter when easterly trade winds generally prevail, and the Austral summer when westerly winds regularly intrude. According to meteorologists, this monsoon pattern arises from the intense heating of the Australian continent during the summer. During the winter, the trade winds blow more or less regularly out of the southeast and across Melanesian waters, northern Australia, and the Indonesian archipelago (fig. 31). With the coming of summer, however, the increased solar radiation causes a low pressure trough to be formed over northern Australia and to extend eastward over the Coral Sea (fig. 32). As the surface winds tend to flow toward regions of low pressure, this means that the wind flow on the northern flank of the trough is from the west and northwest.[5]

These summer westerlies periodically extend far out into the Pacific beyond the Australian monsoon trough. So marked is the seasonal alternation of winds in the South Pacific that in many of the island cultures two main seasons are distinguished: a trade winds season and a westerlies season. For example, the people of Tikopia, a Polynesian outlier located in Melanesian waters just off the eastern end of the Solomon Islands chain, divide the year between *tonga*, the period from April until September when southeasterly trade winds prevail, and *raki*, the period from October until March when the trades are largely replaced by westerlies.[6] Summer westerlies become more and more episodic, however, the farther one moves east across the Pacific. Consider, for example, figure 33, a depiction of wind patterns across the Pacific during January at the height of the westerlies season. The arrows, which depict mean wind flow based on reports from ships and shore stations accumulated over the last century, clearly show a corridor of westerly winds leading from the Bismarck Archipelago almost to Fiji. Although these summer westerlies periodically extend into the Polynesian triangle, they do so less frequently than is the case in the western Pacific. At Tahiti, for example, spells of westerlies may come only every few weeks and last no more than a week or so. Therefore, even during January, the month when these westerlies are most common in Polynesian waters, the only effect they have on the arrows indicating mean wind direction is to skew them from east to northeast.

To appreciate visually how spells of westerlies can periodi-

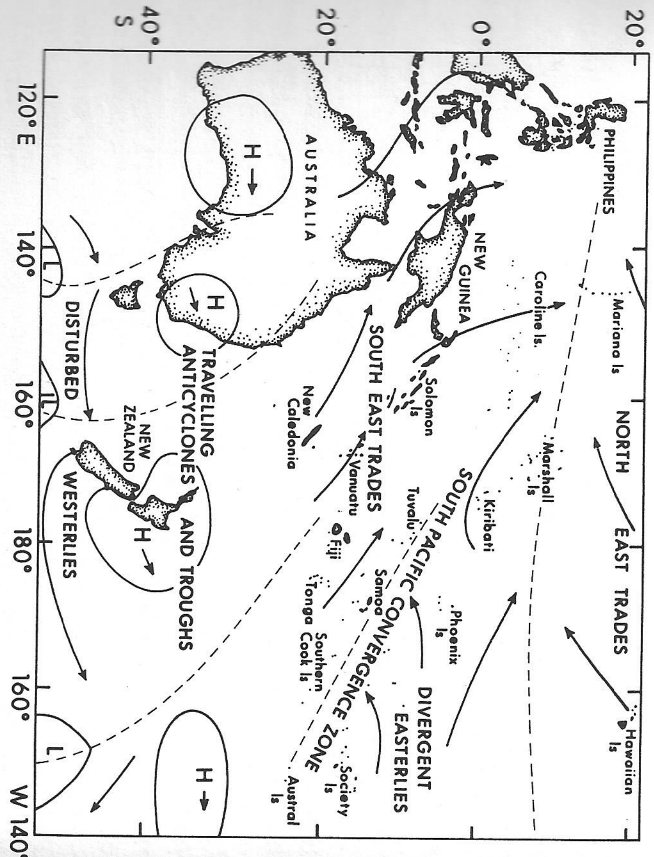


Figure 31. Stylized Austral winter wind circulation in the southwest Pacific (Steiner 1980, 9; Hessell 1981, 43).

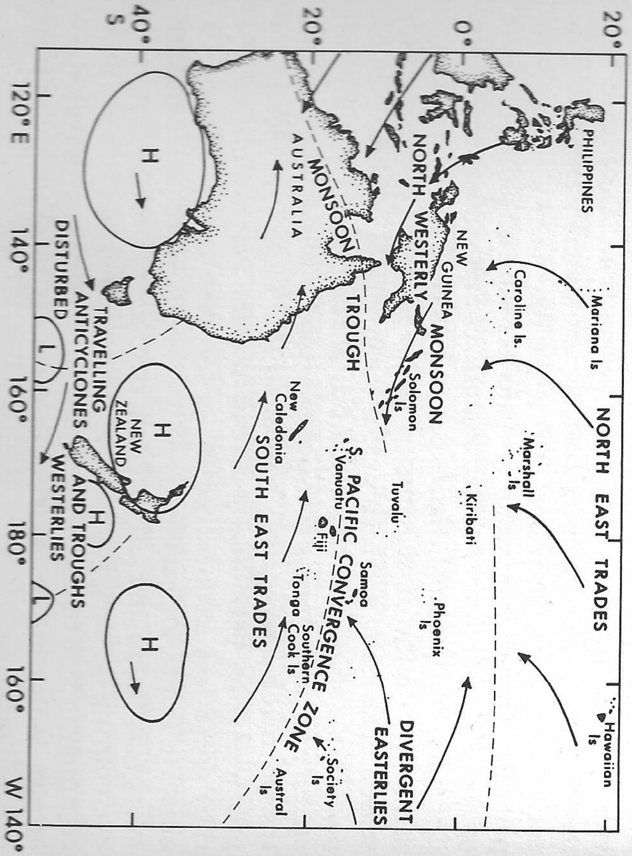


Figure 32. Stylized Austral summer wind circulation in the southwest Pacific (Steiner 1980, 9; Hessell 1981, 42).

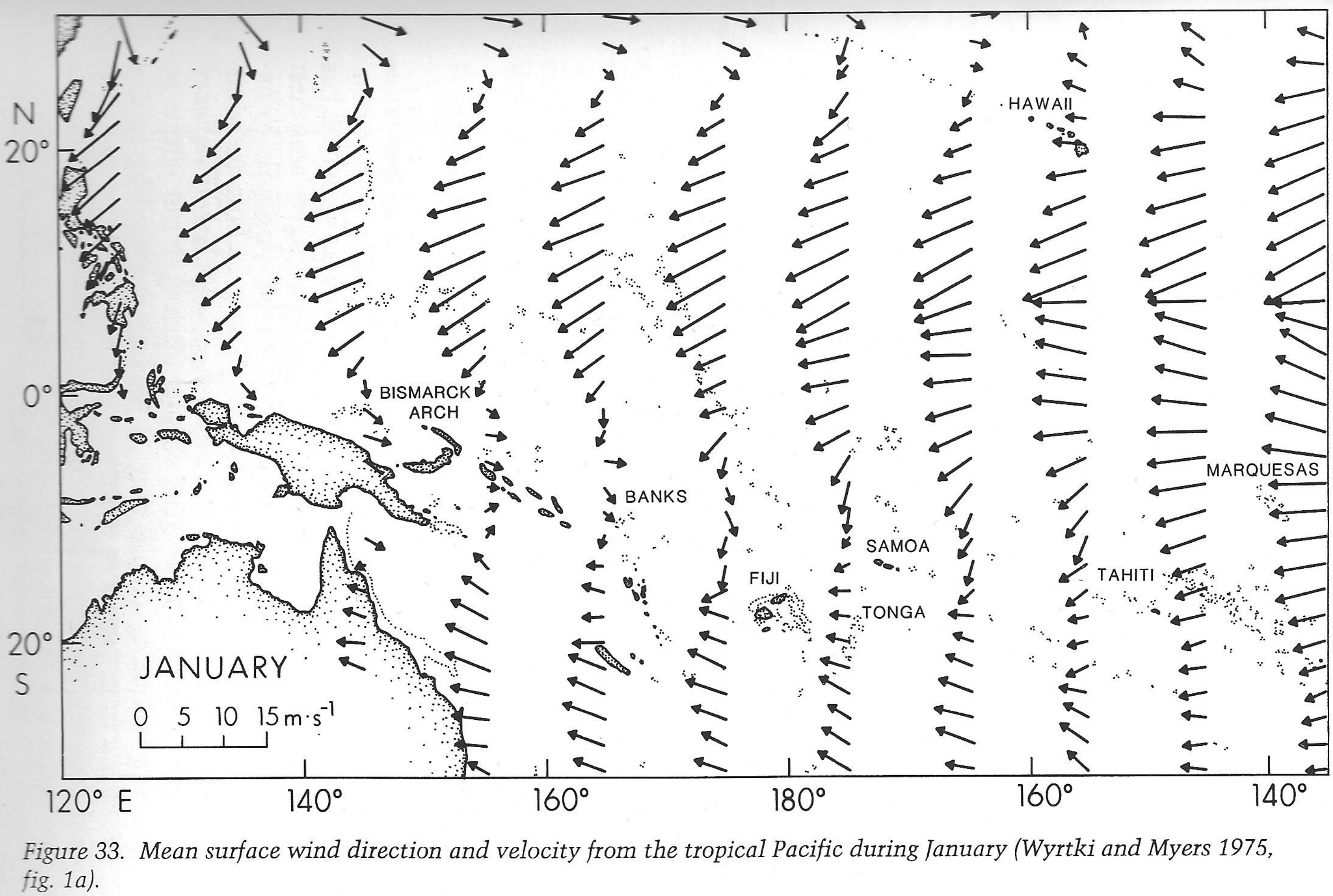


Figure 33. Mean surface wind direction and velocity from the tropical Pacific during January (Wyrtki and Myers 1975, fig. 1a).

cally sweep across Polynesian waters, we need to consult a chart that shows how the winds are flowing at a particular time, such as figure 34 which portrays by means of streamlines the surface wind circulation on 16 January 1979 at the height of a weather system that for over a week brought strong westerly winds across Polynesia as far east as Tahiti.

The main thrust of migration into the Pacific appears to have generally followed the flow of these summer westerlies, suggesting that early canoe voyagers must have used these winds to move across the tropical South Pacific. Their descendants were certainly well acquainted with the alternating rhythm of easterlies and westerlies and knew how to exploit them to sail where they wanted to go. In Melanesian waters, there are memories, and in some cases surviving vestiges, of various trading networks along the coast of New Guinea and among islands to the east where canoe sailors were similarly dependent upon seasonal alternations of wind patterns to facilitate their voyaging. That Polynesian sailors at the time of European contact were familiar with the spells of summer westerlies common in their waters and knew how to use them to sail to the east is documented, as we have seen, in the testimony of Tupaia recorded in Cook's journal, as well as in the writings of other early European navigators, scientists, and missionaries.[7] Furthermore, in Indonesia, one of the few places in the world where large amounts of freight are still regularly carried by sailing craft, traders still use this monsoonal wind pattern to sail east along the Indonesian chain before the westerlies, and then, with the return of the trades, to sail back to the west.

On the basis of the periodic occurrence of summer westerlies in Polynesian waters and their documented use for sailing eastward by Polynesian mariners of the early contact period, it has long been hypothesized that the pioneering voyagers who first sailed from west to east across Polynesia did so primarily by exploiting westerly wind episodes to sail east, tacking to windward only when and if the westerlies dropped and were replaced by easterly trade winds.[8] This chapter reports on our efforts to test the feasibility of this way of moving eastward by sailing *Hōkūle'a* from Samoa to Rarotonga and from there on to Tahiti and explores the implications of this experimental crossing for understanding the colonization of Polynesia.

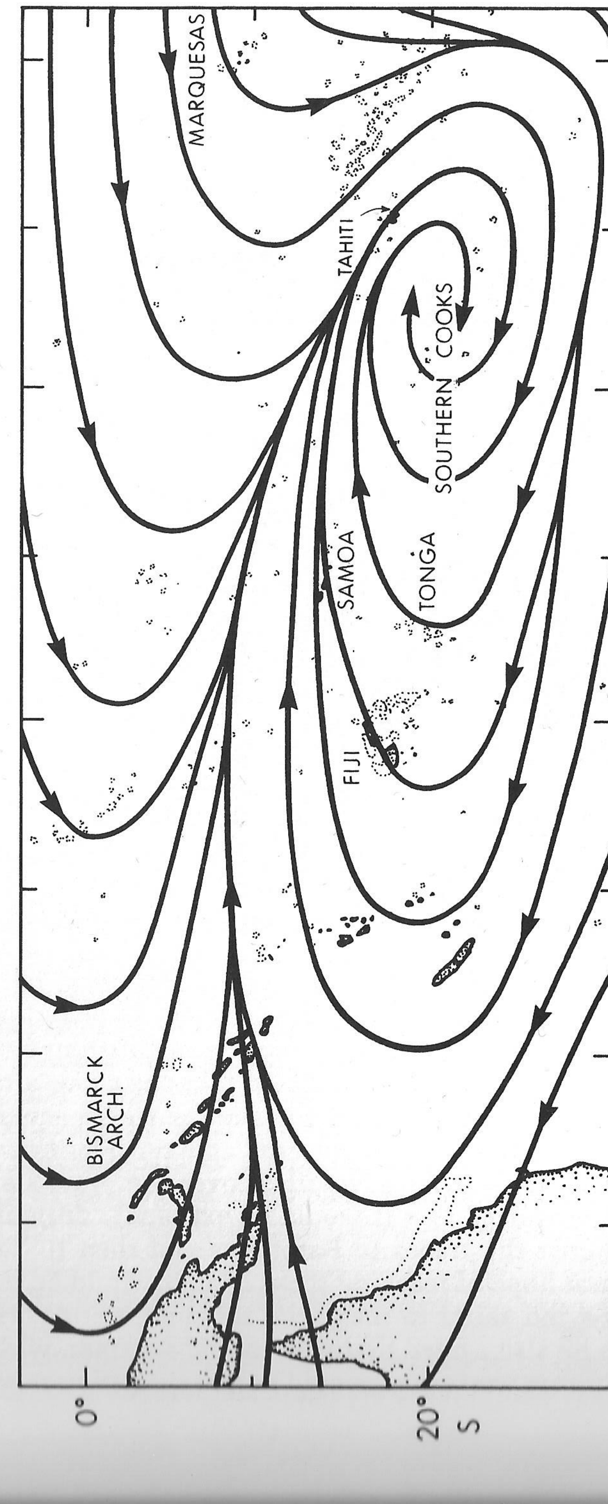


Figure 34. Surface wind analysis for 16 January 1979.

Sailing Strategy

After sailing north from Aotearoa to Tonga and then on to Samoa, *Hōkūle'a* was in position to attempt the eastward crossing. By electing to sail from Samoa to Rarotonga and Tahiti we did not intend to imply that the initial migration eastward from the Polynesian homeland necessarily followed that exact route. Although the Samoan group is a leading candidate as a dispersal point from the West Polynesia homeland region, voyages to the east may also have been made from the Tonga group, or possibly from Futuna, Uvea, or other smaller islands outside these two groups. Besides, because we obviously already knew the location of Rarotonga and Tahiti, as well as that of all the other East Polynesian islands, we were hardly in a position to re-create an early discovery voyage. That would have required that we strike out randomly to the east, without any foreknowledge whatsoever of any archipelagos and islands that might be found there. Actually, our choice of East Polynesian landfalls was in large part dictated by other reasons. We had sailed to Aotearoa via Tahiti and Rarotonga and were obligated to call upon these islands on the way back in order to fulfill pledges made to Tahitians and Rarotongans on the way to Aotearoa. Nonetheless, despite our geographical knowledge, and port-of-call obligations, we believed that by attempting to cross the ocean gap between Samoa and Tahiti we could learn much about the sailing problems faced by early voyagers who had headed east from the West Polynesian homeland, and how these may have affected the settlement of East Polynesia.

Upon Nainoa Thompson, the navigator of *Hōkūle'a*, fell the responsibility of determining the sailing strategy to be followed. The task was formidable because a course straight from Samoa to Rarotonga and then on to Tahiti would take the canoe almost directly against the direction from whence the trades generally blow. After reviewing the wind patterns and considering what had been learned from sailing *Hōkūle'a* over the previous ten years, Nainoa concurred that it would be extremely difficult to try to tack against the trades to Rarotonga and then to Tahiti and that the best hope of reaching these islands would be to exploit westerly wind shifts to make the required easting. However, although he also agreed that the Austral summer, with its episodes of summer westerlies, would be the time of year when

we would most likely be able to find winds good for sailing east, Nainoa rejected the idea of sailing during the summer. The bursts of westerlies that occur then, he argued, are often blustery and accompanied by heavy cloud cover and rain. Furthermore, the summer period when westerlies are most prevalent is also the hurricane season when tropical disturbances are most likely to cross the route between Samoa and Tahiti, particularly during major El Niño events such as that of 1982–1983 when four tropical storms did so. Accordingly, for the safety of crew and canoe, Nainoa ruled out trying to exploit the summer westerlies to sail east.

Instead, he proposed a variant of that strategy. Upon studying the daily meteorological charts for the preceding several years, Nainoa and University of Hawai'i meteorologist Thomas Schroeder found that even during the Austral winter, when the trade winds are normally most dominant, brief spells of westerly winds occasionally interrupt the trades when low pressure troughs emanating from subtropical depressions to the south reach into the tropics. This suggested to them that it might be possible to exploit the westerlies generated by these passing troughs to work the canoe to the east.[9] Accordingly, Nainoa proposed to make *Hōkūle'a* ready for a midwinter departure, then wait for the coming of a low pressure trough at which time he and the crew would try to sail the canoe as far east as possible with the westerly winds that would accompany the passage of the trough. Once the trough had passed, Nainoa was prepared to slant obliquely across the trades while waiting for another trough in order to gain an additional boost to the east. Through a combination of exploiting the westerlies of passing troughs, and slanting against the trades while waiting for the next trough, Nainoa hoped that *Hōkūle'a* could be worked first to Rarotonga, and from there farther eastward to Tahiti. If, however, the troughs did not extend into the tropics that year, Nainoa knew that it would be a long and hard struggle to try to make easting by tacking back and forth against the trades, and that it might not be possible to reach Tahiti, or even Rarotonga.

An Embarrassment of Westerlies

The Austral winter of 1986 turned out to be highly favorable for sailing to the east, although we did not fully realize that until *Hōkūle'a* was well out to sea and did not completely understand what had occurred until after the voyage when we could analyze the meteorological data for the South Pacific gathered by satellites and surface stations. Nainoa's study of the meteorological charts of the South Pacific for previous years had revealed an uneven pattern. During the winter of 1984, for example, the trades had broken down seven times with the passage of low pressure troughs. During the winter of 1985, however, the trade winds appeared to have stayed solidly in place all winter long, for he could find no evidence of any troughs significantly interrupting them. The first indications that the 1986 winter might be more like 1984 than 1985 came from daily meteorological charts of the southwest Pacific consulted before departure. These showed that a major disruption of surface wind circulation patterns over a large part of the South Pacific was developing: low pressure troughs were beginning to extend into the tropics, sweeping across the route the canoe would follow to Tahiti, bringing with them wind shifts that looked ideal for sailing eastward.

In the typical winter pattern shown in figure 31, trade winds dominate the route between Samoa and Tahiti. These blow primarily from the southeast between Samoa and Rarotonga, and more out of the east from Rarotonga to Tahiti. These southeast trades and "divergent easterlies" usually meet in a cloudy region called the South Pacific Convergence Zone, which is typically located along a line that runs southeast to northwest from the Austral Islands between the Southern and Northern Cook Islands toward Kiribati (formally known as the Gilbert Islands). Well south of the trades, along the latitude of Aotearoa's North Island, high pressure systems move from west to east. Slightly to the south of these highs and alternating with them, low pressure systems also move from west to east.

Sometimes troughs extend far enough north from these low pressure systems to reach into tropical latitudes where they interrupt the trades and bring westerly winds. The winter of 1986 proved to be unusual in that respect. The traveling highs were centered about 10° farther south than normal and were persistent and slow moving. Pressures at their centers were also higher than normal. These displaced highs and anomalous upper air conditions at the same latitude blocked the normal passage of the low pressure systems, shunting some of them to the north

between 25° and 35° South latitude before they could continue their eastward movement. The troughs from these displaced lows therefore extended farther north than usual, repeatedly reaching into trade wind latitudes where vertical coupling between them and an unusually persistent and quasi-stationary upper air trough located between Tonga and Tahiti acted to intensify surface disturbances. In addition, the South Pacific Convergence Zone was largely absent. The subtropical ridges of high pressure extending from the migrating highs were also displaced farther north than usual and tended to connect to the semipermanent high pressure system centered to the southeast between the Austral Islands and South America. This combination of displaced troughs and ridges frequently interrupted the trades and gave rise to long periods during which the winds were ideal for sailing eastward to Tahiti (fig. 35).

Actually, "westerlies" seldom blow directly out of the west. Sailors use the term to refer to any winds with a westerly component, that is, to winds from the northwest and southwest as well as straight out of the west. In fact, winds blowing from the northwest or southwest are best for sailing due east, as a canoe generally sails best on a broad reach, with the wind coming over the stern at an angle, rather than directly from astern (fig. 29). Moreover, a canoe can still make good progress to the east reaching across a north wind, or a south wind, or even sailing into a wind blowing from slightly to the east of either north or south. Typically, the passage of a low pressure trough through the trade wind zone causes a counterclockwise rotation of the wind that usually brings at least two or three days of such "westerlies" favorable for sailing to the east. The first sign of the approach of a trough is usually a shift in wind direction from southeast or east to northeast. As the trough comes closer the wind becomes more and more northerly, until, as the trough passes, the wind starts coming from west of north, then more out of the west, then out of the southwest, then out of the south, and so on until, once the trough has completely passed, the easterly trade winds return.

Some critics, of course, may wish to object to our use of modern weather data and meteorological theory to plan a re-creation of an ancient voyage. To be sure, by consulting satellite photographs, daily weather maps, and detailed weather records we could plot the occurrence of these westerlies before departure

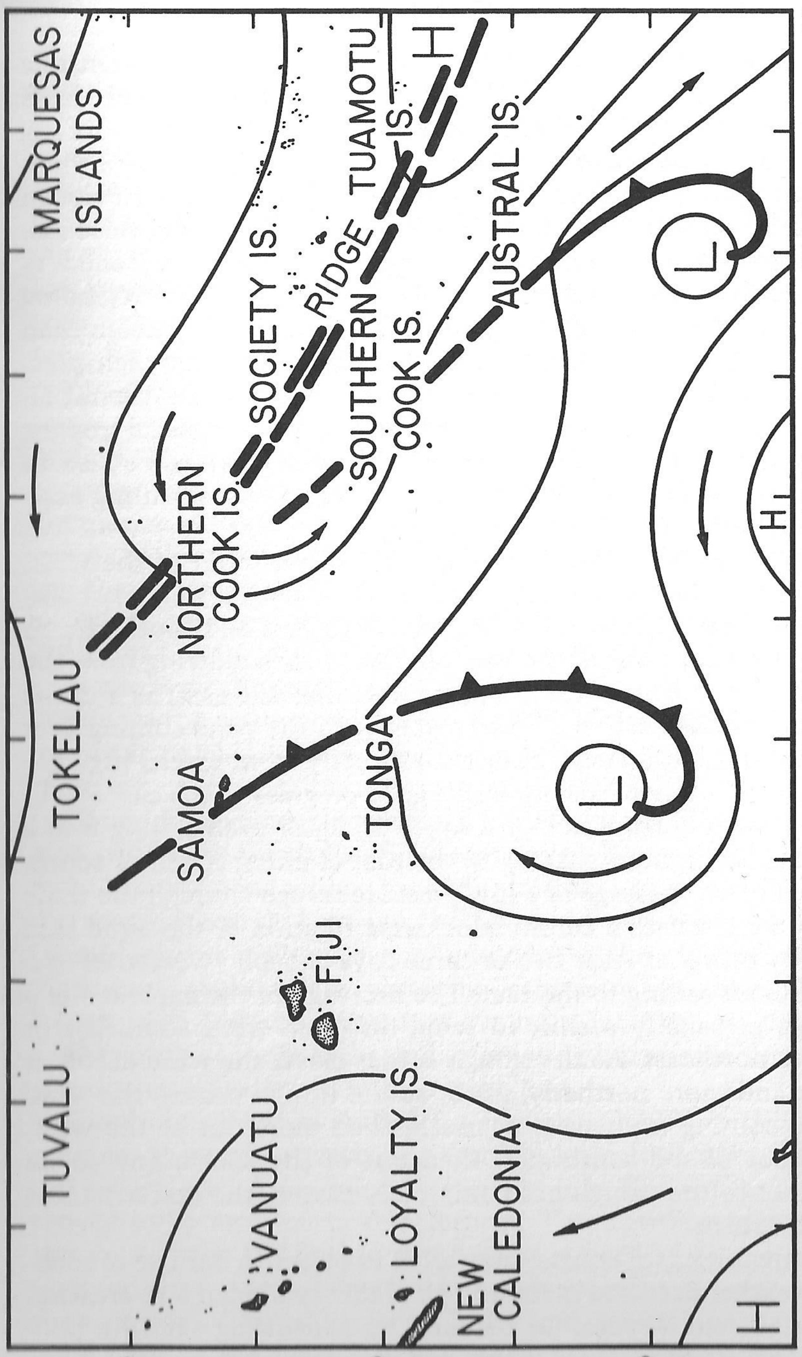


Figure 35. Stylized wind circulation between Samoa and Tahiti during the winter of 1986. See figure 36 for a key to meteorological symbols used. Arrows indicate surface wind direction.

and explain their origin. Nevertheless, although early Polynesian mariners lacked such modern aids, they must have had a deep practical knowledge of weather matters that comes to people whose lives depend upon the sea. Certainly the European explorers who took the time to become acquainted with Polynesian sailors praised their meteorological skills. For example, concerning the two Tahitians he took with him from Tahiti to Ra'iatea, the Spanish navigator Andia y Varela reported that:[10]

> What took me most in the two indians [Tahitians] whom I carried from Otahiti [Tahiti] to Oriayatea {Ra'iatea] was that every evening or night they told me, or prognosticated, the weather we should experience the following day, as to winds, calms, rainfall, sunshine, sea and other points, about which they never turned out to be wrong: a foreknowledge worthy to be envied, for, in spite of all that our navigators and cosmographers have observed and written anent [about] the subject, they have not mastered this accomplishment.

While their sea-level perspective and lack of knowledge of global weather dynamics might seem limited to us today, had such weather-wise Tahitians wanted to sail to the east during a winter such as that of 1986, they surely would have seized upon the unseasonable westerlies just like we did. Furthermore, although before the voyage Nainoa enjoyed a "God's-eye" view of the weather furnished by satellite photographs and detailed meteorological charts, once at sea he was in the same situation as the Tahitians who sailed with Andia y Varela and other early Polynesian sailors who had only their observations of the wind, clouds, and swells made from sea level to guide their sailing decisions—and he probably acted more or less as they would have.

From Samoa to Aitutaki

In early July of 1986, Nainoa and part of the crew flew from Honolulu to American Samoa in order to join the canoe and the rest of the crew at tiny Ofu Island in the Manu'a group at the easternmost end of the Samoan chain. Although they arrived just as a low pressure trough was approaching, they were not able to ready the canoe for departure quickly enough to take advantage of the accompanying wind shift. By the time the canoe was ready, the westerly winds had passed and the trades were reestablished.

Nonetheless, Nainoa chose to leave then, setting sail on the afternoon of 7 July, by which time a small high spreading eastward along 25° South had become embedded in the subtropical ridge extending to the west from southeast of Tahiti, bringing a flow of easterly winds north of the ridge axis and into the region where *Hōkūle'a* was sailing (fig. 36). With the east-southeast trades then blowing, the canoe could have been sailed either to the north-northeast or to the south. To sail north-northeast would have taken the canoe away from Rarotonga and eventually out of range of any troughs extending up from the south. Nainoa therefore chose to make a long slant to the south—both to approach the latitude of Rarotonga (which, at 21° 15′ South, is almost 350 miles south of the latitude of Ofu) and to get farther to the south in order to be in a better position to catch any passing troughs. For the next two days, 8 and 9 July, the trades continued blowing from between east by south and east-southeast. As long as the wind had a major easterly component, *Hōkūle'a* was able to hold a course to the south by sailing on the port tack. Briefly, however, when the wind shifted more toward the south, to avoid being forced to the west the canoe was put onto the starboard tack and headed east-northeast until the wind shifted back around to the east.

As navigator, Nainoa's role was to set the course for the steersmen to follow and to make sure the canoe stayed on course by constantly monitoring the ocean swells, the sun by day, and the stars at night, and by mentally tracking the canoe's heading and speed. Mau Piailug was sailing with his colleague, but as a guest and an advisor, rather than as a back-up navigator, for the Micronesian master was by then fully confident of Nainoa's abilities. Serving as captain on this leg was Milton "Shorty" Bertelmann, a quiet, intense *Hōkūle'a* veteran who was in charge of the crew as well as the setting of the sails, maintenance of the canoe, and the like. Shorty, a contractor from the island of Hawai'i, had sailed on *Hōkūle'a*'s first crossing from Hawai'i to Tahiti in 1976 and had already skippered the canoe on the Hawai'i to Tahiti and Rarotonga to Aotearoa legs this voyage.

Others on board from the island of Hawai'i were: Clay Bertelmann, a rancher and Shorty's younger brother; Ben Lindsey, a fireman and farmer; and Te'ikihe'epo "Tava" Taupu, a Marquesan long resident on the Kona coast of Hawai'i where he maintains the quasi-traditional Polynesian houses of a luxury resort. Representing the island of Moloka'i was paramedic Mel Paoa.

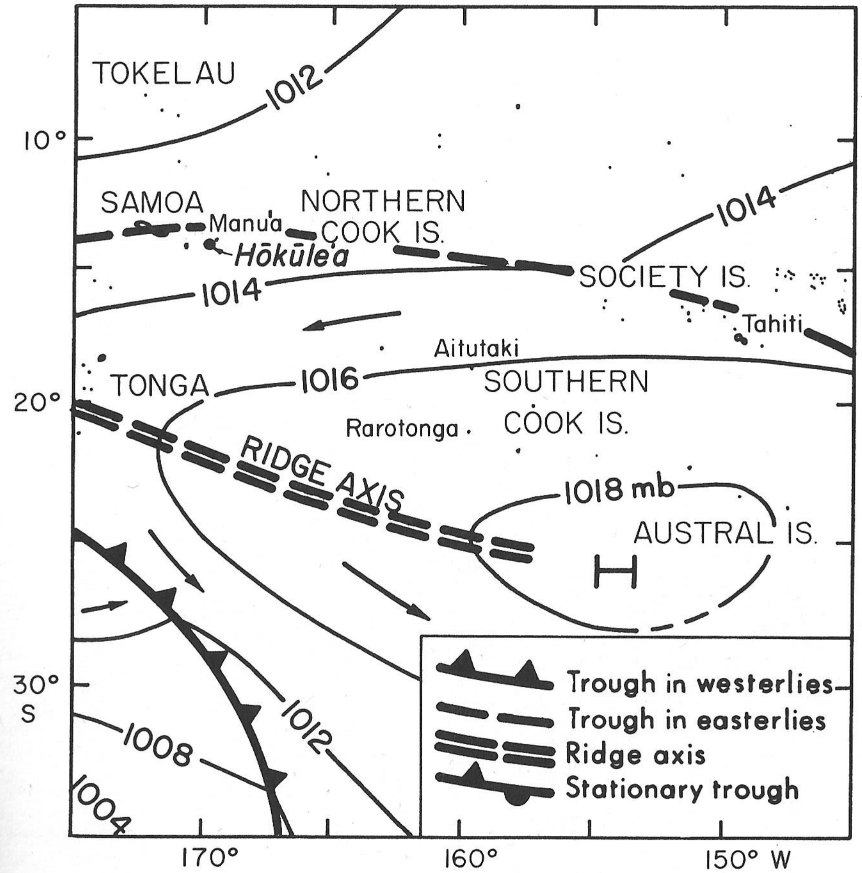


Figure 36. Surface weather map for 7 July 1986. This map, and subsequent weather maps, depict conditions at 1400 Rarotonga Time. Sea-level pressure is indicated in millibars in this and subsequent weather maps. Arrows indicate surface wind direction.

From the island of O'ahu were: Harry Ho, a Honolulu architect who was also in charge of the provisioning of the canoe for the entire voyage and other logistical chores; Bernard Kilonsky, a meteorologist from the University of Hawai'i; and Pauahi Ioane, a young student who was the only woman on board as well as the only crew member fluent in Hawaiian. Completing the crew was Tua Pittman, a tall, young Cook Islander who worked for Air New Zealand in Rarotonga.

On 10 July the wind began to shift to slightly north of east as *Hōkūle'a* approached the axis of the high pressure ridge. This can be seen in figure 37, which also shows westerlies strength-

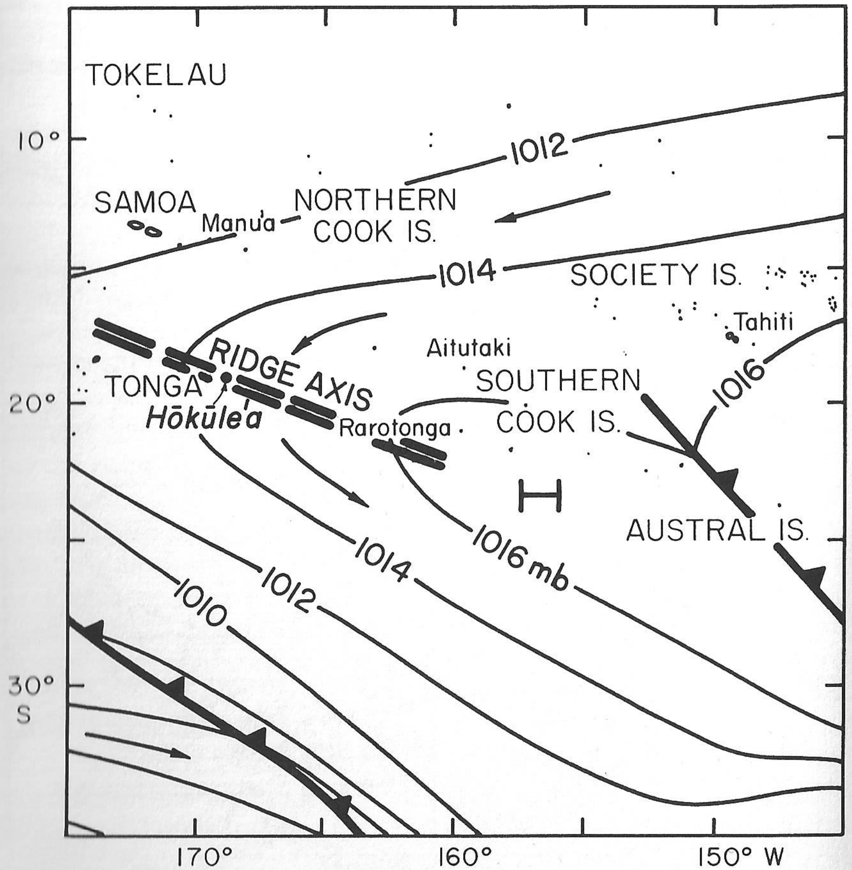


Figure 37. Surface weather map for 10 July 1986.

ening farther to the southwest as a major trough was approaching the ridge axis. With the wind blowing from slightly north of east, Nainoa was able to put the canoe onto a southeast course. He anticipated that soon they would be able to sail more directly to the east, for Nainoa interpreted the wind shift as a sign that a trough was approaching and that the wind would therefore continue to shift in a counterclockwise direction. The next day, 11 July, the wind continued shifting to the north as expected, and then became light and at times variable, a sure sign that the trades had broken down. Once the wind was coming from the north, *Hōkūle'a* was able to sail due east in fairly clear skies and calm seas. On the 12th a line of dark clouds to the south-

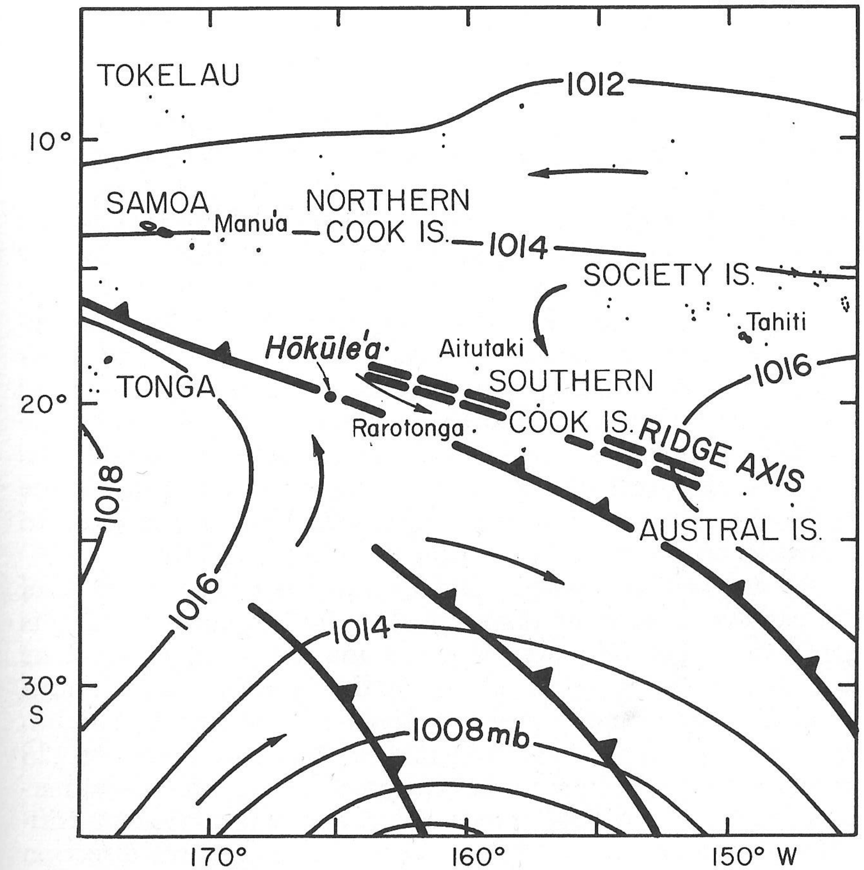


Figure 38. Surface weather map for 12 July 1986.

west announced the approach of the trough. The crew tried to keep the canoe sailing in front of the trough, but it was moving much faster than the canoe could sail and soon engulfed *Hōkūle'a* with clouds and rough seas. As the trough passed, the wind shifted quickly to the northwest, then to the west, and then finally to the southwest (fig. 38), all directions that allowed the canoe to continue to be sailed due east. By the morning of the 13th, however, the trades started coming back as the wind shifted from south to south-southeast, and then in the late afternoon started blowing directly out of the southeast, forcing the canoe to sail to the east-northeast.

On the 14th and 15th the boisterous trades developed more of an easterly component, forcing the canoe onto a northeasterly course. Nainoa figured that if they continued sailing northeast for a day or so more, they could then tack south to Rarotonga. At this point, the *Dorcas*, the yacht serving as the canoe's escort vessel, began experiencing trouble in the strong winds and heavy seas. *Hōkūle'a*, which was rigged with extra large sails in anticipation of having to tack in light airs, was moving too fast for the heavy cruising yacht, and at one point in squally weather the crew was forced to lower all the sails to wait for the *Dorcas*. Then, on the evening of the 15th, Dan Wright, captain of the *Dorcas*, signaled that he was having trouble with his mainmast and would have to head for a port in order to make repairs. Accordingly, by mutual agreement, Dan disclosed the canoe's position to Nainoa so that an accurate course could be laid to the nearest island, Aitutaki, which lies 140 miles due north of Rarotonga. Nainoa then had *Hōkūle'a* tacked south to Aitutaki, where she arrived on the morning of 16 July.

As on previous voyages, Nainoa had been keeping track of the canoe's progress by his method of dead reckoning which is based on visual estimates of speed and course made good, as well as the effect of the current. At the time Dan Wright notified him of the canoe's position, Nainoa found that he had underestimated the eastward progress of the canoe by about 125 miles. Such a wide margin of error may have stemmed primarily from the roundabout course sailed, and the consequent difficulty of estimating the canoe's progress, as well as the direction and strength of the current. In addition, because *Hōkūle'a* was sailing with a set of sails larger than the ones usually employed, Nainoa may have slightly, but consistently, underestimated the canoe's speed.

Aitutaki lies almost 650 miles to the east-southeast of Ofu. *Hōkūle'a* had made it there in a little over eight and a half days, sailing a roundabout course dictated by the direction of the winds and Nainoa's strategy for making maximum easting. Although the passage of the low pressure trough brought winds favorable for sailing to the east for only a little over three days, the easting thus gained, plus the smaller amount won when forced to sail to the northeast with the return of the trades after the passage of the trough, was enough to enable the canoe to make it to Aitutaki, a day's sail north of Rarotonga (fig. 39).

Had *Hōkūle'a* not stopped at Aitutaki, and instead had been

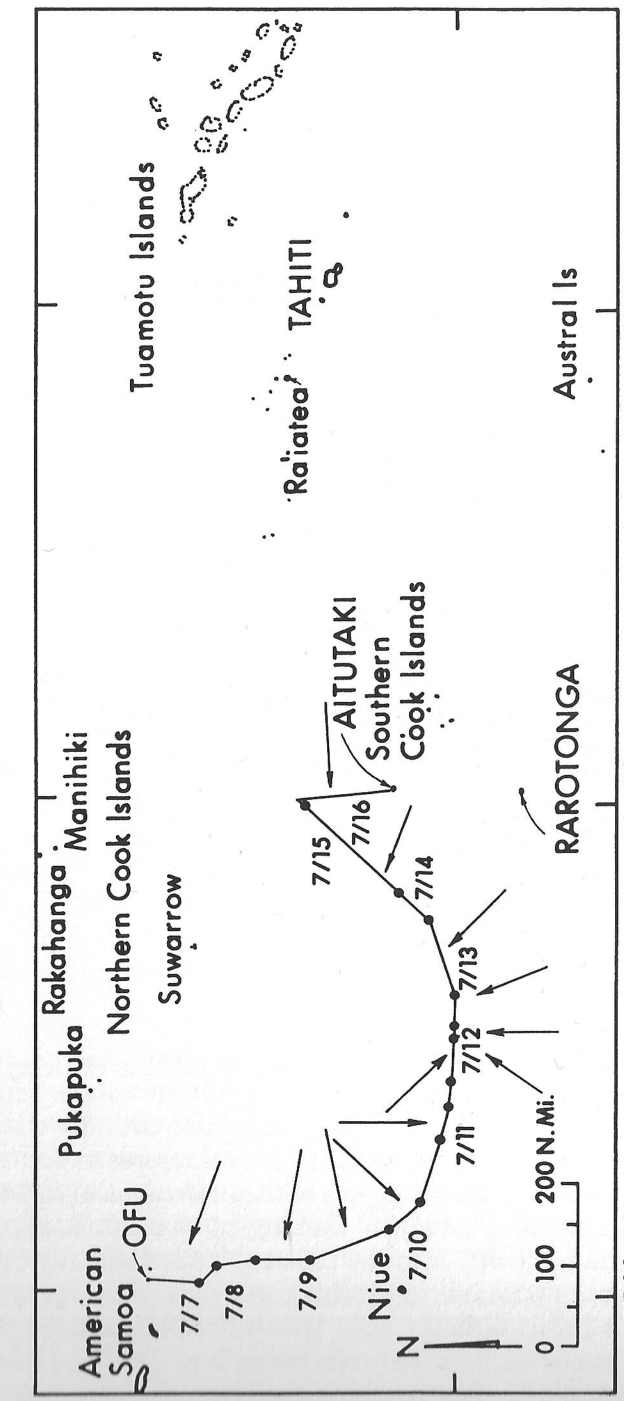


Figure 39. Sailing track (based on satellite navigation fixes taken from a following yacht) of Hōkūle'a *from Samoa to Aitutaki during July 1986, and winds (indicated by long, straight arrows) encountered along the way.*

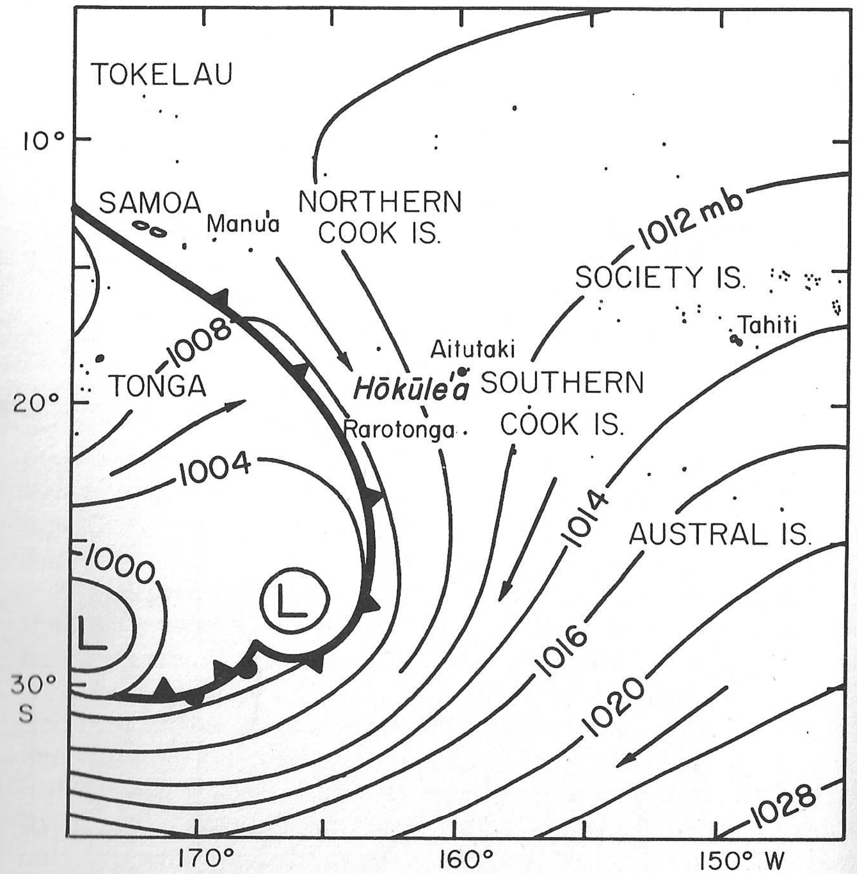


Figure 40. Surface weather map for 16 July 1986.

kept sailing with the trades on the same northeast course, the canoe would have moved into a position from which Tahiti could have been reached. On the afternoon of the 16th, by which time the canoe was anchored at Aitutaki, a depression moving east at 25° South began spreading westerlies northward, and the wind in the Cook Islands began shifting to the north as the trough approached (fig. 40). Had the canoe stayed at sea, it would probably have been possible to exploit the winds of this passing trough to reach Tahiti directly, or at least to attain enough easting so that the canoe could eventually make it to Tahiti by slanting into the trades and then catching the westerlies brought on by the passage of the next trough.

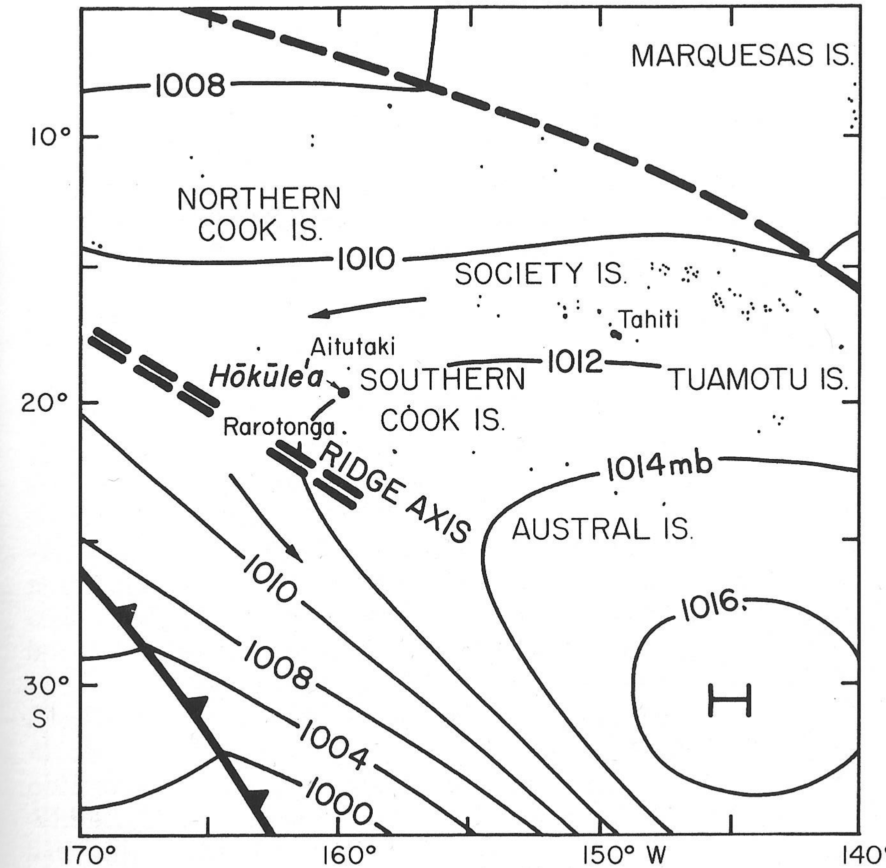


Figure 41. Surface weather map for 10 August 1986.

From Aitutaki to Rarotonga

The crew reassembled at Aitutaki in early August in order to make the canoe ready to sail first to Rarotonga and from there on to Tahiti. As they were working on the canoe yet another low pressure system transited the seas to the south, with its associated trough reaching far north into the tropics. By the time the canoe was ready on 10 August, the trough had passed and clear weather with easterly trade winds had been reestablished (fig. 41). These were ideal for sailing directly south to Rarotonga, and the canoe left just before noon. Nainoa delegated the task of navigating to Rarotonga to his understudy, Chad Baybayan, who when he was not sailing on *Hōkūle'a* worked as a supervisor in a major tourist hotel on Maui. While Aitutaki was still in sight, Chad backsighted on a small *motu* (islet) on the fringing reef, keeping it aligned with one of the peaks of the central mountain core of the island in order to maintain a course due south. As the *motu* was lost from view, the young Hawaiian switched to steering by the descending sun. That night he used the stars, particularly those in the Southern Cross, to keep the canoe on course and was rewarded with a predawn sighting of Rarotonga dead ahead.

From Rarotonga to Tahiti

As Shorty Bertelmann had to return to his work and family in Hawai'i after skippering the canoe to Aitutaki, Nainoa was serving as both captain and navigator for the crossing to Tahiti. Assisting him were Chad Baybayan and Mau Piailug. Other *Hōkūle'a* veterans on the crew included: Harry Ho, who had just made the crossing from Samoa; Michael Tongg, a Honolulu lawyer who had sailed with me on *Nālehia* in the 1960s and who served as president of the Polynesian Voyaging Society at the time of the 1980 voyage; Bruce Blankenfeld, a Honolulu fireman and professional fisherman (and Nainoa's brother-in-law); Abraham "Snake" Ah Hee, a slim, sinuous construction foreman from Maui; and Wallace "Wally" Froiseth, a retired fireman and renowned surfer and sailor from Honolulu who had been working diligently with the project since its inception in the early 1970s. Making their first South Pacific crossings on *Hōkūle'a* were: Glenn Oshiro, representing the island of Lāna'i (located just to the south of Maui) where he manages a service station; Aaron Kalei Young, a Honolulu fireman who like Mike Tongg had participated in the *Nālehia* experiments during the 1960s; and Richard Rhodes, a graphic artist who had just retired from the University of Hawai'i where he specialized in scientific illustration.

To reach Tahiti, Nainoa intended to employ the same strategy of exploiting favorable winds brought on by the passage of low pressure troughs as had been used on the Samoa to Aitutaki leg. Since Rarotonga, at 21° 15′ South latitude, lies almost four degrees south of Tahiti (17° 30′ South), the canoe was in a good position to reach Tahiti through a combination of sailing east with the westerlies, and then north-northeast against the trades whenever they reasserted their dominance. Accordingly, Nainoa planned to wait for the passage of a trough in order to sail eastward, keeping south of Tahiti until forced to the north by the return of the trades.

Hōkūle'a entered Avarua harbor on Rarotonga in the early afternoon of 11 August. As the wind had already begun to swing to the north, indicating the approach of another trough, it was tempting to leave that evening to take full advantage of the favorable angle, but waiting ashore was an exchange of speeches and gifts between the *ariki*, the traditional chiefs, of Rarotonga and the leaders of the Polynesian Voyaging Society, to be followed by a lavish feast.

The canoe left the following morning, sailing east on the port tack with 12 knot northerly winds (fig. 42). By the morning of the next day, 13 August, the wind had shifted to the west. Around 9 A.M. the canoe was engulfed by heavy rain, and the wind appeared to switch from northwest to southwest, apparently indicating that the trough was passing (fig. 43). The rainy, overcast skies that completely hid the sun, and seas confused by shifting winds, made it practically impossible to know whether the canoe was on course. At times Nainoa was tempted to take the sails down and drift until he was able to gain a firm indication of direction. Since, however, navigational accuracy was less important than making easting, Nainoa kept the sails up and tried to keep track of all the wind shifts in order to maintain the canoe on an easterly heading.

To Nainoa, the wind appeared to switch to the south at midday, and then, at sunset, to the southeast, as would be expected with the passage of a trough. That night, however, the wind started shifting back, clockwise, toward the southwest, and then went calm. Nainoa had the sails triced by drawing the booms and sails up against the mast while waiting for the wind to pick up again. It was a most confusing night. Judging from the few directional cues he could get from occasional glimpses of the moon through the overcast and from studying the turbulent seas, Nainoa reckoned that when the wind did start to pick up again it had shifted further around in a clockwise direction to the north. This did not immediately make sense. Had the trough actually passed the canoe, the wind should have continued to shift counterclockwise until it came from the east-southeast

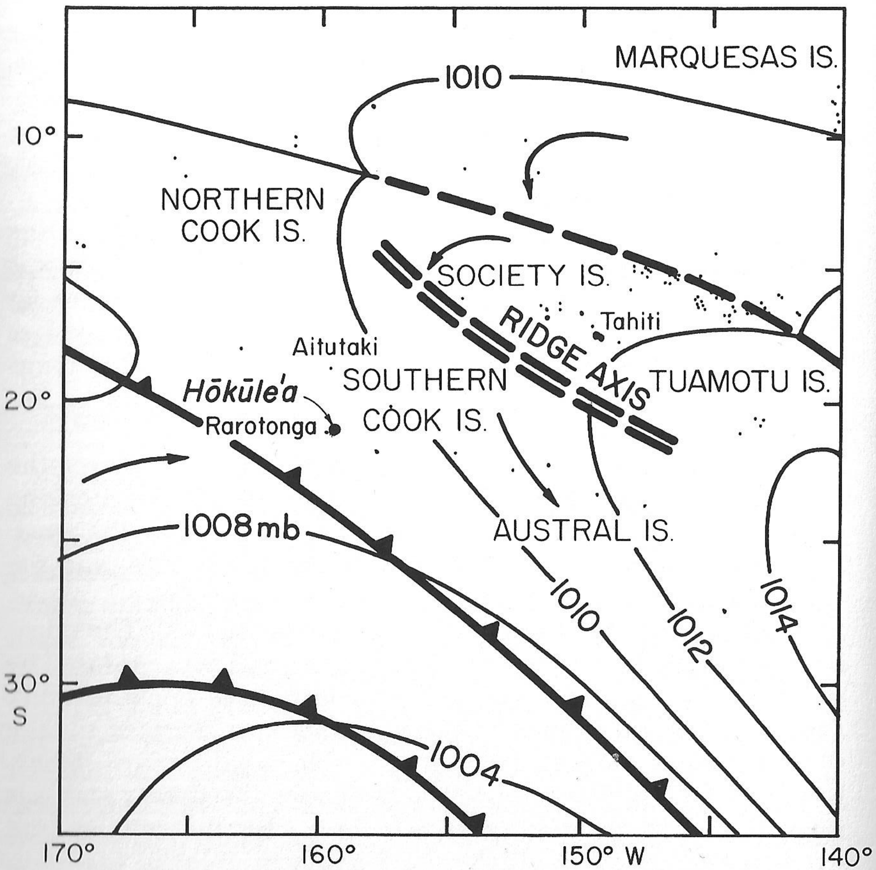


Figure 42. Surface weather map for 12 August 1986.

trade wind direction, as had occurred on the way to Aitutaki. So, Nainoa kept the sails triced for a few hours more until he finally got a glimpse of Jupiter and the moon setting which confirmed that the wind had indeed shifted back to the north and indicated that somehow they were forward of the trough again. He then ordered the sails let out and the canoe be put on the port tack to resume sailing eastward. Judging from the meteorological charts consulted after the voyage, what had happened was that a small depression traveling in the rear of the trough along about 27° South had generated a strong north to northwest wind field which then merged with and reactivated the main trough (fig. 44).

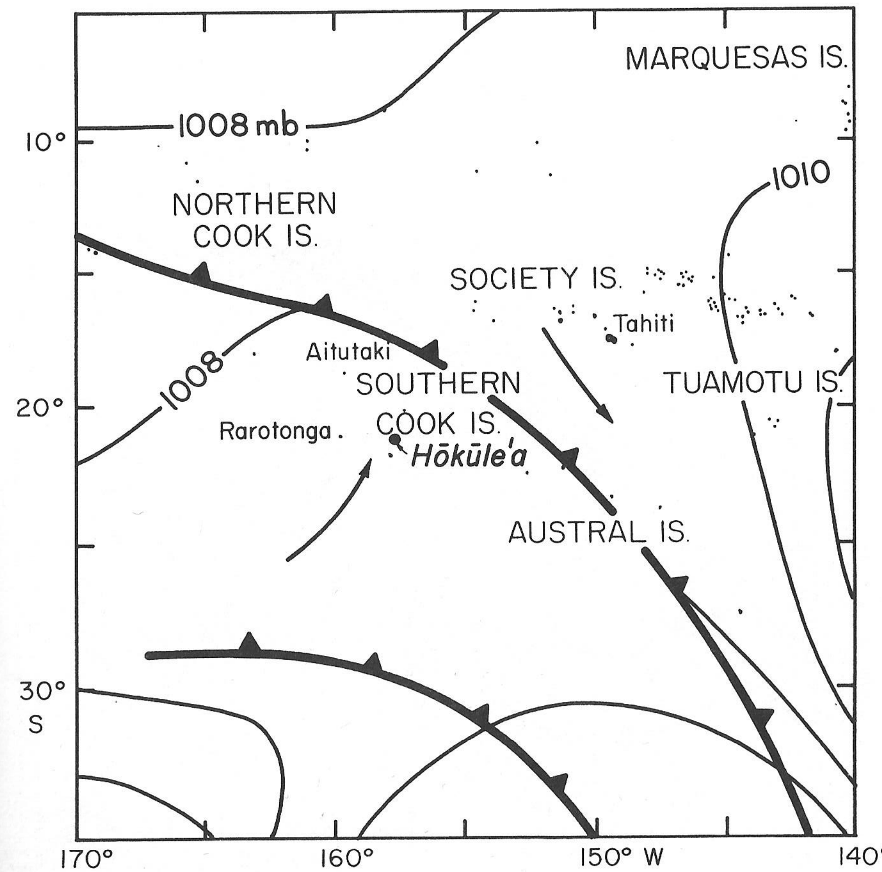


Figure 43. Surface weather map for 13 August 1986.

While sailing so close to the trough brought favorable winds, the overcast skies associated with the reactivated trough (fig. 45) continued to make navigation extremely difficult. On the night of the 15th Nainoa made an observation of a star in the constellation Cassiopeia, the only good star sight he had been able to make for several nights. According to his method of estimating latitude from the elevation of a star at the time of its meridional passage, this sight indicated that the canoe was sailing along latitude 23° South, not along 20° 25′ as Nainoa had mentally calculated by his dead reckoning method of keeping a cumulative estimate of course and distance made good. If true,

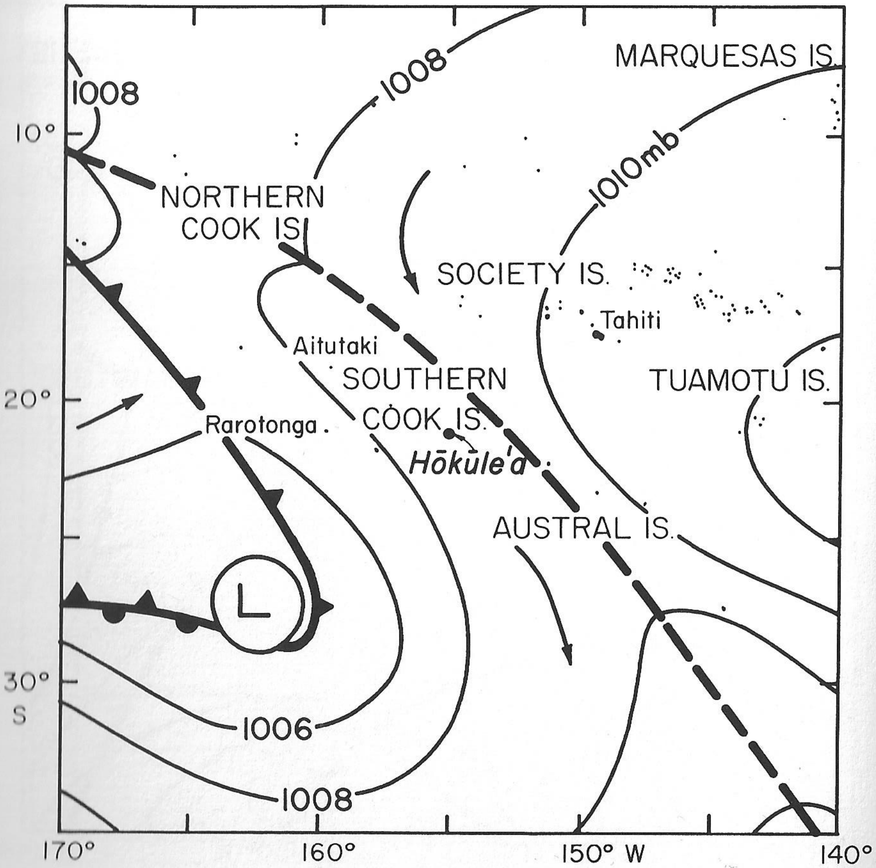


Figure 44. Surface weather map for 14 August 1986.

that would have meant that they were getting uncomfortably close to the Austral Islands and therefore should turn more toward the north. On the next day, 16 August, the sight of patches of seaweed drifting from north to south further confused the situation. If, on the one hand, they had been sailing as far south as 23°, then they would have been in the midst of the Austral Islands, and the seaweed might therefore have been coming from Rurutu, the northernmost island of that group. If, on the other hand, they were at 20° 25′, the seaweed would most likely have been coming from the westernmost islands of the Society chain far to the north of them.

This confusion over the canoe's position was cleared up that

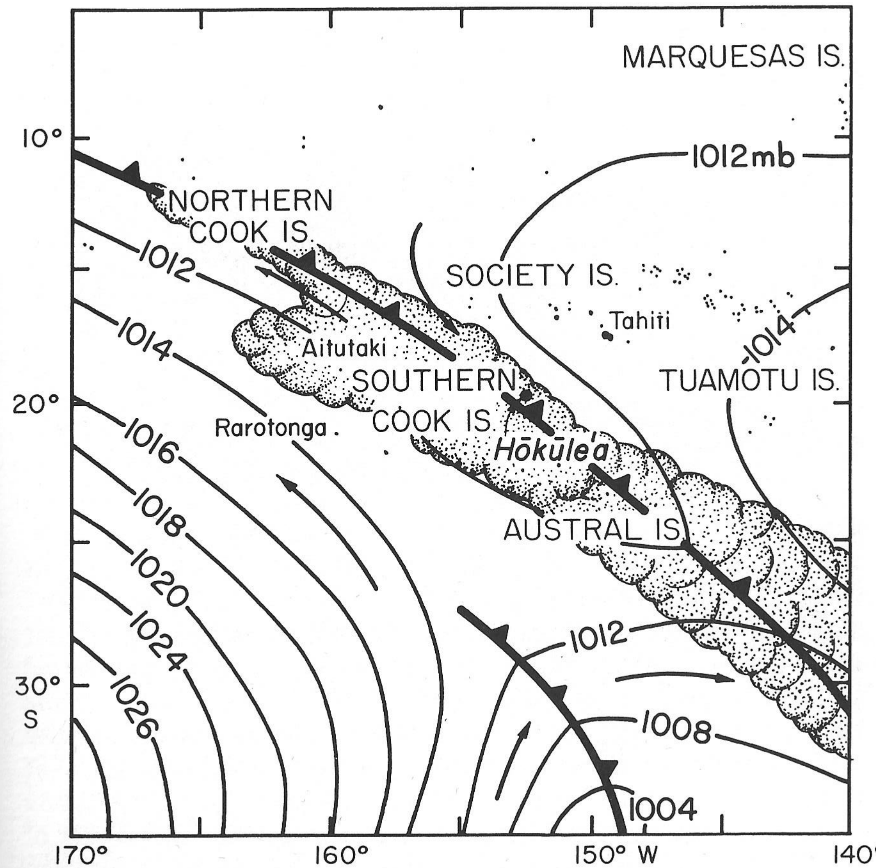


Figure 45. Surface weather map for 16 August 1986.

night when Nainoa made several star sights that seemed to indicate that his observation of the previous night was in error and that they were really sailing at about latitude 21°, safely north of the Australs but still well below the Societies. (Satellite navigation fixes from the escort yacht *Dorcas* indicate the *Hōkūle'a* was actually sailing at about 20° 15′, some 45 miles north of where Nainoa estimated.) So sure, in fact, was Nainoa that they were not within close range of land that he ignored the sighting made that day of a few boobies and white terns, land-based birds that can mean that land is nearby.

At this point Nainoa would have liked to have been closer to Ra'iatea, as plans called for a stop there to pay a ceremonial visit at the ancient stone temple of Taputapuātea before making landfall on Tahiti. But the northerly winds would not allow the canoe to be sailed due north to Ra'iatea. With northerly winds the canoe could continue to sail on the port tack to the east-northeast or go over onto the starboard tack and sail to the west-northwest. As Nainoa did not want to sail back toward the west, he gave up the idea of visiting Ra'iatea and concentrated on trying to make directly for Tahiti.

By dawn of the next day, 17 August, even making Tahiti began to look problematic, as it was realized that the persistent northerly winds could force *Hōkūle'a* to sail past Tahiti well south of the island. For a while that day the canoe did seem to get out in front of the trough and move into a region of clearing skies and east-northeast winds that dried off the deck for the first time on the voyage (fig. 46). The wind shift and dry air seemed to indicate that the canoe was entering into a ridge of high pressure and that the trade winds might soon come back in force. The east-northeast winds did allow the canoe to be sailed almost directly to the north on the starboard tack, but that night the wind shifted back to the north as the trough gathered speed and began to catch up with *Hōkūle'a*, forcing the canoe back onto the port tack and an easterly heading. As the squally winds continued to blow from the north, Nainoa realized that not only were they going to be pushed past Tahiti, but they might even be blown into the hazardous labyrinth of atolls of the Tuamotu Archipelago. After worrying for months how they were going to make enough easting to reach Tahiti, Nainoa saw that the problem might soon be how to make enough westing to sail back to the island!

As the northwest winds kept forcing the canoe to the east, the crew could look back to the southwest where a band of towering cumulus clouds appeared to mark the front of the trough. If only, they thought, the canoe could somehow get to the rear of the trough they would find trade winds that would allow them to sail northwest back to Tahiti. Finally, at sunset on the 19th the wind started to shift to the northeast, indicating perhaps that the trough was about to pass them. Then the wind died altogether, and after a brief calm a succession of squalls moved in from the west. The squalls, accompanied by winds blowing up to 40 knots, persisted throughout the night, periodically forcing the sails to be triced and lowered to the deck, totally exhausting the crew. At dawn, a strong wind and a big swell started

coming from the south-southwest, indicating that the trough must be passing, and that *Hōkūle'a* was almost back in the trades. Accordingly, Nainoa ordered the canoe to be sailed to the north-northwest, the direction he thought might bring them to Tahiti.

Although the navigator reckoned that Tahiti was somewhere in that general direction, because of the cloud cover that had plagued them throughout the voyage and had been especially heavy during the last few nights, he was not sure of the exact bearing to Tahiti or how far away the island was. Accordingly, Nainoa planned to keep sailing to the north-northwest until sunset, when, if they had not spotted Tahiti, he intended to start tacking back and forth to the southwest to search out the island.

The latter part of that strategy never had to be put into action. After a few hours of sailing, the mist parted to reveal, just a few miles ahead of the canoe, the steep peak of Mehetia (Me'e-tia), a minuscule volcanic island lying 60 miles east-southeast of Tahiti. From then on the sail to Tahiti was straightforward. The canoe passed Mehetia, and as its lone peak began to disappear astern, the high mountains of Tahiti could be seen rising out of the sea ahead. By then the trough lay to the east of the canoe's position, the skies had cleared, and the winds had continued their counterclockwise rotation so that *Hōkūle'a* was at last sailing in strong southeast trades (fig. 47). For the first time since leaving Rarotonga, Nainoa and the crew could relax.

By the late afternoon the canoe was sailing along the rugged

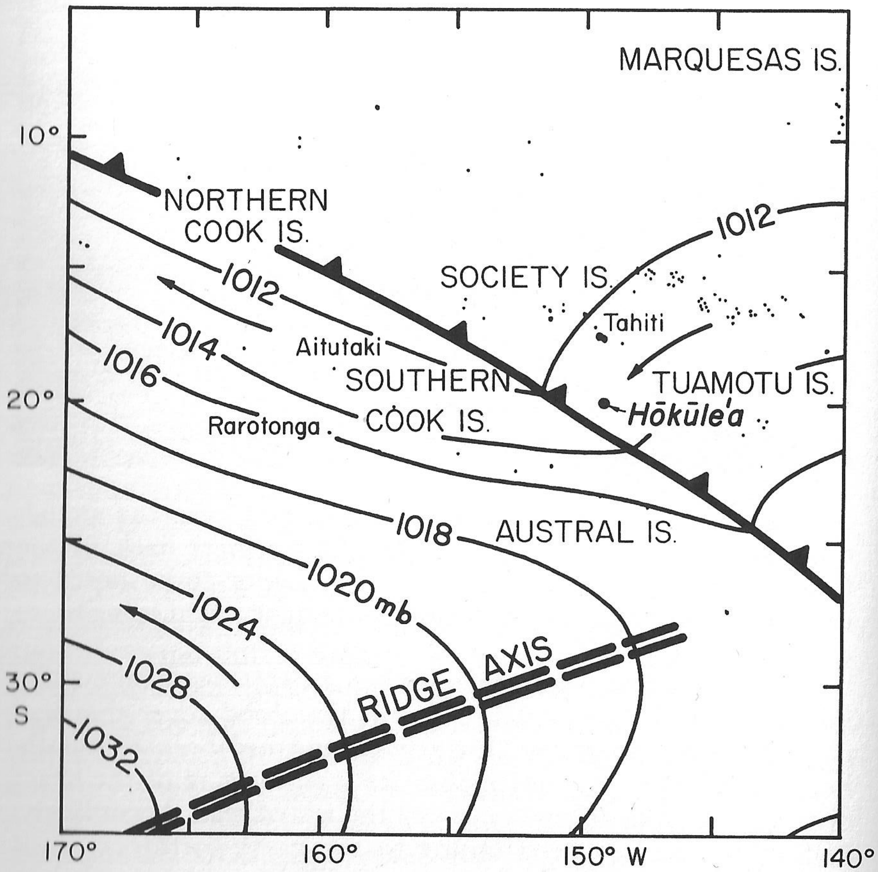


Figure 46. Surface weather map for 17 August 1986.

shore of Tahiti-iti, the uninhabited eastern end of the island that is visited only rarely by fishermen and sightseers. The sight of densely vegetated mountain slopes unscarred by roads or cultivation, and of secluded little bays without a house or other sign of human presence, gave everyone on board a feeling of what it must have been like many centuries ago for those first canoe voyagers to sight this stunningly beautiful island. After waiting offshore that night, the next morning the canoe was sailed into the pass at Tautira, a village located midway along the northern shore of the Tahiti-iti peninsula (fig. 48). There a warm welcome from the mayor, Tutaha Salmon, and the many friends of *Hōkūle'a* and her crew from the Maire-Nui canoe racing club, awaited the weary voyagers.

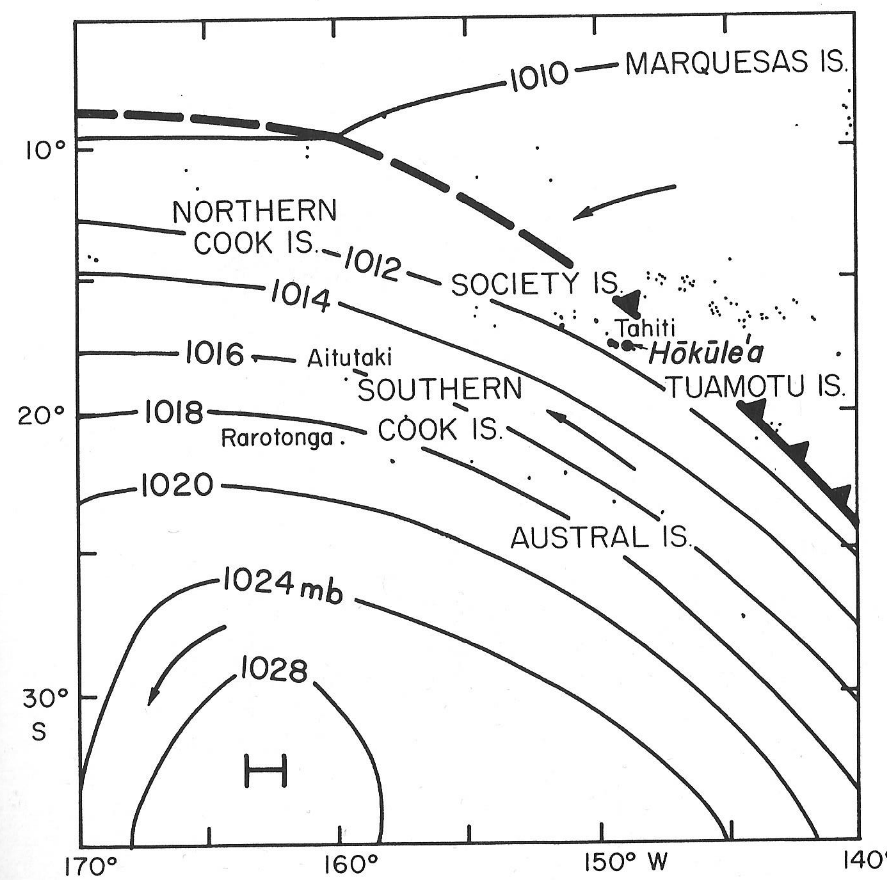


Figure 47. Surface weather map for 21 August 1986.

Winter Westerlies

If any experience could lay to rest the notion, promulgated by theorists from Martínez de Zúñiga to Heyerdahl, of a permanent trade wind barrier keeping canoe voyagers from sailing eastward across the tropical South Pacific it would be this one. Nainoa and the crew were able to sail *Hōkūle'a* from Samoa to Tahiti during the Austral winter when the trades are supposed to be at their steadiest. The second part of that crossing, that from Rarotonga to Tahiti, was especially noteworthy. Instead of the anticipated hard struggle to reach Tahiti, an embarrassment

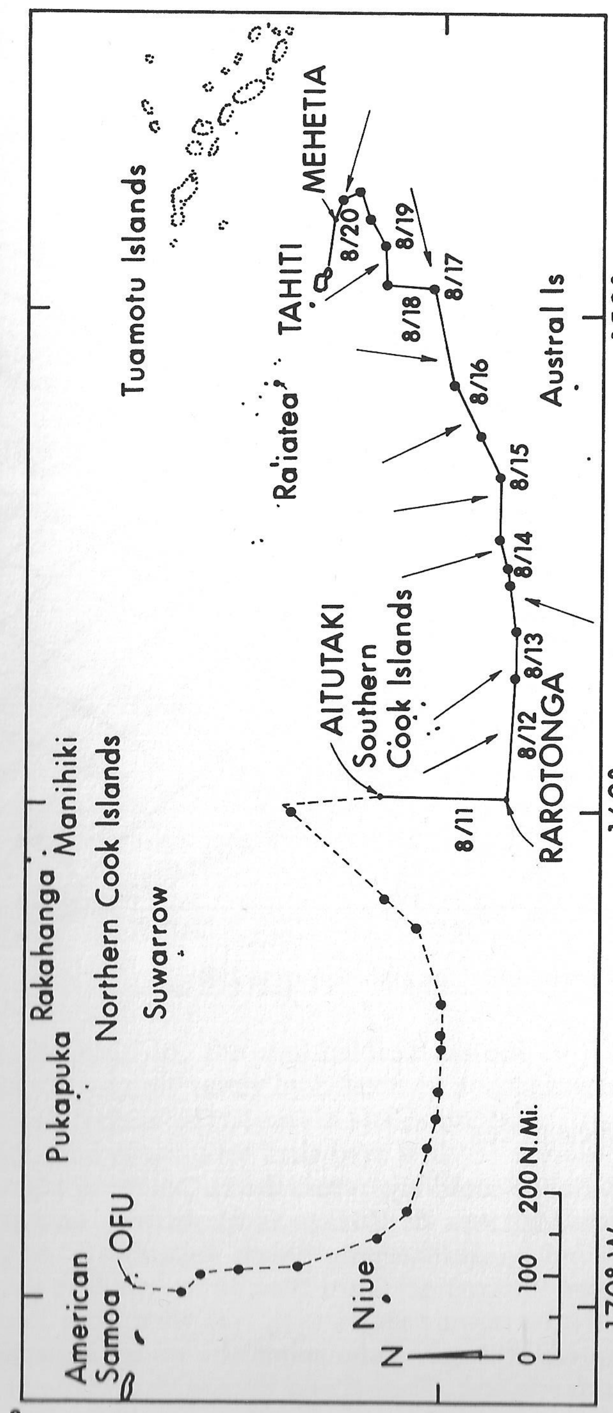


Figure 48. Sailing track of Hōkūle'a *from Aitutaki to Tahiti during August 1986.*

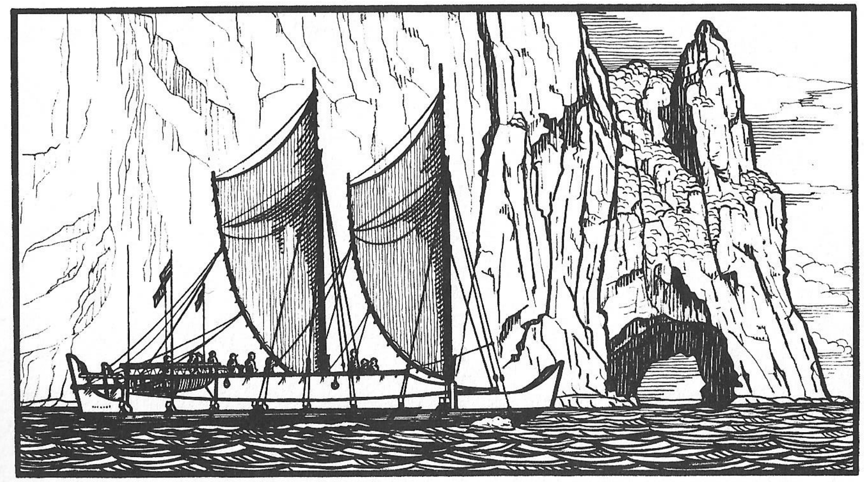
of favorable northwesterly winds sped *Hōkūle'a* eastward and even forced it past Tahiti before the trades finally returned and allowed the canoe to be sailed back to the northwest to reach the island. Ironically, the low pressure trough that generated these winds needed for sailing east also brought the cloudy, squally weather that Nainoa had wanted to avoid by sailing during the winter instead of the summer. The overcast skies, and the frequent squalls that forced the crew to trice the sails and lower them to the deck so many times that they lost count, made the job of navigating without instruments most difficult. Even so, once the trades returned, Nainoa had an accurate enough idea of the general location of Tahiti to set a course that led to landfall first on Mehetia, and then Tahiti itself.

The favorable winds that enabled *Hōkūle'a* to sail from Samoa to the Southern Cooks and then on to Tahiti may be labeled "winter westerlies" to distinguish them from the more regular summer westerlies. Although these winter westerlies may be much less frequent and enduring than the summer variety, they do seem to occur periodically. In studies of Southern Hemisphere weather patterns, meteorologists have found that the region southeast of the Samoa to Tahiti route is prone to episodes when high pressure systems block the normal passage of lows, shunting some of them onto a more northerly course.[11] On the basis of weather records from Rarotonga, the testimony of experienced sailors and fishermen there, and more general meteorological data, we can roughly estimate that the extraordinary outbreaks of winter westerlies such as those encountered by *Hōkūle'a* in 1985 may occur in Rarotonga waters in about one year out of ten, and that less extensive episodes may occur at least every few years. In addition, therefore, to the westerlies of the summer, it would appear that early seafarers seeking to sail eastward during the winter could also have exploited the periodic if less frequent spells of westerlies that sometimes occur then.

Discussions on how seafarers ultimately originating in Southeast Asia acquired the voyaging ability to expand eastward into the Pacific have centered mostly on the evolution of canoes capable of crossing the progressively wider gaps between islands, and on the development of ways for navigating far out of sight of land. As this crossing from Samoa to Tahiti underlines, it is clear that in addition to voyaging canoes and ways of navigating adapted for long distance exploration and colonization a third maritime adaptation was required. Seafarers had to learn how to exploit periodic spells of westerly winds to keep pressing eastward against the direction from which the trade winds often but not always blow.

6

VOYAGE TO AOTEAROA



Retracing Māori Migration

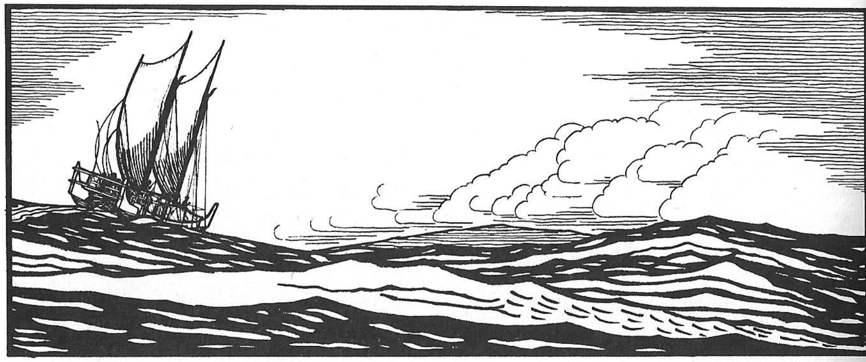
In early December of 1985, sixteen days after leaving Rarotonga, *Hōkūle'a* sailed into the Bay of Islands on the northeastern coast of the North Island of Aotearoa. In keeping with the dual experimental and cultural nature of the Voyage of Rediscovery, this crossing was undertaken both to learn more about how seafarers from the tropical heartland of East Polynesia were able to sail to this huge land lying so far to the southwest and to extend the cultural reach of *Hōkūle'a* by sailing to a Polynesian nation whose constituent tribes still express their identity and claims to land by recalling how their ancestors voyaged to Aotearoa from the legendary homeland of Hawaiki, and where they landed and made their first settlements.

In sailing to Aotearoa we wished to retrace the general direction of migration to that land, though not necessarily the exact route. The available evidence indicates that, despite their loca-

*With Chad Baybayan, Bernard Kilonsky, and Nainoa Thompson

7

SAILING BACK AND FORTH BETWEEN HAWAI'I AND TAHITI



The voyage *Hōkūle'a* made in 1976 from Hawai'i to Tahiti and return set a new standard in experimental voyaging, for it was the first time a reconstructed craft had sailed both ways over a long oceanic course. *Hōkūle'a*'s passage to Tahiti and back in 1980 replicated the 1976 voyage and extended its significance in that both legs were navigated without instruments. Considered together, the first leg of the Voyage of Rediscovery from Hawai'i to Tahiti in 1985 and the last leg from Tahiti back to Hawai'i in 1987 comprise the canoe's third roundtrip between these two Polynesian centers. To have made not one but three roundtrip crossings between such distantly separated islands stands as an accomplishment unparalleled in the field of experimental voyaging, particularly since *Hōkūle'a* was guided by noninstrument navigation techniques on all legs except the return one to Hawai'i in 1976.

*With Tai Crouch, Thomas Schroeder, E. Dixon Stroup, Nainoa Thompson, and Elisa Yadao

The Route and the First Two Roundtrips

Although the alignment of the Hawai'i-Tahiti route across the trade winds lends itself to two-way voyaging, it is not totally ideal, for the islands do not fall exactly on a north-south line, and the trade winds do not blow constantly from due east. If Hawai'i and Tahiti were on the same meridian of longitude, and if the trade winds and accompanying currents came directly out of the east, sailing both north and south between the two would present no problem at all. It would simply be a matter of sailing a canoe on a reach across the easterly trade winds, pointing only slightly into the wind in order to make up for leeway and the westward set of the ocean currents that accompany the trades. But the meridian of Tahiti lies hundreds of miles to the east of that of Hawai'i, and the trade wind and current flow varies significantly along the route. In fact, the route crosses three separate wind zones, each with a distinctive ocean current flow: the northeast trade winds, the doldrums, and the southeast trade winds.

Northeast Trade Wind Zone

During the Northern Hemisphere summer, the northeast trade winds are usually dominant roughly from around 28°–30° North (some 400–500 miles north of Hawai'i) to around 9° North (about 600 miles south of Hawai'i). Although these winds are named for the quadrant from which they blow, their actual direction in the zone between Hawai'i and their southern limit is more typically east-northeast than straight northeast. In this zone the North Equatorial Current flows westward with an average speed of about a half a knot, or around 12 nautical miles a day.

Doldrums

Although it is sometimes possible to sail from one trade wind zone to the other without interruption, sailing vessels frequently have to work their way slowly through the doldrums, a band of calms and light, variable winds punctuated by squalls, heavy overcast and rain, and sometimes interrupted by still, cloudless, torrid days. This band is typically 200–300 miles wide and is located during much of the year between approximately 4° and 9°

North. Here the Equatorial Countercurrent flows eastward, typically at around 12–24 miles a day.

Southeast Trade Wind Zone

Although the Southeast trade winds are centered in the Southern Hemisphere, in this part of the Pacific they typically cross over the equator and extend as far north as the southern limit of the doldrums, generally located around 4° North (240 miles from the equator). Although below the equator these winds typically blow from between east and southeast, as they cross the equator and flow toward the low pressure trough of the doldrums they become more southerly, particularly during the summer. Like its Northern Hemisphere counterpart, the South Equatorial Current of this zone flows westward at about 12 miles a day.

The south-southeast slant of the route from Hawai'i to Tahiti means that a canoe has to be worked hard to windward against the trade winds in order to make up the deficit in longitude. The strategy we adopted in 1976 and 1980 was to try and gain as much easting as possible in the northeast trades and the doldrums in order to get to the east of Tahiti, and then, when sailing in the southeast trades, to hold onto as much of that easting as possible in order to keep from being driven to the west of Tahiti. As detailed in chapters 2 and 3, those first two voyages to Tahiti were accomplished more or less as expected. Upon clearing the island of Hawai'i, the east-northeast angle of the trades enabled the canoe to sail to the south-southeast and, before entering the doldrums, to attain a position about 160 miles to the east of the meridian of Tahiti in 1976 and 125 miles to the east in 1980. On both voyages, as the canoe slowly crossed this shifting zone of calms and light variables, the eastward flowing Equatorial Countercurrent gave *Hōkūle'a* a welcome boost eastward, pushing the canoe still farther to the east of Tahiti (to a point about 285 miles to the east of Tahiti in 1976 and 225 miles in 1980). Then, again on both voyages the canoe was able—despite the unfavorable, south-southeast angle of the trade winds encountered immediately upon exiting the doldrums—to hold onto enough of these hard-won miles of easting to make landfall in the western Tuamotus and from there easily sail to Tahiti. Both crossings took slightly over a month—32 days in 1976 (plus 2 days spent at the atoll of Mataiva) and 31 days in 1980—and it was equally remarkable that the landfalls in the Tuamotus were within about 15 miles of each other.[1]

On both crossings, however, some problems were experienced. In 1976 the south-southeast trades encountered upon exiting the doldrums extended much farther south than had been anticipated and pushed the canoe onto a course that would have taken it to the west of Tahiti had not the wind finally become more easterly some 650 miles south of the equator. That shift enabled *Hōkūle'a* to turn back to the south-southeast to make a landfall on Mataiva, the westernmost atoll of the Tuamotus, and from there to sail to Tahiti. In 1980 gale-force trade winds encountered soon after clearing the island of Hawai'i forced the canoe to lower sails and drift for a while and then to tack to the northeast to regain lost easting before continuing on its course to the southeast. Thereafter sailing conditions were fairly mild and the canoe reached first the Tuamotus and then Tahiti without incident.

Both times, the navigation also proceeded more or less as planned. The generally good visibility over the route (except in the doldrums where overcast skies frequently obscured the sun, moon, and stars) enabled Mau Piailug in 1976, and Nainoa Thompson in 1980, to utilize star sights to keep the canoe on the right heading or monitor its heading whenever adverse winds forced the canoe off the intended course. Although in 1976 the novelty of the long route into unfamiliar seas and Southern Hemisphere skies may have made it difficult for Mau Piailug to keep in mind the exact track of the canoe as it curved toward Tahiti, the canoe made landfall in the Tuamotus just about as he had anticipated. In 1980, the postvoyage comparison of the satellite-derived track of the canoe with navigator Nainoa Thompson's estimates of where the canoe was sailing revealed that (except for one period when an unexpectedly strong current affected the canoe) he was fairly accurate in mentally tracking the canoe's progress and in visualizing where the canoe would make landfall in the Tuamotus.

The windward position of Tahiti made the legs home to Hawai'i much easier and faster than the outbound ones. Both times *Hōkūle'a* was able to sail swiftly back, reaching across strong and relatively steady trade winds (with, fortunately, minimal doldrum conditions at the convergence of the southeast and northeast trade wind systems) to draw abeam Hawai'i in slightly under twenty days in 1976, and in twenty-two days in 1980. From there, the canoe was able to sail downwind to O'ahu in a few days to complete the voyages in twenty-two and twenty-six days, respectively. Although without the services of Mau Piailug the 1976 return to Hawai'i had to be navigated by modern means, in 1980 Nainoa Thompson employed his noninstrument systems to guide *Hōkūle'a* back to Hawai'i accurately and without incident.

Because these first two roundtrips had been so successful, we did not focus on the Hawai'i-Tahiti route when planning the Voyage of Rediscovery. Instead, we concentrated on those legs of the voyage where *Hōkūle'a* had not yet sailed, particularly on those routes where it seemed likely that the canoe might encounter adverse winds or rough weather, such as the route from Samoa to Tahiti and that from Rarotonga to Aotearoa. This confidence about being able to sail routinely between Hawai'i and Tahiti was to be shaken by doldrum calms alternating with sharp squalls where steady trades were expected, winds that blew from the "wrong" quarter, and scores of land-finding birds that flew around the canoe when she was still far from land. This recounting of *Hōkūle'a*'s third roundtrip between Hawai'i and Tahiti highlights these and other seeming anomalies and the problems they engendered, particularly for navigation, to show how even under such adverse conditions it is possible to sail a double canoe between these two widely spaced Polynesian centers and to do so without instruments or other navigational aids.

Hawai'i to Tahiti: 1985

Both in 1976 and in 1980 the canoe had sailed for Tahiti during the early spring in order to have enough time to reach Tahiti and then sail back to Hawai'i before the late summer when tropical disturbances, some of which develop into hurricanes, periodically form far to the southeast of Hawai'i and then spin northwestward on trajectories that often cross the sailing route between Hawai'i and Tahiti and occasionally intersect the Hawaiian chain. Because in 1985 the canoe was continuing on to the Cook Islands and New Zealand after reaching Tahiti, there was no need for so early a departure in order to be able to get

back to Hawai'i before the summer hurricane season. Nonetheless, a late spring or early summer sailing was scheduled so that the canoe would be at sea when there would be a high probability of steady trades and a low probability of storms. Unfortunately, however, because of delays in arranging for an escort vessel and then getting her ready for the voyage, the canoe was not able to leave until the second week of July, putting her on the seaway to Tahiti several months later than on the previous voyages and at a time when tropical storms begin developing north of the equator.

The Northeast Trade Wind Zone

Early on the afternoon of 10 July, *Hōkūle'a* left her anchorage off the little fishing village of Miloli'i, located on the rugged, lava-strewn South Kona coast of the island of Hawai'i. As the waters off this coast are sheltered from the trades by the massive slopes of Mauna Loa, the canoe did not pick up the trade winds until late that night after she had cleared Ka Lae, the island's southernmost point, and was sailing in seas clear of any obstructions to windward for thousands of miles. With the trades blowing steadily and the canoe riding over the accompanying trade wind swell, the crew settled down to the routine of holding the canoe as close to the wind as possible without losing speed in order to gain maximum easting in the northeast trade wind belt.

Captain Shorty Bertelmann and navigator Nainoa Thompson were joined by ten other crewmen for this first leg of the voyage. These included a number of veteran *Hōkūle'a* sailors: Tava Taupu and Clay Bertelmann from the island of Hawai'i; Harry Ho, Buddy McGuire, and Jim Shizuru from O'ahu; and Mau Piailug from Satawal atoll. Completing the crew were Dr. Larry Magnuson, a physician from Kaua'i who served as the canoe's doctor; Richard "Tai" Crouch, a former student of mine who, after earning a B.A. degree in anthropology and an M.A. in Pacific Islands Studies at the University of Hawai'i, was teaching at Honolulu's Punahou School; Dennis Chun, the coordinator of the Hawaiian Studies program at Kaua'i Community College; and Thomas Reity, Mau's nephew and apprentice from the island of Satawal.

The satellite-derived track (fig. 63) shows that *Hōkūle'a* made

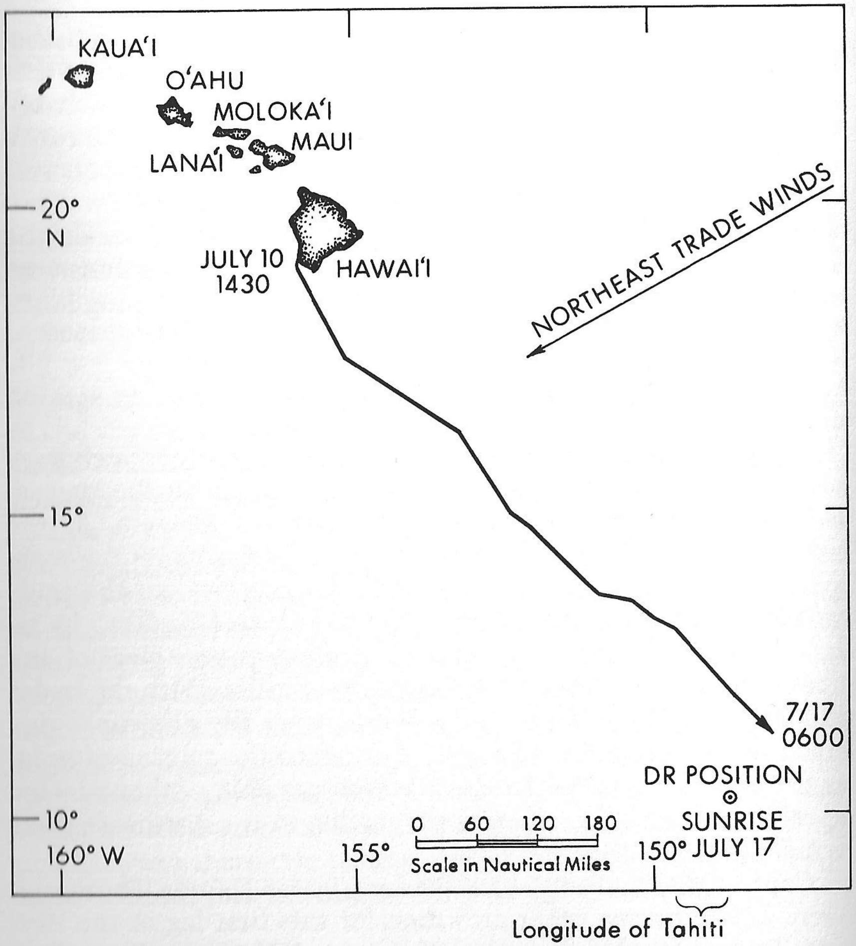


Figure 63. Making easting in the northeast trades during first week of the 1985 voyage of Hōkūle'a *from Hawai'i to Tahiti.*

good progress to the east as she slanted across the trades during this first segment of the voyage, for the canoe reached 148° West longitude, a degree east of the meridian of Tahiti, on the morning of 17 July after just six and a half days at sea. Compared to the eastward position reached by the canoe in 1976 and in 1980 at the same latitude (11° North; 660 miles north of the equator), at this stage of the voyage the canoe was making much better progress to windward than on the previous two crossings.

Although the overall direction of the wind, averaging between east-northeast and northeast, was favorable for gaining easting,

the weather conditions were unexpectedly uneven. The clear skies and fairly steady winds enjoyed upon clearing Ka Lae had soon given way to heavy cloud cover, shifting winds, and the occasional squall. Then, on the 14th, at about 13° 30′ North, the canoe ran into a weak tropical disturbance that brought sharp squalls with strong, variable winds and heavy downpours, alternating with periods of absolute, oily calm. At first, Nainoa had interpreted these conditions to mean that the canoe had entered the doldrums, raising the unwanted prospect that this zone might then be especially wide and consequently would delay the canoe for longer than the week it took to transit the doldrums in 1976. To everyone's relief, however, after a couple of days of this disturbed weather trade wind conditions returned, indicating that the canoe had not yet reached the doldrums.

During this period Nainoa and the crew were able to keep the canoe headed southeast, despite the shifting winds that required constant adjustments in steering and periods of total cloud cover when the canoe had to be guided by the swells, which was not at all easy to do in the confused seas engendered by the frequent wind shifts. At this time Nainoa's dead reckoning calculations were fairly close to the actual track of the canoe, although toward the end of that first week he was beginning to place the canoe to the southwest of its true position. For example, at sunrise on 17 July, when the canoe was actually at about 11° 20′ North and 148° 05′ West, Nainoa placed her about 70 miles to the southwest (fig. 63).[2]

The Doldrums

On the afternoon of the 17th, the trade winds died again. There followed over the next six days classical doldrum conditions: calms, punctuated with squalls and spells of wind that shifted all around the compass, as well as periods of heavy cloud cover and soaking rains. An infrared weather satellite image (fig. 64) shows a markedly cloudy convergence zone that blanketed the region until the 22nd, when it began weakening as tropical storm Ignacio approached several hundred miles to the east-northeast of the canoe. At that point, however, the canoe was not yet out of the doldrums; throughout the daylight hours of the 22nd and far into the night squall after squall struck the canoe.

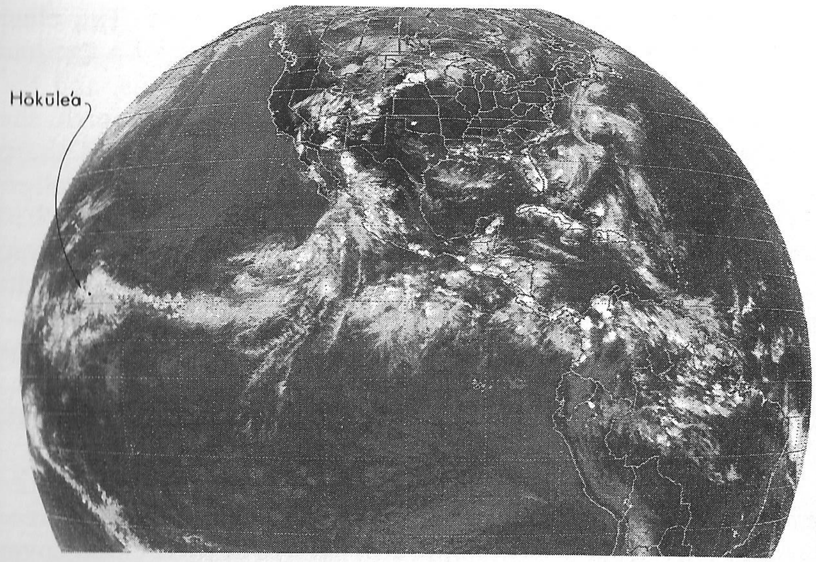


Figure 64. Infrared satellite image of heavy cloud cover on the afternoon of 17 July 1985 as Hōkūle'a *enters the doldrums.*

Not until the morning of the 23rd did the skies really clear and steady winds come back for the first time in almost a week, indicating, it seemed, that the canoe had exited the doldrums and entered the zone of southeast trade winds. At this point the canoe was at about 7° 30′ North, which meant that the doldrums, entered at 11° North, had been several degrees north of where they had been encountered in 1976 and 1980. Only after the voyage when we examined weather records did we realize that at this time of year the doldrums are often displaced to the north, for the convergence zone between the two trade wind belts shifts progressively northward as the summer wears on and does not migrate southward until the Northern Hemisphere begins to cool with the coming of winter. Similarly, our retrospective study of weather records reminded us that the encounter with the small tropical disturbance just before reaching the doldrums, and then the approach of tropical storm Ignacio, were also not that unusual for this time of year, as the frequency of tropical disturbances in this region goes up with the increased warming as the summer wears on.

The Southeast Trade Wind Zone

As expected, the trade winds encountered upon exiting the doldrums had a marked southerly component that forced the canoe onto a course slightly to the west of south. This led Nainoa to consider tacking to the east, for he was worried that the canoe may not have gained enough easting in the northeast trades and the doldrums and that the long spell coming up of sailing in the southeast trade wind belt might see them driven to the west of Tahiti. He nonetheless decided to remain on the port tack, for to go over on the starboard tack would mean that the canoe would be heading slightly north of east. The miles of easting to be gained on that tack would have been welcome, but the northerly component of the course would have eventually taken the canoe back into the doldrums region, something definitely to be avoided. So, there was nothing to be done but to keep the canoe sailing on the port tack as close to the wind as possible and hope that after they crossed the equator the winds would start coming more out of the east than the south.

Throughout this first day in the southeast trades, the 23rd, and well into the following night, Nainoa kept the canoe on the port tack. According to Nainoa's reckoning, after factoring in leeway and current drift to the west, this resulted in the track curving toward the southwest. Then, at about one in the morning of the 24th a squall hit with winds gusting up to 50 knots, forcing the crew to lower the sails to the deck. After the squall had passed and the sails were raised, another squall hit, and the sails were lowered again. After drifting with sails down until dawn, a wind sprang up from the south. This time Nainoa decided to take the opportunity to tack in order to gain easting and so gave the order to raise the sails and go onto the starboard tack. The canoe stayed on that tack—first heading due east, then, as the wind shifted a little toward the south-southeast, slightly north of east—until early in the afternoon when the wind became more easterly and Nainoa had the canoe put back onto the port tack to resume sailing southward.

During this period between sunrise on 23 July and the early afternoon of the 24th Nainoa's dead reckoning estimates began to diverge significantly from the satellite track of the canoe. Where the satellite fixes indicated that the track started to curve slightly southeastward, then made an abrupt turn to the east followed by a slight swing to the north, Nainoa estimated that *Hōkūle'a* continued to sail toward the southwest. So, by the morning of the 25th when the canoe was actually at about 6° 15′ South and 146° 45′ West, Nainoa's dead reckoning placed *Hōkūle'a* over 200 miles to the west-southwest of there (fig. 65).

It is not clear from the notes and tape recordings made during the voyage, or from Nainoa's recollections after the voyage, exactly why he reckoned that the canoe was being pushed by wind and current toward the southwest when her track seems in fact to have curved toward the east. A simple mental slip of not including in his dead reckoning the tack eastward on the morning of the 24th would account for only part of the difference, as before then Nainoa's position estimates and the satellite fixes had already begun to diverge, perhaps because he did not anticipate the effect of the eastward-flowing Equatorial Countercurrent.

The speed of the Equatorial Countercurrent, which is typically encountered in the doldrum belt between about 4° and 9° North, varies seasonally, generally being weakest in May–June and strongest (approaching 1 knot, on the average) in September–November. Nor is its speed uniform across the width of the flow; faster and slower bands can occur in an unpredictable pattern.

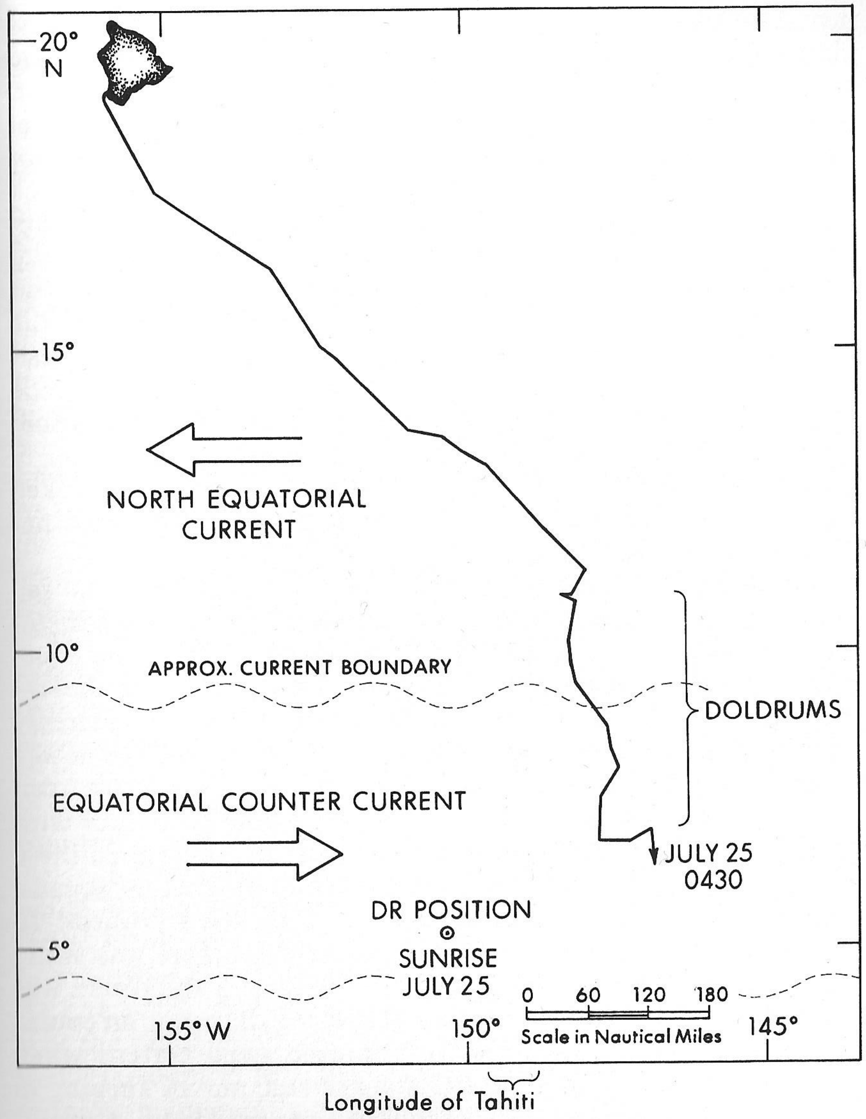


Figure 65. Through the doldrums and into the southeast trades, 25 July 1985.

In 1976 and again in 1980 *Hōkūle'a*'s track bulged markedly to the east when crossing the doldrums, indicating the effect of the Countercurrent. In contrast, the 1985 track shows no such marked deviation eastward while transiting the doldrums, which is not surprising since the doldrums were encountered above the usual northern limit of the Countercurrent. Only during the last day and a half of doldrum conditions, after *Hōkūle'a* had crossed 9° North, did the canoe's course turn slightly to the southeast, which may indicate that she was then in an outlying band of the Countercurrent, though probably not the main stream, for toward the end of the doldrums the canoe's course turned back toward the southwest. When, on the first day out of the doldrums (23 July), the canoe's course began curving back toward the southeast, *Hōkūle'a* may have actually entered the main body of the eastward-flowing current, particularly since at the time Nainoa was sure that the canoe was heading southwest. Then, the sharp turn of the course eastward when the canoe was drifting with sails down in the early hours of the 24th would seem to indicate that *Hōkūle'a* was then in the grip of a strongly flowing Countercurrent band. If so, when the canoe was tacked east just after sunset, this current would have accelerated her progress eastward.

Whatever the exact cause of the sudden widening of the gap between the estimated and actual course of the canoe—a memory lapse about tacking east, the unperceived effects of the Equatorial Countercurrent, or more probably a combination of these—the toll on Nainoa's mental concentration of the unexpectedly adverse weather conditions experienced so far must have been a contributing factor. Particularly after the wildly shifting conditions of the first few days and the unwelcome encounter with a tropical disturbance right before entering the doldrums, these northerly displaced doldrums and their debilitating calms, squalls, and overcast skies were particularly hard on the navigator. To be constantly working to catch whatever wind there was while making sure sudden squalls did not overwhelm the canoe was tiring enough. But the added tasks of keeping the canoe on course by reading vague clues from the confused swell pattern when leaden skies denied any view of stars or sun, and of keeping in mind all the twists and turns of the track in order to have a mental picture of where the canoe was at all times, had utterly exhausted Nainoa.

On the 23rd, once the canoe finally cleared the doldrums and was back in trade winds, Nainoa voiced his concerns about the problems he was having keeping his mind on the situation:

> The thing that has been so hard about these days is that I can't go to sleep because if I go to sleep we'll have no idea of where we're going. That's what is so tough about this kind of adverse weather . . . you can't rest. It is showing that when I am fatigued my thinking is not clear. I know I'm making mental errors. I'm in the position where I need rest to keep my head clear, but I can't because of the situation.

The westward deviation of Nainoa's dead reckoning estimates from the canoe's actual course greatly increased when Nainoa apparently overestimated the westward set of the South Equatorial Current as the canoe was sailing southward toward and then across the equator. At that time, Nainoa reckoned that the canoe's track was being displaced just slightly to the west of south by the westward-flowing current that typically accompanies the southeast trade winds. The satellite track shows, however, that the canoe was sailing virtually due south, with only some minor deviations first to one side and then to the other. As a result, at dawn on 1 August when the satellite fix showed the canoe to be at 3° 22′ South and 146° 59′ West, Nainoa's reckoning placed her almost 300 miles to the west-southwest of where she actually was (fig. 66).

The tape-recorded interviews made during this period indicate that Nainoa was extremely worried about the possibility that ever since they had entered the doldrums the current had been setting strongly toward the west, each day skewing the canoe's course farther in that direction. For example, after exiting the doldrums Nainoa speculated that there may have been no countercurrent at all in the doldrums and that instead "all the days we sat there we were getting shoved to the west." Then, while sailing southward after the doldrums, he frequently referred in his interviews to the danger that a continued current flow westward might push them farther and farther to the west. At one point, Nainoa and interviewer Tai Crouch even joked that the canoe might end up being driven so far to the west as to make landfall on Maupiti, a small high island that is the westernmost permanently inhabited island in the Society chain.

Part of Nainoa's concern about a strong current set to the west may have stemmed from the unsettling experience on the 1980 voyage, recounted in chapter 3, when a swift but unperceived current jet pushed the canoe 90 miles to the west. Although after the 1985 voyage Nainoa did not recall having been especially worried about being again driven westward by another such unperceived current jet, in his interview on 27 July with Tai Crouch he mentions that the canoe was then nearing

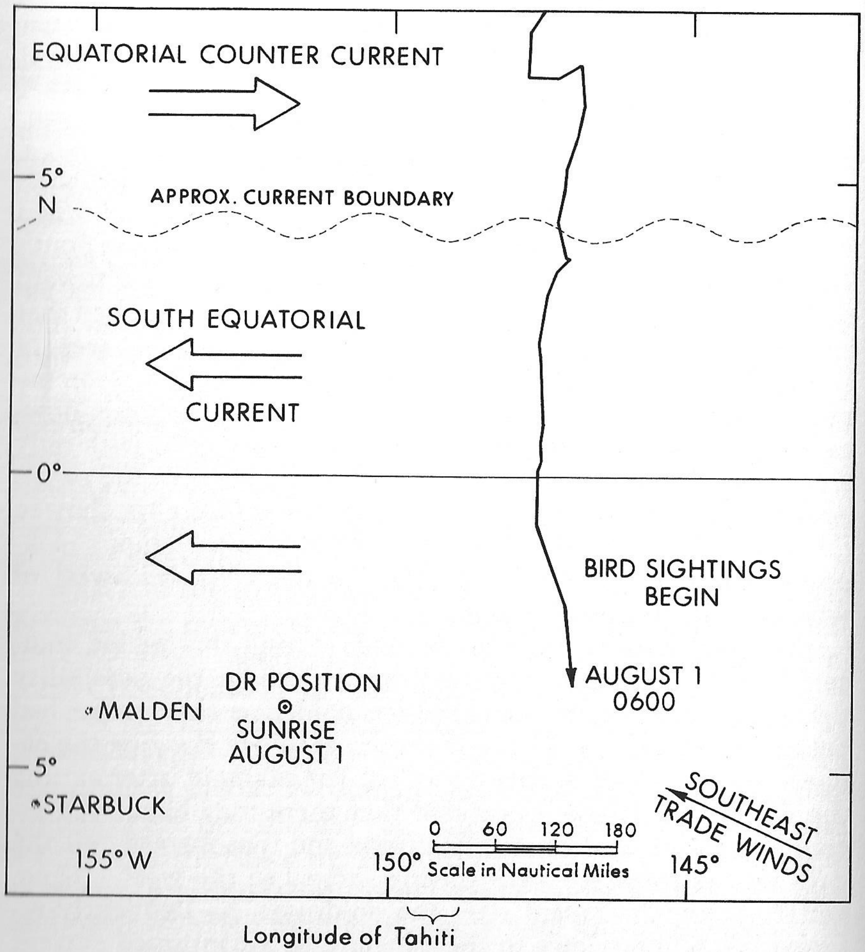


Figure 66. Across the equator and into the Southern Hemisphere, 1 August 1985.

the latitude of 3° North where *Hōkūle'a* encountered the current jet in 1980 and speculates that they might again be set west by such a current.

Whatever contributed to this overestimate of westward current set, it is important to note that Nainoa had no way to check his estimates of how far the canoe was being pushed to the west by reference to the stars. Unlike estimates of movement north or south which can continually be checked and revised with observations of Polaris or other stars that yield a measure of latitude from their elevation above the horizon, there is no way for Nainoa to determine movement east or west through sighting on the stars, for to do so would require a chronometer in order to calculate longitude. Because Nainoa has no means to check and revise his estimates of movement along the east-west axis, there is always the danger that misestimates can accumulate in one direction, skewing his dead reckoning farther and farther to the east or west. Although in 1980 the failure to perceive the strong current set to the west when the canoe was just north of the equator was later offset by an overestimation of the westward set of the current south of the equator, on this voyage Nainoa's misestimates of current set were mostly additive, leading to a progressively greater divergence westward of his dead reckoning relative to the actual track.

Further complicating the situation after the canoe crossed the equator were numerous sightings of land-finding birds: primarily what appeared to be white fairy terns, called *manu-o-Kū* in Hawaiian (literally "bird-of-*Kū*," one of the major Hawaiian gods), plus some grayish terns that looked like the Hawaiian noddy tern (*noio*) and a few booby birds and frigate birds. Seeing a few stray booby birds was no cause for alarm, for as had been shown by a similar sighting far from land in 1976, juvenile boobies without nesting responsibilities often wander widely over the ocean. But starting at about 2° South, the almost daily sightings of snow-white fairy terns flying singly and in small flocks could not be so easily discounted, for these birds have a reputation of seldom straying in any number more than 50 miles or so from land.

When the birds were first spotted at the end of July, Nainoa reckoned that they might possibly be coming from Malden and Starbuck, isolated coral outposts in the Southern Line Islands located far to the west of the intended course to Tahiti. But although the bird sightings tended to reinforce his belief that the canoe had been set far to the west by the South Equatorial Current, the more Nainoa thought about it, the less sure he was, for he reckoned that these islands were still 200 miles to the west of where he thought the canoe was, too far away to be the source of the birds. (At the time the islands were actually about 500 miles west of the canoe's position; fig. 66.)

This perplexing situation led Nainoa to speculate that either the current had set the canoe much farther to the west than he had assumed, or that he was mistaken in his identification of the birds as fairy terns, or, alternatively, that the fairy terns in this part of the Pacific have a greater range than those he was familiar with in Hawaiian and Tahitian waters. Close-up sightings of these birds in the following days confirmed that indeed they were fairy terns, but the question of whether or not sighting these birds meant that the canoe had been pushed as far west as the Southern Line Islands was not to be satisfactorily resolved until the end of the voyage.

On 2 August, the canoe sailed into a zone of convergence with doldrum-like cloudy skies, squalls, calms, and variable winds that lasted for four days, leading the crew to call it the "second doldrums." Passage through this disturbance further exhausted Nainoa, making it even more difficult for him to deal with the issue of whether or not they were sailing as far west as the Southern Line Islands. Although Nainoa tended to assume the worst-case scenario that the bird sightings confirmed that they were passing close by the Southern Line Islands, he continued to suspect that the sightings might be false clues of the close proximity of land. For example, during the evening interview on 5 August, Nainoa speculated that his reckoning might be so far off that instead of sailing in the longitude of the Southern Line Islands, the canoe could actually be sailing directly toward the Tuamotus. The next morning, when his reckoning told him that the canoe should be passing between Caroline and Vostok islands, Nainoa said that if no birds were seen they might indeed be sailing north of the Tuamotus instead of farther to the west.

But many terns were seen throughout the next day, apparently confirming that they actually were near Caroline and Vostok. Yet, because the birds followed a pattern of flying out from the west, and then returning to the west, Nainoa concluded they had not passed between Caroline and Vostok islands as anticipated, but had passed to the east of the islands. The birds, he reasoned, must have been flying out to fish in seas to the east of Caroline Island (the easternmost of the two islands), and then returning westward to that island to feed their chicks and nest there for the night. Accordingly, Nainoa revised his reckoning to bring the estimated position of the canoe to the east of Caroline (fig. 67).

But the next day, 8 August, Nainoa started shifting his as-

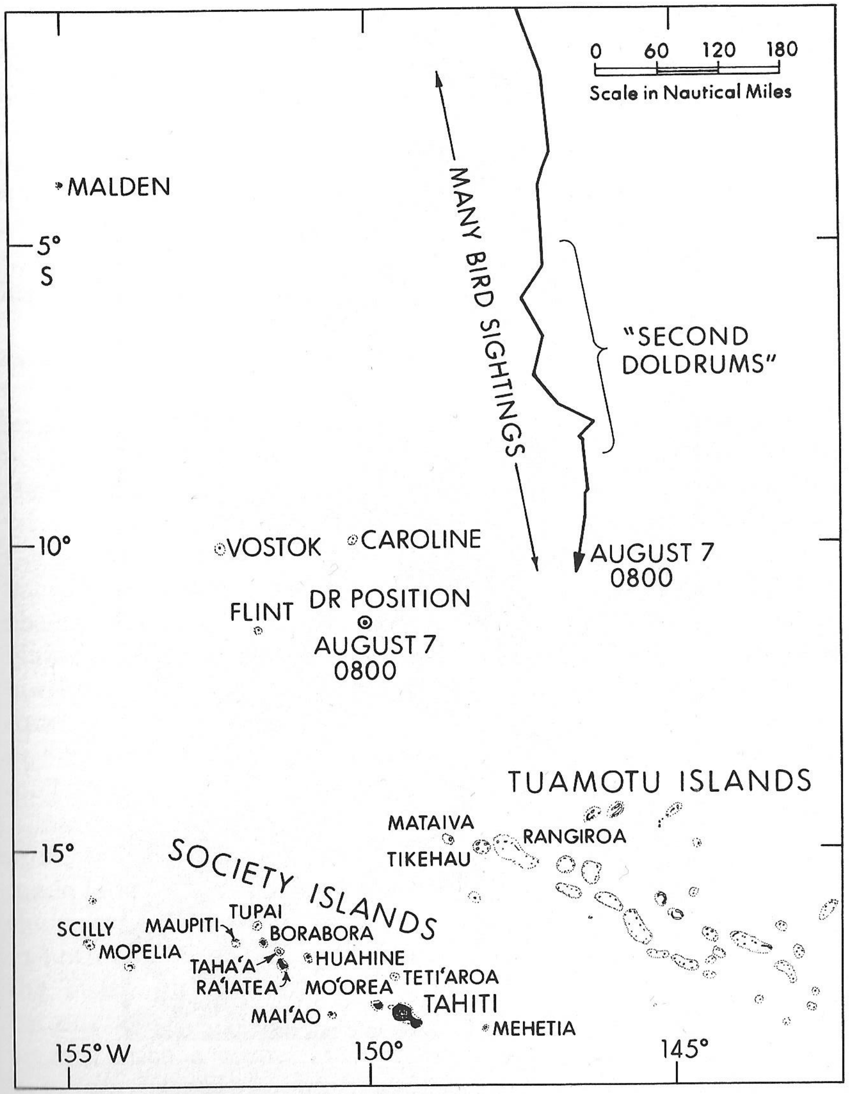
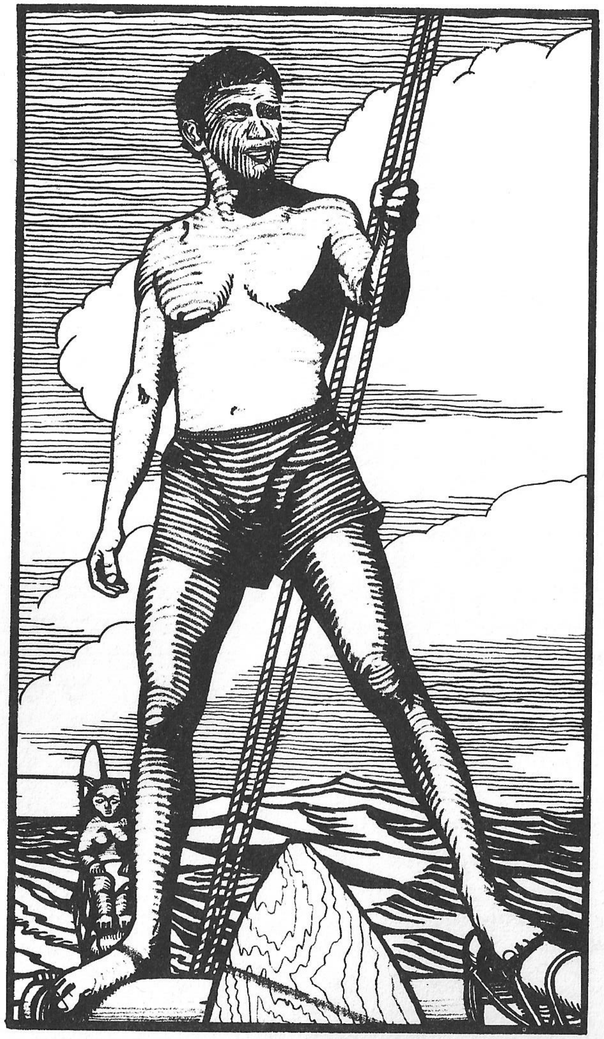


Figure 67. Passing to the east of Vostok and Caroline islands, 7 August 1985.

sumed position back toward the west, for according to his latitude estimates based on star sights the previous nights the canoe should have then been approaching the latitude of the northernmost of the Tuamotu Islands. Since he saw no signs of land—either from birds flying out to sea from islands to the south-



east, floating debris, or the blockage of the southeast trade wind swells—that indicated they were nearing this extensive archipelago, Nainoa reverted to his earlier assumption of the extreme westward set of the canoe, and once again began worrying about being driven so far west as to be lucky to make land at Maupiti at the far western end of the Societies.

That evening of 8 August the wind shifted to almost due east, allowing the canoe's track to trend to the east of south, giving Nainoa hope that they might make a landfall on Borabora or Taha'a, the two high islands immediately to the east of Maupiti. The following day, the 9th, flocks of birds and a change in the swell pattern, plus a glimpse of a passing aircraft, led to the expectation that land was very near. As night fell and fairy terns repeatedly flew directly over the canoe, Nainoa and the crew anxiously searched for land but could see nothing. Rather than keep sailing southward and risk running aground on the barrier reef of whatever island was out there, the sails were lowered to the deck and the canoe drifted while everyone continued looking for land in the darkness.

Finally, a few hours before dawn, in the dim moonlight, sharp-eyed Thomas Reity, Mau's nephew, spotted the tops of coconut palms poking above the horizon. *Hōkūle'a* had made landfall on an atoll. But which atoll was it: one of those scattered along the northern edge of the Societies, or one in western Tuamotus? Here Nainoa's estimate of the canoe's latitude was crucial. Mataiva, Tikehau, and Rangiroa at the western end of the Tuamotus all lie at about 15° South, whereas the atoll outliers of the Societies are just a little north of 16° South. So, when his star observations indicated that the canoe was at about 16° South, Nainoa ruled out the Tuamotu atolls in favor of those along the northern edge of the Societies. Since Nainoa did not think the canoe had been driven as far west as the atolls of Bellingshausen or Scilly at the far western end of the Societies, his choice fell on Tupai, a small atoll just to the north of Borabora.

As the canoe started sailing westward along the coast of the atoll, it became apparent, however, that they could not have made landfall on tiny Tupai, which is only about 4 miles long, for the morning light revealed the vista of coconut palms stretching in both directions as far as the eye could see. They had reached the Tuamotus after all, Nainoa concluded, because neither Tupai nor any of the other Society Island atolls is large enough to present such a scene. He even correctly surmised that it was Rangiroa, because of the great length, 44 miles, of this largest of Tuamotus atolls (fig. 68).

It took much of the day to sail westward along the coast of Rangiroa, round its western cape, and then pass through the channel between it and the atoll of Tikehau just to the west. At a little after noon on the next day, Sunday 12 August, after an uneventful passage to Tahiti made reaching across the trades, *Hōkūle'a* sailed into the lagoon and landed at Ta'aone beach a few miles to the northeast of Pape'ete harbor to complete the voyage thirty-two days after leaving Miloli'i.

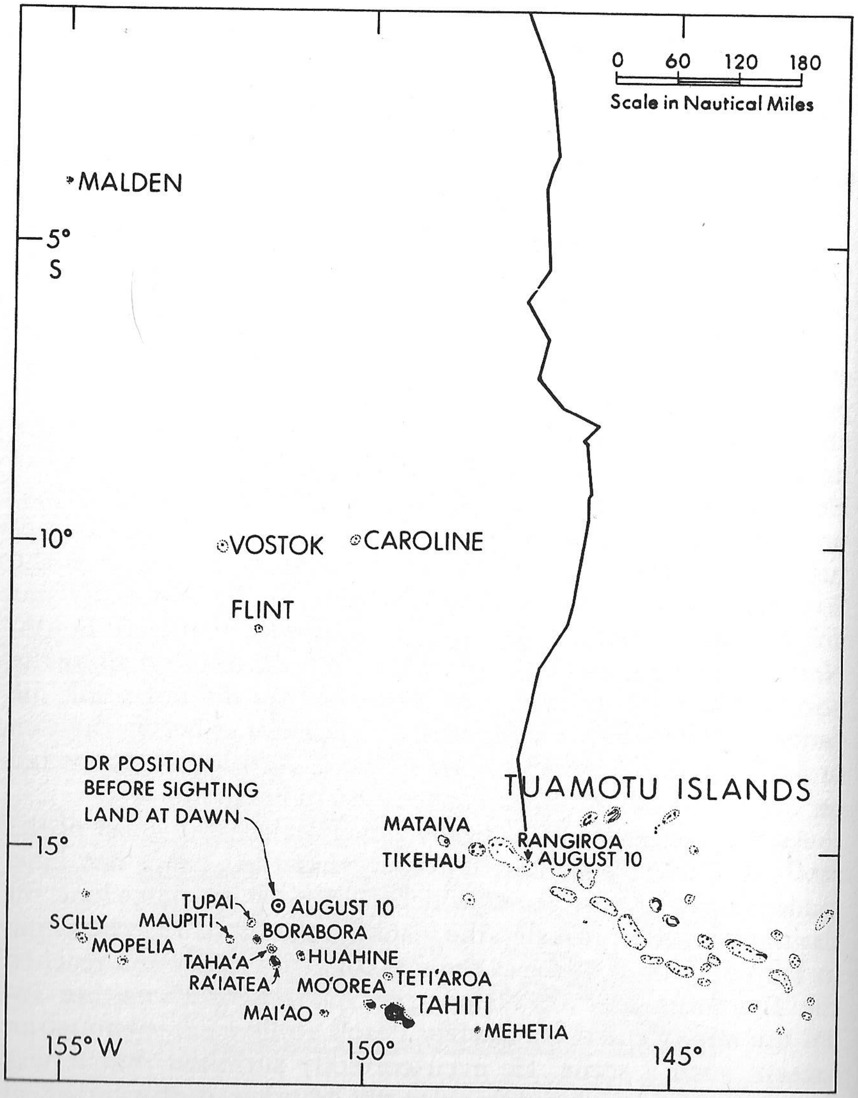


Figure 68. Landfall on Rangiroa atoll, 10 August 1985.

A Voyage of Surprises

Compared to the first two trips to Tahiti, this third crossing had been full of surprises: the displacement of the doldrums several degrees north of where they had been located the previous two voyages, the equally unexpected encounters with a

small depression immediately north of the doldrums, and then, south of the equator, the spell of doldrum-like conditions and the repeated sightings of fairy terns and other land-nesting birds when the canoe was really hundreds of miles from land. These unanticipated conditions made the voyage more difficult, especially for Nainoa who overestimated both how far the canoe had been set west by the current and its progress southward. The latter was not simply a matter of overestimating the speed of the canoe: all but the first three of Nainoa's latitude estimates based on star observations were too far to the south by an average of slightly over 50 miles. Whatever the exact cause of these overestimates—fatigue from the weather conditions, lack of practice (it had been five years since the last time Nainoa had undertaken to navigate over such a long route) or a combination of these and perhaps other factors—during the last two-thirds of the voyage they combined to skew Nainoa's dead reckoning positions to the west-southwest of the canoe's actual course (fig. 69).

Nonetheless, despite these difficult conditions and navigational problems they caused or at least made worse, *Hōkūle'a* made its landfall on Rangiroa in the northwest Tuamotus close to the 1976 and 1980 landfalls (about 70 miles east of the 1976 landfall on Mataiva, and some 55 miles east of the 1980 landfall on Tikehau), and from there sailed without difficulty to Tahiti just as had been done in 1976 and 1980. Although the eastward curve of the track of the 1985 voyage is more irregular than those of the two previous voyages, figure 70 shows how on all three voyages the canoe followed more or less the same curving route to Tahiti through the three wind and current zones. Clearly, even given the far from ideal conditions encountered in 1985, the voyage between Hawai'i and Tahiti is well within the capabilities of a double canoe such as *Hōkūle'a*.

In terms of noninstrument navigation, landfall on Tahiti would also appear to be repeatedly attainable—primarily because Tahiti is not a lone island lost in the vastness of the open ocean, but is one of many islands that form an arc extending eastward from Bellingshausen atoll at the western end of the Societies for over a thousand miles to the atolls on the eastern fringe of the Tuamotus. It would be difficult, though not at all impossible, for a competently crewed canoe approaching from Hawai'i to slip through this long arc without anyone aboard spotting an island. Once any island along the arc was sighted, then identi-

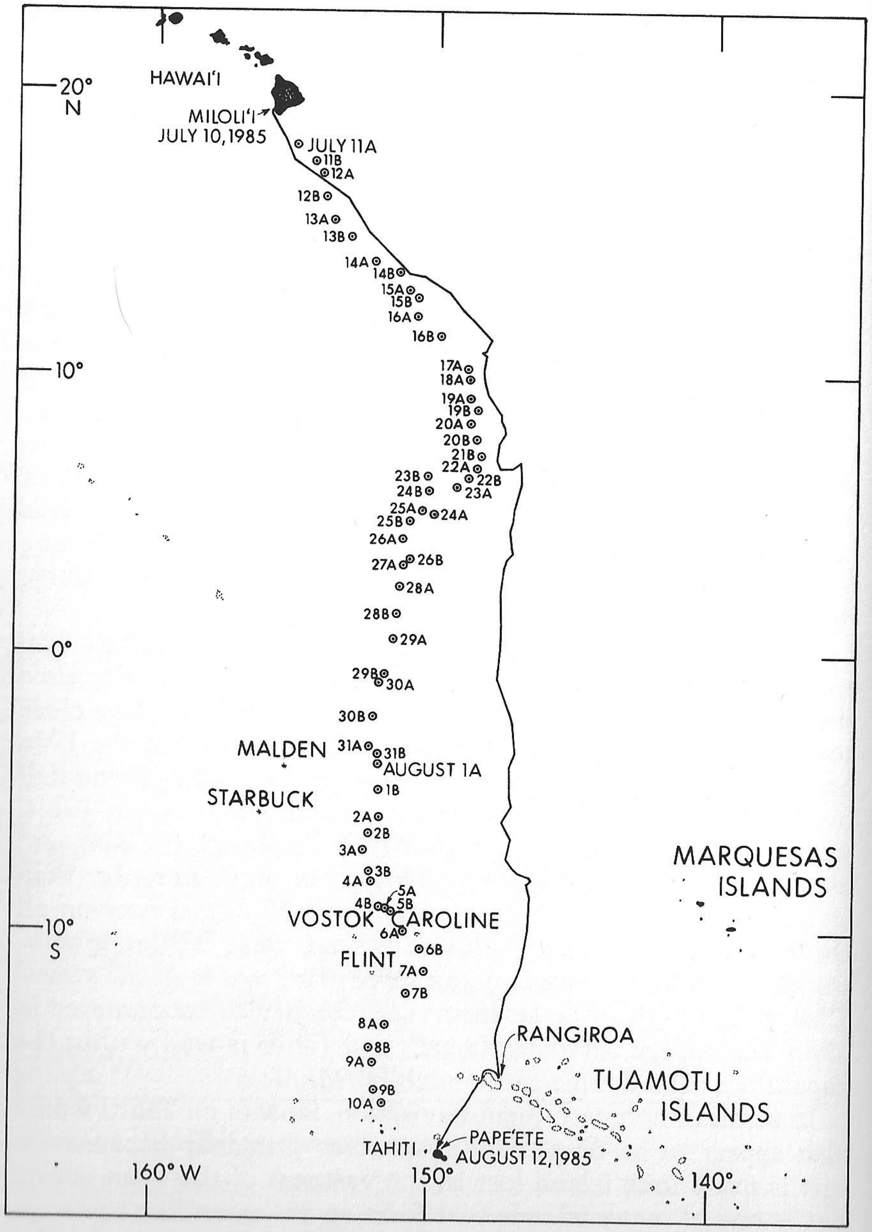


Figure 69. 1985 voyage of Hōkūle'a *from Hawai'i to Tahiti showing actual track of the canoe and Nainoa Thompson's dead reckoning (D.R.) positions estimated at sunrise (marked by "A" following the date) and sunset (marked by "B" following the date).*

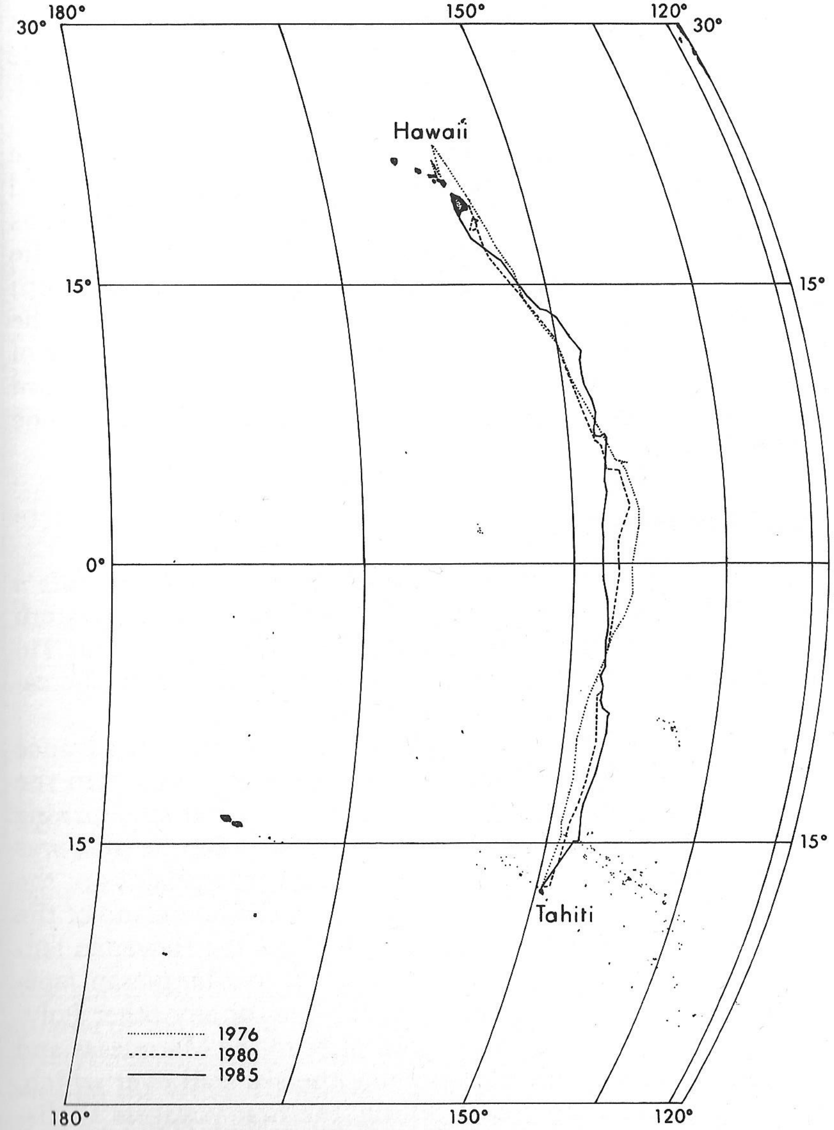


Figure 70. 1976, 1980, and 1985 voyages of Hōkūle'a *from Hawai'i to Tahiti.*

fied, a navigator acquainted with the Societies and Tuamotus would then know the direction and bearing to Tahiti and, given the right wind conditions, could sail there. Thus a landfall anywhere along the Society or Tuamotu chains should enable a canoe to reach Tahiti.

Had Nainoa's worst-case scenario come true with landfall at the western end of the Societies, *Hōkūle'a* could still have made it from there to Tahiti, either by laboriously tacking to windward or waiting for more favorable northerly or westerly winds. But there turned out to be no need to resort to either of these tactics. Nainoa may have reckoned that the canoe had missed the Tuamotus and been driven to the west of Tahiti, but just as occurred on the last two voyages *Hōkūle'a* had arrived off the western Tuamotus, the ideal location along the Society-Tuamotu island arc to make landfall on the way to Tahiti. Although the dead reckoning may have been somewhat off on this first leg of the voyage, steadfast application of the strategy of sailing hard against the trades succeeded once again in bringing the canoe safely to Tahiti.

Tahiti to Hawai'i: 1987

After sailing from Samoa to Tahiti in mid-1986, *Hōkūle'a* was hauled onto dry land at the village of Tautira at the eastern end of the island. There, under the able direction of Mayor Tutaha Salmon, our Tahitian friends erected a shelter over the canoe, while the crew returned to Hawai'i.

Early in the Northern Hemisphere spring of 1987 an advance party flew down from Hawai'i to put the canoe back into the water and ready her for the voyage north. Instead of returning directly to Hawai'i, as was done in 1976 and 1980, the plan was to sail home via the Marquesas. That rugged archipelago, not the Society Islands, is the leading candidate for the homeland of the original settlers of Hawai'i—primarily because the Hawaiian language appears to be more closely related to Marquesan (specifically Southern Marquesan) than Tahitian or any other Polynesian language. The plan was to sail first to the Marquesas and from there head for Hawai'i following the sea trail over which, if the language relationship is telling, the first voyagers to discover Hawai'i may have set sail some 1,500 to 2,000 years ago.

Because the Marquesas lie far to the east, to windward, of the meridian of Hawai'i, we were anticipating a swift passage home from there sailing on a broad reach. Sailing the 700 miles from Tahiti northeast to the Marquesas posed a problem, however (fig. 71). To sail there on one tack would require winds almost directly out of the southeast, yet in this region the trades most commonly come from somewhere between east and east-

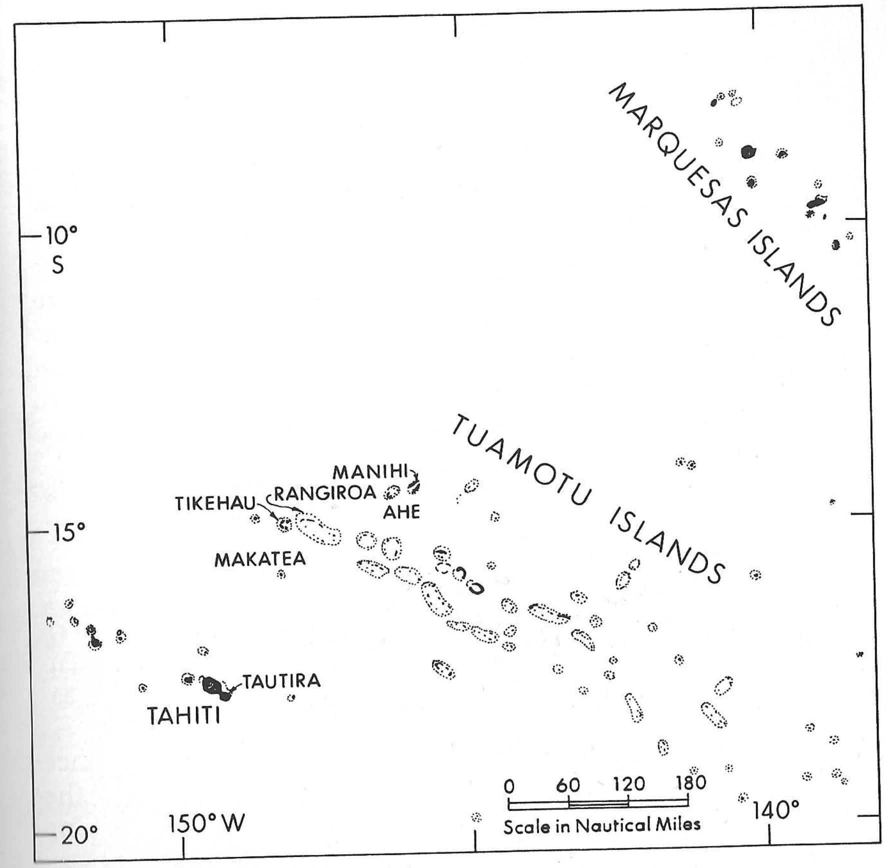
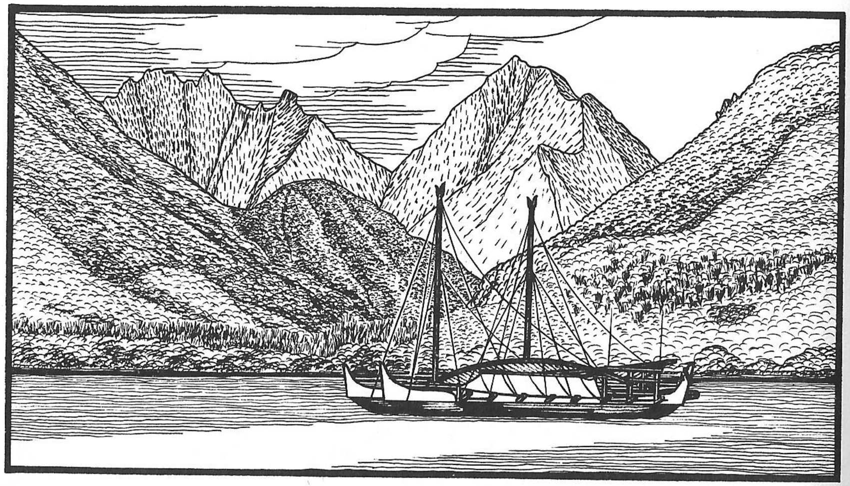


Figure 71. Tahiti, the Tuamotus, and the Marquesas.

southeast. Furthermore, a direct route would take a canoe into an area of the Tuamotus where the islands are especially closely spaced, leaving little room to maneuver, particularly if sailing hard on the wind. To wait at Tahiti for a spell of westerly winds in order to get a boost directly to the east was a possibility but one fraught with danger, for that would mean heading straight into the Tuamotus with boisterous winds pushing the canoe, and a high probability of overcast skies and poor visibility along the horizon. That would be a sure recipe for disaster when approaching any atoll chain, but particularly so for the Tuamotus, which the eighteenth-century navigator Bougainville had so aptly named the "Dangerous Archipelago" because of its many reefs and the swiftly flowing currents between them.



Rather than tempt fate, Nainoa decided on a more prudent strategy. First, he would wait on Tahiti for fair, trade wind conditions and then sail directly to the Rangiroa located 170 miles to the north-northeast at the western end of the Tuamotu chain. Once there, he would wait for a spell of steady trades with a strong southerly component in order to be able to sail to the northeast and try to make it to the Marquesas on one long tack.

Normally, it would have been advisable to wait at least until late May or early June to attempt this sail, for by then the unsettled weather of the Austral summer usually gives way to a pattern of trade wind dominance. But *Hōkūle'a* was scheduled to be back in Hawai'i by 23 May for a welcoming ceremony planned as major part of the statewide "Year of the Hawaiian" celebration. This made it necessary to leave by late March at the latest in order to have enough time to make it to Rangiroa, wait there for the right winds to reach the Marquesas, and then sail from there to Hawai'i. Such an early departure meant that *Hōkūle'a* would be sailing before the trade wind pattern of the Austral winter months might be fully established.

Tautira to Rangiroa

On previous legs of the Voyage of Rediscovery Nainoa and the crew had been experimenting with larger sails than had been used on earlier voyages. Although the regular sails were well

adapted for sailing in strong winds, the new, larger sails were designed to make the canoe sail faster in light winds, a particular advantage for going to windward when forward speed is all important. On this final leg home, these experiments were taken a step further by putting an extra-large sail on the after mast, increasing sail area and changing the balance of the rig in that the after sail was then larger than the forward sail. To accommodate this rigging change, Wally Froiseth, an expert craftsman and long-time *Hōkūle'a* sailor, scarfed onto the after mast and boom the extensions needed in order to carry the big sail. In addition, the step for the after mast was moved forward almost six feet to the next *'iako*, as Hawaiians call the cross beams linking the hulls, to balance the forces acting on the sails and the hull so that the canoe could be more easily steered, as well as to make it easier to sheet in the larger sail.[3]

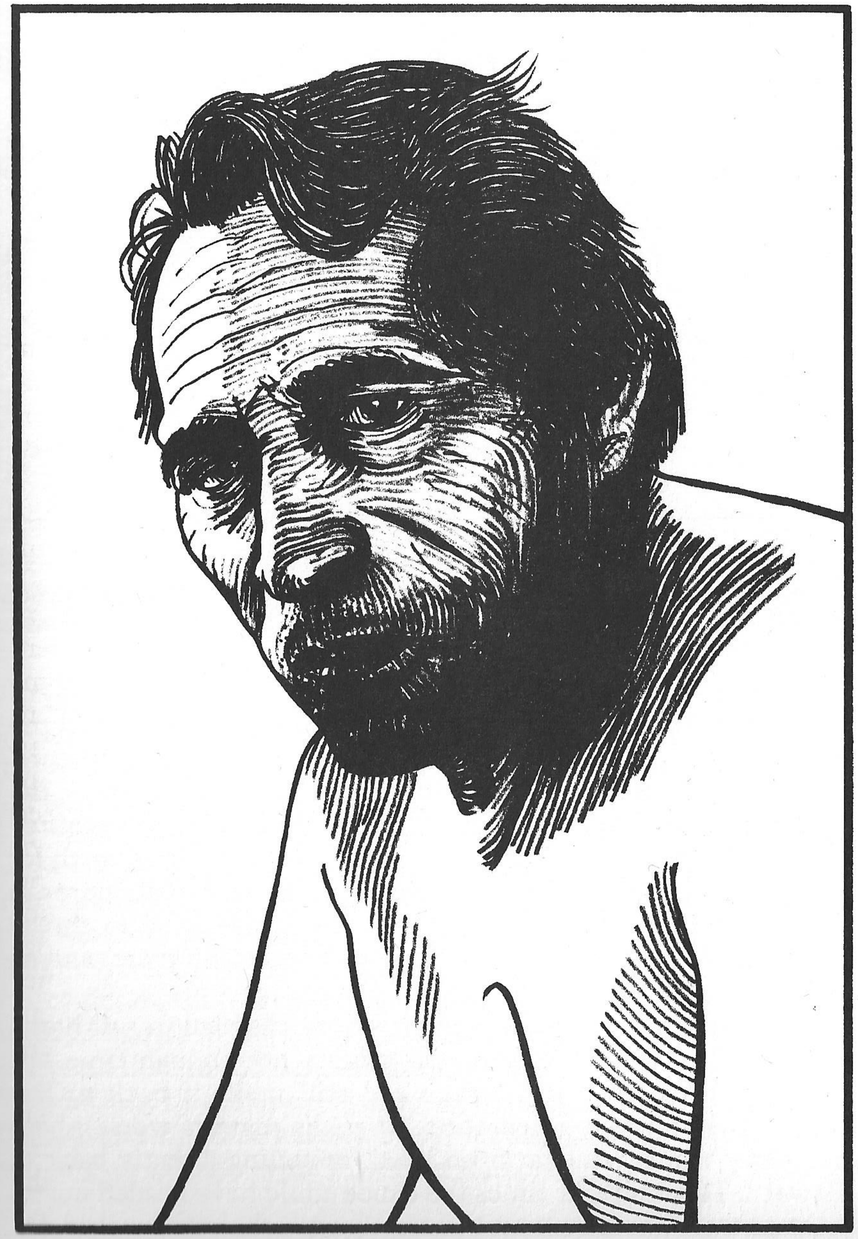
The canoe was ready to sail in late March, but first a ceremonial visit to Pape'ete was in order to inaugurate a striking stone structure, loosely modeled on an ancient *marae* and dedicated to *Hōkūle'a*, that the City had erected at the beach where the canoe had first landed in 1976. On 29 March, after the ceremonies, *Hōkūle'a* returned to Tautira to wait for a spell of steady trade winds to make the 170-mile trip to Rangiroa. But light, variable winds and overcast skies kept the canoe from leaving until the morning of 2 April, when a breeze from east-southeast started blowing. Unfortunately, after sailing three hours northward, the wind started coming out of the north-northeast, forcing the canoe onto a course west of north. Then it became light and variable, and rain squalls swept over the canoe. By evening the canoe had been forced back to a point about 10 miles northeast of Tautira, where she was hove to for the night.

An easterly wind started blowing before dawn, and at midmorning the canoe got underway again. Three-quarters of the way to Rangiroa was the upraised coral island of Makatea, which, if it could be spotted during the night, would give an exact fix for a landfall on Rangiroa for the following morning. Although there was some concern that the canoe might be set to the west of the island by the current, several hours before dawn the dark outline of Makatea appeared to port, giving the needed navigational fix. Late that morning land-nesting birds were sighted. Then, a half hour later a line of surf, then the sight of coconut palms, announced the presence of land ahead. Nainoa correctly assumed that they had made landfall on Rangiroa and so turned the canoe westward to sail along its southern shore and then north through the channel between Rangiroa and the neighboring atoll of Tikehau. The canoe then entered Avatoru, the main pass at the northwest end of Rangiroa, and anchored in the atoll's huge lagoon.[4]

Waiting for the Trades

Once anchored at Rangiroa, those who had joined the crew just for the Tautira-Rangiroa leg flew back to Tahiti, and from there on to Hawai'i, while new crew members flew in to replace them. For the return to Hawai'i, Shorty Bertelmann and Nainoa Thompson were serving as captain and navigator, respectively. Six other experienced *Hōkūle'a* sailors anchored the crew: Tava Taupu, originally from the Marquesas but long resident on the island of Hawai'i; Chad Baybayan and Snake Ah Hee from Maui; Bruce Blankenfeld and Mike Tongg from O'ahu; and from Kaua'i, Dr. Pat Aiu, who was again serving as the canoe's doctor. Five additional crewmen represented the main island groups where the canoe had stopped along the way: Puaniho Tauotaha, a champion racing canoe paddler from Tautira, Tahiti; Tua Pittman, the Cook Islander who had made the crossing from Samoa to Aitutaki; Stanley Conrad, the Māori youth who had sailed from Rarotonga to his native Aotearoa; Sione Taupeamuhu, the skilled Tongan sailor who had piloted the canoe through the reef-strewn Ha'apai Archipelago; and Eni Hunkin, a Samoan high chief, who was also the Lieutenant-Governor of American Samoa. Rounding out this diverse crew were: University of Hawai'i oceanographer Dixon Stroup, a longtime board member of the Polynesian Voyaging Society, and reporter Elisa Yadao and cameraman Cliff Watson of Honolulu's television station KGMB, who were making a documentary of the voyage.

To sail to the Marquesas, a steady wind from the southeast, or south-southeast, would have been ideal. That would have enabled the canoe to sail northeast, safely clear Ahe and Manihi atolls that lie just to the east-northeast of Rangiroa, and then head directly for the Marquesas some 500 miles farther to the northeast. Unfortunately, however, the wind started coming out of the northeast, and over the next two and a half weeks varied between northeast and northwest. These unwelcome northerly winds, often accompanied by overcast skies and spells of rain,



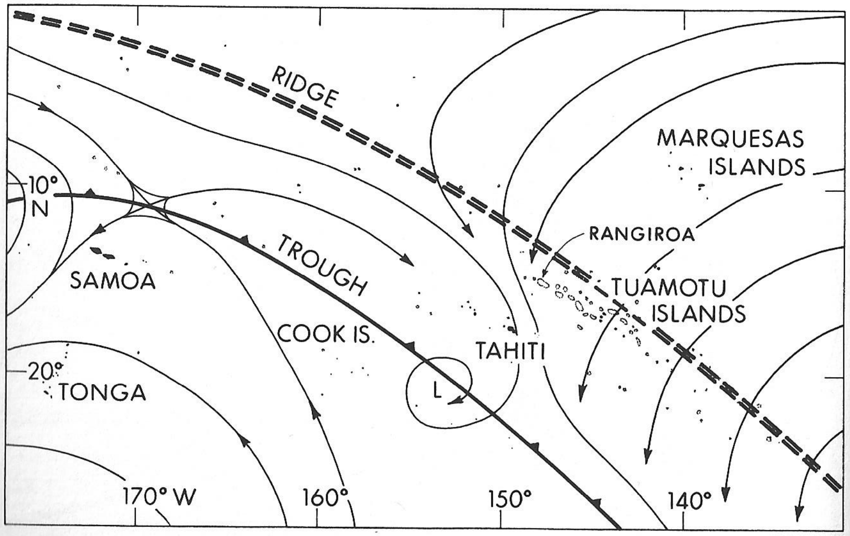


Figure 72. Surface wind analysis 7:00 P.M. (local time), 16 April 1987, showing El Niño trough bringing westerly winds to Tahiti and northerly wind to the Tuamotus.

blocked *Hōkūle'a* from leaving Rangiroa, for they were from the worst possible quarter for sailing to the Marquesas. To be sure, they might have allowed the canoe to sail eastward to reach the longitude of the Marquesas (from where, if the wind then shifted back to the trade wind direction, the canoe could head north for that archipelago). But the sea directly to the east of Rangiroa is filled with atolls. Although Nainoa could have tried to thread the canoe past these, he judged the risk to be too great, and so *Hōkūle'a* remained tied up in the Rangiroa lagoon.

This long delay forced abandonment of the plan to sail home via the Marquesas, for there was simply not enough time left to try to reach that archipelago and still make it back to Hawai'i for the 23 May celebration. To make matters worse, these northerly winds were far from ideal for sailing directly back to Hawai'i. To be sure, at times the canoe could have headed northwest or west-northwest on the starboard tack, but it would not have taken too many days of sailing on such a course to have put the canoe to the west of the meridian of Hawai'i—when the navigational strategy called for an approach from the eastern, windward side of the islands.

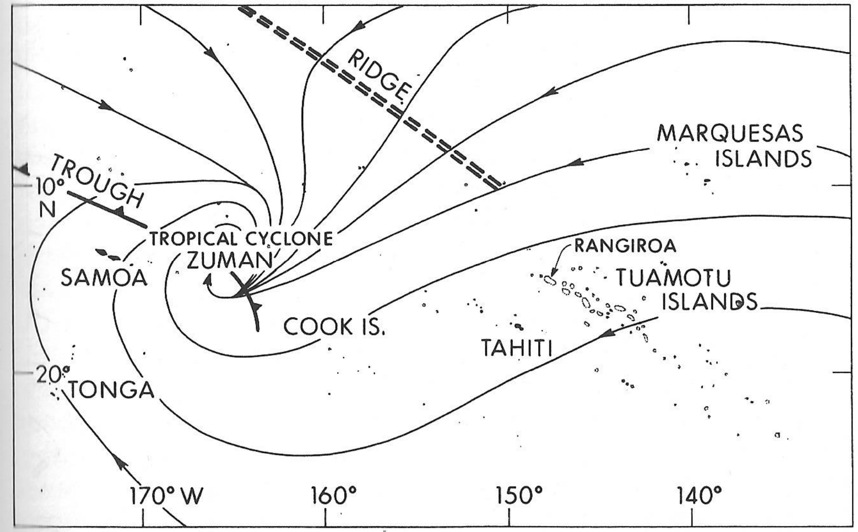


Figure 73. Surface wind analysis 7:00 P.M. (local time), 23 April 1987, showing tropical cyclone Zuman disrupting El Niño trough, bringing easterly winds to the Tuamotus.

These anomalous northerlies were apparently part of a widespread El Niño disruption of atmospheric and ocean circulation that had been developing over the South Pacific during the Austral summer of that year and was extending into the early fall.[5] The monsoon trough of the southwestern Pacific had shifted eastward, bringing the northerlies that were keeping *Hōkūle'a* from sailing (fig. 72). A break in these winds did not come until after almost three weeks of frustrating waiting in the lagoon of Rangiroa. Such a monsoon trough is a spawning ground for tropical cyclones,[6] and at this time a tropical cyclone formed to the north of Samoa in the El Niño–extended trough and began to affect wind flow to the east. As the surface wind analysis in figure 73 indicates, by the evening of 23 April, this cyclone, christened Zuman and by then located at 16° South and 168° West, was bringing an easterly wind flow over Rangiroa.

The Southeast Trade Wind Zone

The next afternoon, on 24 April, twenty days after arriving at Rangiroa, *Hōkūle'a* finally cleared the pass and headed for the equator 900 miles away. The desired heading was not due north, but somewhat east of north so that by the time the canoe entered the northeast trade wind zone she would be well east of the meridian of Hawai'i. Fair skies marked by only a few cumulus clouds and a 15-knot breeze blowing out of the east-southeast which enabled the canoe to make good a course toward the north-northeast led everyone to hope that the unwelcome conditions that had kept the canoe at Rangiroa were over at last and that they would have a swift crossing to Hawai'i.

Hopes for uninterrupted trade wind sailing held up only until around midnight, when a series of intense squalls forced the sails to be triced, leaving the canoe to drift aimlessly until the trades returned a few hours after dawn. But the gusty winds that soon developed proved to be too strong for the big sail then being carried on the after mast, and a smaller, heavy weather sail had to be substituted. Even with this smaller sail, the canoe was able to make a good 6 knots in the trades, which sometimes reached 30 knots or more. Strong winds continued throughout the 25th and into the 26th when they shifted to the north of east and forced the canoe onto a heading almost due north.

At midmorning on the 26th, when the canoe was at about 10° 50′ South and 146° 35′ West, Nainoa spread into the sparkling blue sea the ashes of Dan Wright, the owner and skipper of the escort vessel *Dorcas*, who had tragically died from a sudden illness that struck him while the yacht was anchored off Mo'orea after the leg from Rarotonga to Tahiti. Having the *Dorcas*, crewed so competently by Dan and his family, shadow the canoe throughout the Voyage of Rediscovery had proved to be invaluable from the point of view of documentation and safety. At this point, however, the broad-beamed cruising yacht—now being sailed by a hired captain and crew—was having trouble keeping up with the fast-moving *Hōkūle'a*. Several times during this period of strong trades, the crew was forced to trice the sails as the *Dorcas* faded from sight astern and each time wait a couple of hours for the yacht to catch up.

At about 10:30 on the night of 27 April, after a day and a half of boisterous winds, the sails went limp, leaving *Hōkūle'a* to drift at about 9° South (540 miles from the equator) until dawn when light easterlies began blowing. These held for several hours, until the wind veered to the north, then west of north, forcing the canoe to tack to the east. At this point Nainoa, who was then correctly estimating that the canoe was less than 300 miles due west of the Marquesas, reckoned that if the wind held and they could keep heading east there might still be a chance to call on these islands. Unfortunately, the northerly winds lightened late that afternoon, then went flat at around 10:00 P.M., eliminating, to everyone's disappointment, the last possibility for making a call upon this remote archipelago that is thought to have played a vital role in the early history of Hawai'i.

At dawn on the 29th a light wind started coming out of the south, then the southeast, allowing the canoe to slowly sail in a direction slightly east of north. Although the canoe was once again on the desired course of north by east, by now Nainoa was thoroughly disillusioned with the idea that after their long wait on Rangiroa they might enjoy smooth trade wind sailing back to Hawai'i. In his tape interview that morning, Nainoa stressed how the "weird weather" of this voyage—the squalls, calms, and northerly winds—erased any notion that the ancient Polynesian voyagers could always count on steady trade winds in this part of the Pacific. The anomalous wind conditions associated with the El Niño event had not been left behind. Once Cyclone Zuman moved farther to the southeast, the easterly wind flow that had enabled the canoe to sail from Rangiroa had faded, and the "weird weather" that followed was apparently part of the widespread anomalies associated with the renewed intrusion of the monsoon trough into the East Polynesian waters.

Despite the presence of the trough, however, Nainoa and the crew were to continue to enjoy brief periods of trade wind–like conditions between squalls and spells of northerly winds. For example, during the night of 29–30 April, right after Nainoa had recorded the remarks quoted above about how strange the weather had been, the canoe was sailing in 10–15 knot winds from the east-southeast, with mild seas and clear skies—all of which led Nainoa to exclaim in his interview the following morning how this had been the first time they had been able to sail through the whole night without having to trice the sails because of squalls or stop for the lagging escort vessel. Unfortunately, this good weather continued only until the late afternoon, when the canoe had to fall off to the north-northwest to avoid a mass of towering black clouds that had suddenly loomed up on the horizon. But this weather system proved too big to avoid, and it soon engulfed the canoe, bringing humid sticky weather, gusty winds, and messy, rough seas. Then, several hours after sunset, squalls forced the crew to trice the sails once more and sit out the bad weather. At this point the canoe was about four degrees, or some 240 miles, south of the equator.

By around two that morning (1 May) the squalls had passed, and the wind started to blow steadily, but out of the east-northeast. This forced the canoe onto a course toward the north-northwest, causing Nainoa to speculate in his interview the following day that if they kept on this course they might end up being driven west of the meridian of the island of Hawai'i, a concern that was to grow as the voyage wore on.

Although the wind briefly shifted back toward the east-southeast during the daylight hours of 2 May, by which time the canoe was just a degree and a half (90 miles) south of the equator (fig. 74), that evening the wind switched back to east-northeast. For the next five days the canoe encountered light winds that came mostly out of the east-northeast and northeast, forcing her onto a course slightly to the west of north as she crossed the equator on 3 May and headed toward the zone between 4° and 9° North where the doldrums are normally found.

Contrary to expectations, the canoe reached and then crossed this zone unimpeded by any doldrums. As they sailed northward, the crew could see huge convection clouds, punctuated from time to time with lightning flashes, developing behind them along the southern horizon, but they seemed always to be able to stay ahead of the threatening build-up. Yet the lack of boisterous northeasterlies with well-developed trade wind swells made Nainoa hesitate to believe that they had escaped the doldrums so easily. But, on 6 May, by which time they had reached 7° North and had enjoyed a full day of sailing in strong winds from the northeast by east and what looked like the beginning of organized trade wind swells, Nainoa conceded that maybe they had missed the doldrums and were indeed in the northeast trade wind zone. Perhaps, he speculated in his interview that evening, there had been no doldrums because, in the absence at the time of a well-developed southeast trade wind system, the northeasterlies had simply extended southward across the belt where the doldrums are commonly found and had even penetrated into the Southern Hemisphere.

Analysis of meteorological data after the voyage indicates that it is not unprecedented for the doldrums to be absent or weak during April, but that the extension of the east-northeasterly

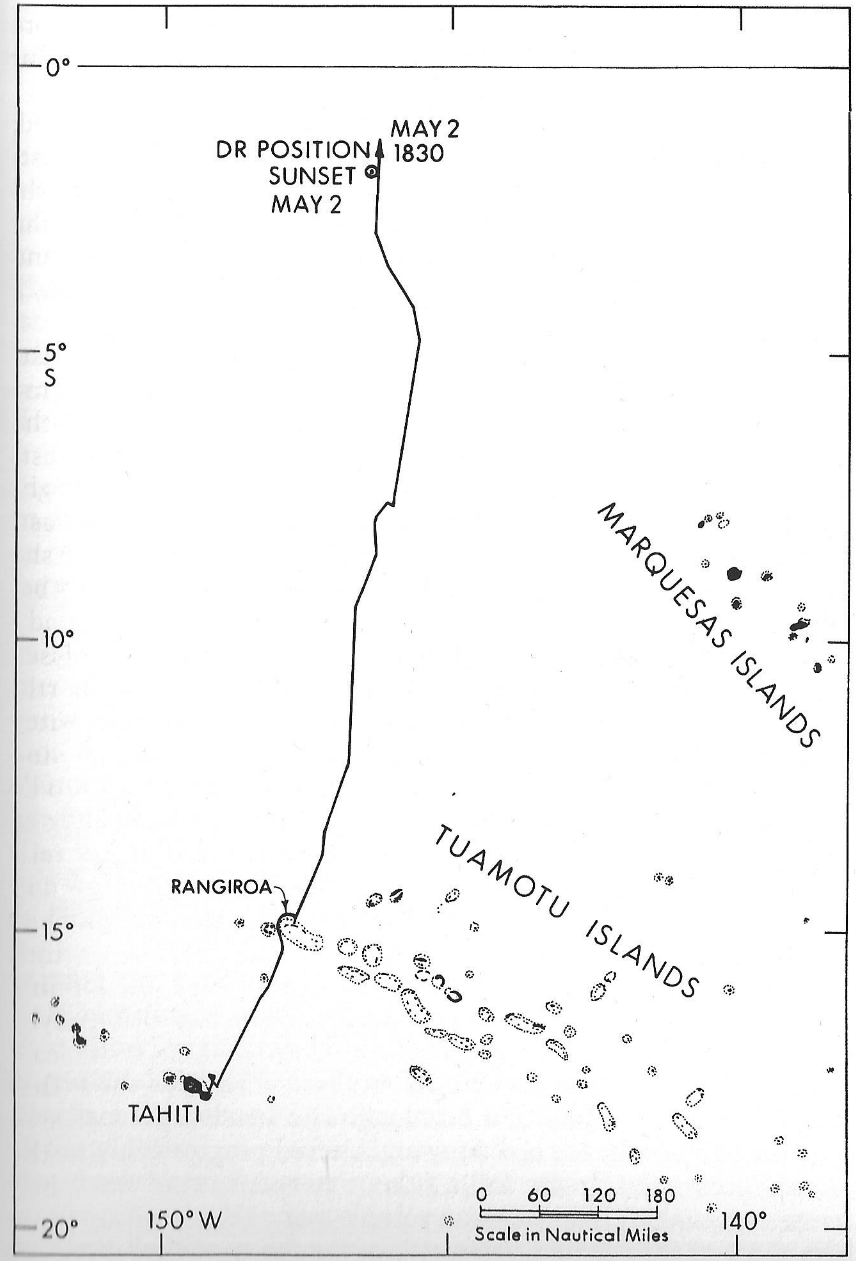


Figure 74. Approaching the equator, 2 May 1987.

trade wind belt south of the equator was most unusual—though perhaps understandable in the context of the basin-wide anomalies in wind flow associated with the El Niño condition that had then developed.

A comparison of the actual track of the canoe during this period with Nainoa's dead reckoning positions shows that for the first time since leaving Tahiti the two diverged significantly. Up until 2 May, when the canoe was a hundred or so miles south of the equator, Nainoa's dead reckoning positions had fallen fairly close to the actual track, sometimes even right on it. As the canoe had sailed further toward and then across the equator in the light northeast and east-northeast winds, however, the dead reckoning positions fell progressively farther and farther to the west of the actual track. While the canoe was actually sailing at this time on a bearing about 7° or 8° to the west of north, Nainoa's estimates indicate that he thought the canoe's track was bearing some 20° to the west of north. As a result, by sunrise 7 May, Nainoa's dead reckoning was some 150 miles too far to the west (fig. 75).

Two factors may have combined to throw Nainoa's reckoning off. First, he may have overestimated the westerly set of the current, as he apparently had done in these same latitudes when sailing to Tahiti in 1985. Second, he may have been too conservative in judging the windward performance of *Hōkūle'a* against these light northeast and east-northeast winds and the relatively smooth seas that accompanied them. The larger sails (particularly the extra-large after sail) which the canoe now carried may have been more efficient than expected in going to windward in these light airs.[7]

The Northeast Trade Wind Zone

Hopes for strong, steady trades and fast sailing for the rest of the way to Hawai'i did not last long. The winds lightened during the daylight hours of 7 May and shifted progressively northward, forcing the slowly sailing canoe to veer toward the northwest and making Nainoa worry once more about ending up to the west of the island of Hawai'i. Although the wind direction improved that night, during the next day the winds turned more northerly, forcing the canoe once again to the northwest. Then around sunset, the wind shifted all the way around to north,

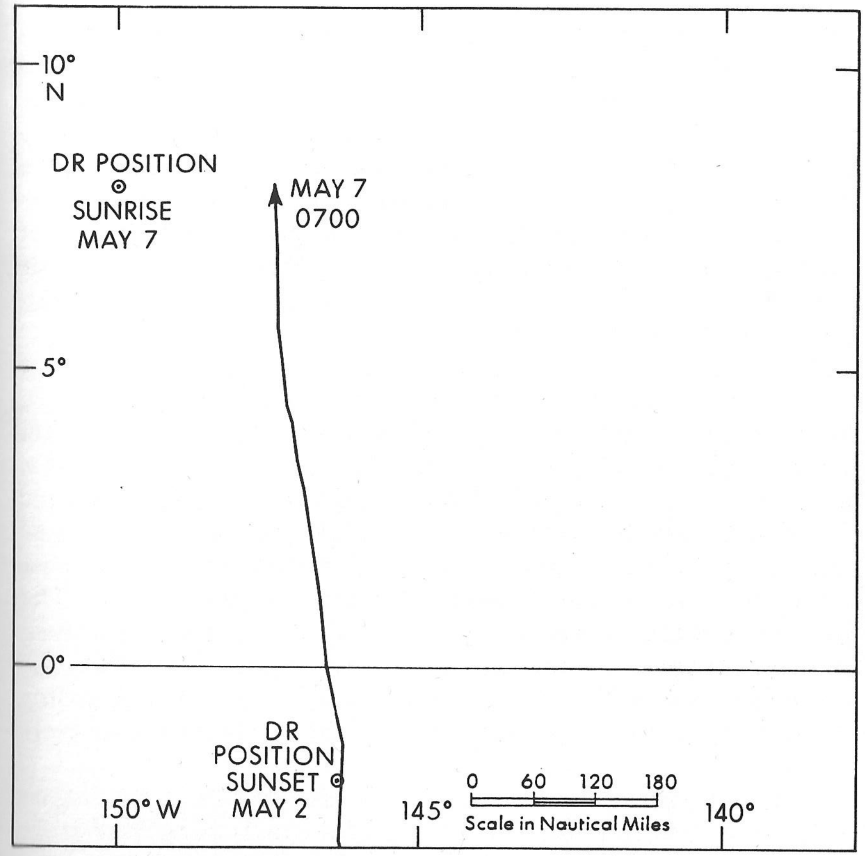


Figure 75. Divergence of dead reckoning and actual positions north of the equator, 2–7 May 1987.

forcing the canoe to be tacked due east until around two the next morning (9 May), when the wind shifted back to the northeast allowing the canoe to change tack again and resume sailing toward Hawai'i. At this time *Hōkūle'a* was at about 10° 15′ North, a little over 600 miles north of the equator.

In addition to constantly watching the swells so that he could use them for steering during cloudy periods or when the sun was too high in the sky for orientation, Nainoa also kept a lookout for the sudden appearance of big swells, as these can provide an advance warning of any storms that might lie in the canoe's path. For example, in his interview on the morning of the 9th, Nainoa pointed out the large, highly developed swells that were coming from the north and proposed that these indicated that a subtropical depression was moving somewhere north of Hawai'i, interrupting the normal trade wind flow. The surface wind analysis for 7:00 A.M. (Hawai'i time) on 7 May shows that in fact a well-developed subtropical disturbance (known among Hawai'i meteorologists as a "Kona low") was then centered northeast of Hawai'i at 28° North, and 149° West (fig. 76). This disturbance was producing brisk northerly winds along longitude 150° West and the strong north swell that Nainoa noticed when it reached the canoe.

Although the wind continued to come from the northeast and east-northeast for the next day and a half, at sunset on 10 May the canoe, then at about 13° North, sailed into a weather front, and the wind once more shifted counterclockwise until it was again coming out of the north. To keep from being forced westward, Nainoa had the canoe tacked to the east; he assumed that this was just a small front and that they would soon pass through it and be able to resume sailing toward Hawai'i. The weather system proved to be larger than expected, however, and, except for one short spell of tacking northward when the winds briefly became more easterly the canoe continued sailing to the east across the northerly wind field for the next thirty-six hours.

While the canoe was sailing on this eastward tack, the frigate *U.S.S. Brewton*, directed by position information radioed from the escort vessel, rendezvoused with *Hōkūle'a* in order to evacuate Dixon Stroup, who had a fast-spreading and potentially life-threatening leg infection. The efficiency and goodwill with which the frigate's captain, Commander Paul Mallet, and crew carried out this operation typified the relations our project has enjoyed with the U.S. Navy and the Coast Guard as well. As professional seamen, Navy and Coast Guard personnel have followed the voyages of *Hōkūle'a* with keen interest, particularly because they fully understand the difficulty of navigating long distances without modern instruments. We especially appreciate their willingness to make the rendezvous with the canoe without revealing any position information that would have compromised the navigational effort.[8]

At dawn on 12 May, the wind shifted a bit toward the east, and Nainoa gave the order to go back on the starboard tack, even though the north-northeasterly direction of the wind forced the canoe onto a northwesterly course. *Hōkūle'a* continued sailing

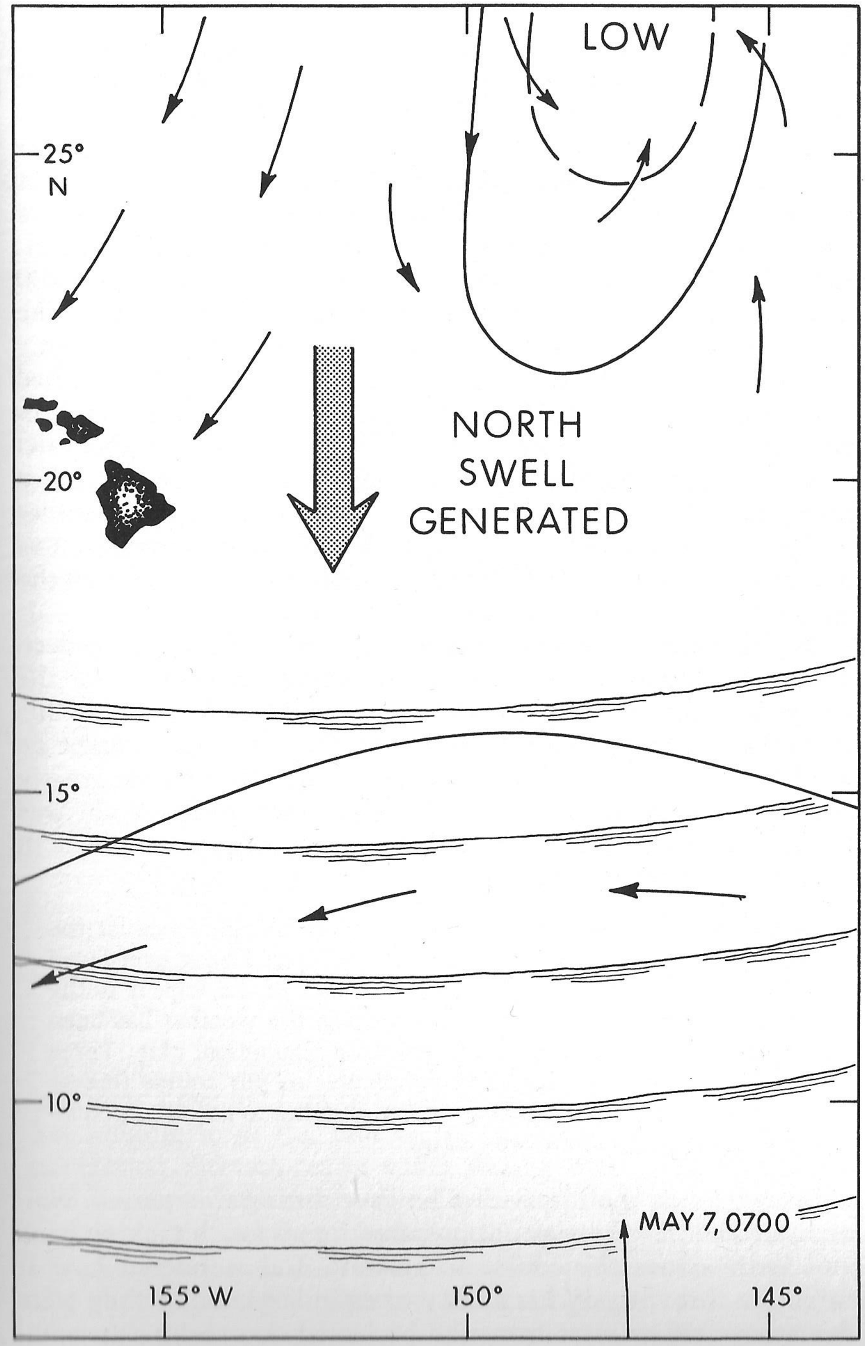


Figure 76. Low pressure system northeast of Hawai'i generating north swells, 7 May 1987.

northwestward in these light north-northeasterly winds until the 13th, when, during a period of shifting winds, Nainoa had the canoe tacked to the east, then back to the northwest, and then eastward once more before turning back to the northwest once the light northeasterlies became reestablished. Despite this tacking back and forth, during the early morning hours of 14 May the canoe did manage to cross the 15th parallel of latitude (900 miles north of the equator and almost to within 400 miles of the southernmost point of Hawai'i). That morning the motor vessel *Ma'alaea* rendezvoused with the *Dorcas*, bringing diesel fuel from Hawai'i to replenish the yacht's tanks that had been emptied in trying to keep up with the canoe on the lengthening voyage. The *Ma'alaea* also brought to *Hōkūle'a* Tua Pittman, the crew member from Rarotonga who had been forced to leave the crew at Rangiroa when he had dislocated his shoulder while the canoe had been detained there by adverse winds. Tua was most grateful for this chance to rejoin the crew to finish the voyage.

By this time Nainoa was beginning to feel unsure of his dead reckoning. In particular, he was wondering whether or not the canoe was really headed toward the island of Hawai'i as his mental calculations indicated, or whether the canoe might be headed to the west of the island on a course that would greatly complicate making a safe landfall. The source of his doubt was the extraordinary character of this voyage. As Nainoa put it in his interview on the 14th:

> By far this is the strangest trip in terms of being so against the average. . . . To me, it is the biggest challenge I have ever faced for a number of reasons. One is the length of the trip; it is the longest voyage so far. Two is the weather; the weather has been so unpredictable that you can't stay on a regular sail plan. Three is that we have had to sail perpendicular to our course line so many times. So, given all that . . . [it] is going to be real interesting to see exactly where we end up.

Elsewhere in the interviews he gave during this period, Nainoa stressed how he was not prepared for so much tacking back and forth across the course to Hawai'i and wondered how it might be throwing off his ability to estimate how far they were deviating east or west from the projected course line. In addition, he expressed concern about how his preoccupation with

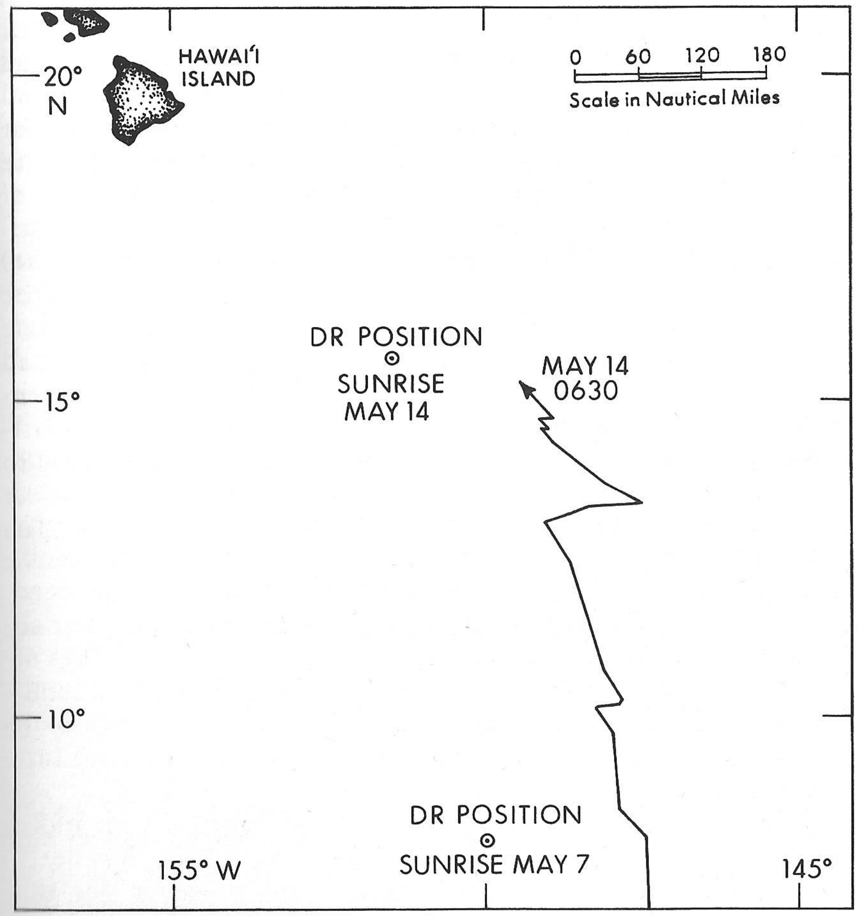


Figure 77. Working north toward Hawai'i, 14 May 1987.

the rendezvous first with the *Brewton* and then with the *Ma'alaea* may have led him to make mistakes in his dead reckoning. Yet judging from the plot of his position estimates, Nainoa's navigation did not really suffer during these tacking episodes and the two rendezvous (fig. 77). If anything, the gap between his estimates and the actual track of the canoe that had opened up when the canoe first encountered northeasterly winds actually shrank during this period. For example, whereas on 7 May Nainoa's dead reckoning had been some 150 miles west of the actual track, at dawn on 14 May, when the canoe was at about

15° 15′ North and 149° 24′ West, his estimates placed her about 120 miles to west-northwest of the actual position.

Nainoa was, of course, unaware of the true position of the canoe and could only rely on his own estimates. Although these indicated that the canoe was heading almost directly toward the island of Hawai'i, given his conservative nature Nainoa was prepared for the worst-case scenario: that, in reality, they were being forced onto a course that would push the canoe to the west of the island. Nainoa wanted to reach the latitude of the Hawaiian chain just to the eastern, windward side of the island of Hawai'i, after which the canoe could be turned downwind and to sail westward toward an archipelago target 315 miles wide, measured from Ka Lae at the southern end of the island of Hawai'i to the northern shore of Kaua'i. If, however, the canoe were approaching the archipelago directly from the southeast, heading in the same northwest direction as the trend of the chain, the width of the target would be greatly narrowed. And, to state the worst-case scenario, if the canoe were being forced by the unfavorable winds onto a course that would take her so far west of the island of Hawai'i that even the towering peaks of the island could not be seen as the canoe sailed past it, a landfall along the chain could become problematic, particularly if continued northerly winds kept making it difficult to work further to the north.

Fortunately, from the 14th on, the wind became a bit more easterly, allowing the canoe to be sailed on a more northerly course. The sailing was frustratingly slow, however, for the wind remained very light and irregular. For example, in his interview on 16 May, when the canoe was approaching the latitude of the island of Hawai'i, Nainoa states that although the wind was out of the east-northeast where it should be,

> the weather is still, I think, certainly not back to trade wind conditions because there is no force in the wind; it is really weak.... We are just lucky to have these big sails that can push us along through this small stuff and still make four and one-half knots.

At this time, Nainoa's estimates of the canoe's position became particularly crucial. The main Hawaiian islands extend from the Ka Lae, Hawai'i at 18° 56′ North to the northern shore of Kaua'i at 22° 14′ North. Based on star sights during the previous night, at midday on 16 May Nainoa placed the canoe at about 18° 30′ North—within sight range of the island of Hawai'i if the canoe was in fact heading toward that island. Lookouts posted throughout the day saw no sign of land, however, for in fact the canoe was actually well to the east of Hawai'i. Although Nainoa's estimate of latitude was basically correct, he was reckoning that the canoe was over 150 miles west of where she actually was (fig. 78).

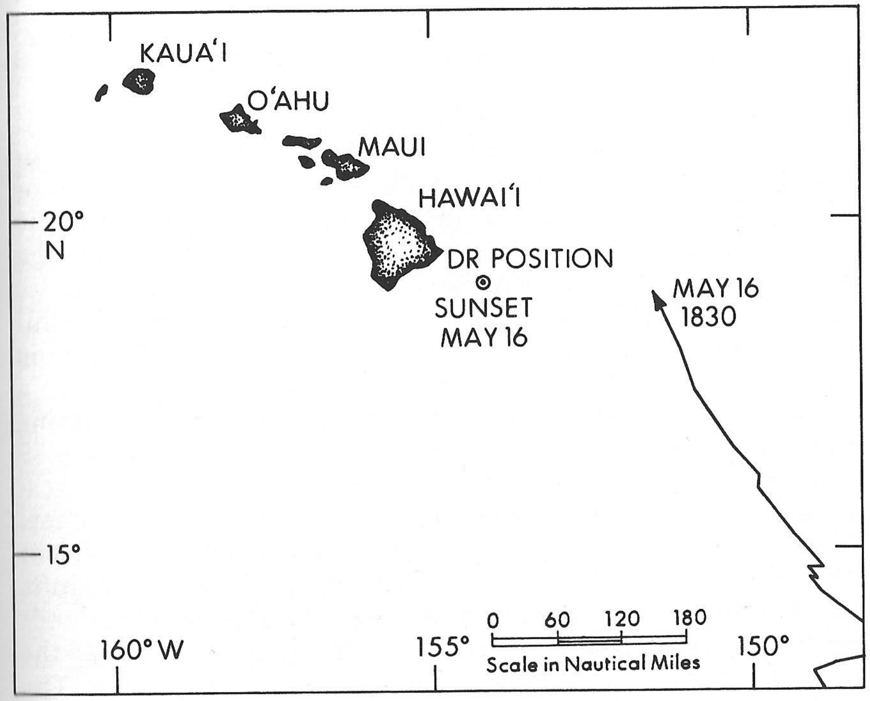


Figure 78. Drawing abeam of the island of Hawai'i, 16 May 1987.

The wind died on the 17th, forcing the crew to lower the sails to the deck in order to prevent chafing as well as damage to the booms as the canoe was rocked violently from side to side by the confused seas. Smoother seas that evening allowed the sails to be raised to take advantage of very light northerly breezes to sail toward the west-northwest. These conditions led Nainoa to comment once more in his tape-recorded interview about how weak the wind was in latitudes where he was used to sailing in brisk trades:

> From 10° North we virtually had no trade winds. We had wind sometimes in the trade wind direction—for slight periods from the east-northeast, but with no strength in it. . . . The absence

> of the normal trade winds—the most consistent wind belt on earth—in the trade wind season is just really baffling.

The frustration of being held up by light, fluky winds at this last stage of the voyage may have made Nainoa forget how variable the trades can be this time of year. Actually, May is not known for consistent trades in Hawaiian waters. It marks the transition from *ho'oilo*, the winter rainy season, to *kau*, the summer dry season. During this transitional period the trades are often light and frequently may fail altogether before becoming steadier during the summer months. For example, during May 1987 the steadiness of the trades at Honolulu (based on a value of 100 percent for blowing from the same direction during the entire month) was only 67 percent, while in June it was 89 percent and in July was 94 percent.[9] A major factor in this seasonal decline in the steadiness of the trades is the Tropical Upper Tropospheric Trough. This trough, which is most evident at 35,000 feet above sea level, moves over Hawai'i as it shifts north with the coming of summer. As it passes over the islands each May, disturbances formed along the trough often cause the surface pressure to fall and the trades to weaken or fail.[10] (The resultant warm, muggy conditions are often termed "termite weather" in Honolulu, in that the heat and humidity triggers evening flights of termites.) The surface wind analysis for 1:00 A.M. on 18 May, when *Hōkūle'a* was stalled east of the island of Hawai'i by very light northerlies, reveals the disturbed conditions near the islands (fig. 79). The trough lay directly over the islands, and a meteorological buoy anchored southeast of Hawai'i Island showed north-northeast winds of just 5 knots.

During the day on the 18th the canoe sailed to the northwest in order to gain a few more miles against these light north-northeast winds. Nainoa's worst-case dead reckoning indicated that they might possibly be passing just to the west of Hawai'i Island and that if they kept heading northwestward they would make land somewhere along the middle of the chain. Nonetheless, even though sightings of oily waste and bits of paper and plastic floating in the water seemed to indicate land to the north or northeast, Nainoa was beginning to express some doubt about this possibility. Perhaps, he wondered, the canoe was not west of Hawai'i Island, but instead was sailing to the east of it. Despite these doubts, however, Nainoa wanted to keep sailing northward as far as 20° 30' North. At that latitude, he reckoned that

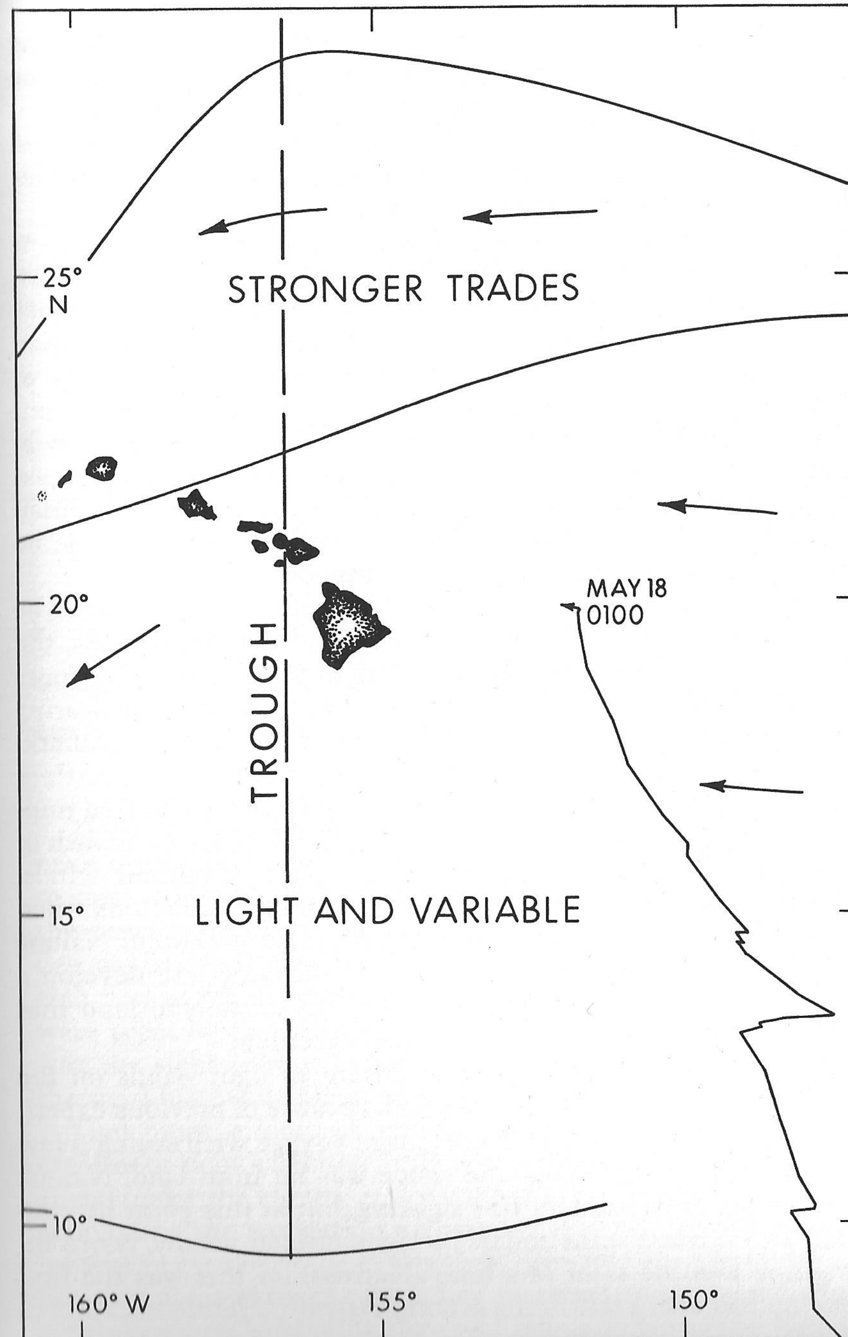


Figure 79. Light and variable winds in Hawaiian waters, 18 May 1987.

if they were in fact west of the island of Hawai'i, they would be able to see the towering volcano of Haleakalā on Maui, or the islands of Kaho'olawe or Lāna'i off the southern shore of Maui. Or, if they had been driven even farther to the west, once it became dark they would be able to see the loom cast in the skies by the bright lights of Honolulu off to the north.

That night Nainoa got what he considered to be an excellent view of Polaris, and estimated from its elevation above the horizon that they were at 21° North, or a little south of there. Since they had seen no indications of land the previous day other than a few stray sooty terns (*'ewa'ewa* in Hawaiian), and no lights or other signs of land to the north during the night, Nainoa concluded that he had indeed overestimated the westward deviation of the canoe's course, and that in fact they were to the east of the island of Hawai'i. Accordingly, Nainoa had the steersman turn the canoe downwind to head westward toward where he now deduced the island of Hawai'i must lie.

The next day, 19 May, Nainoa guessed that they might be about 120 miles away from the island, and that Mauna Kea, the 13,784-foot volcanic peak in the north of the island where some of the world's largest telescopes are located was then bearing southwest by west. His estimate was not too far off the mark, for the canoe was then located about 140 miles east by north of Cape Kumukahi, the easternmost point of Hawai'i located midway along the island's windward coast. After almost a month of struggling northward against frustratingly inconsistent winds, and after radically revising his dead reckoning calculations when land did not appear where he had estimated it should, Nainoa had been quickly able to reorient his thinking and develop a mental image of where the canoe was in relation to land that was essentially correct, if not precisely accurate.

As the canoe slowly sailed westward in light winds on the 19th, more sooty terns were sighted. Because of previous experiences on the various legs of the entire voyage with seeing a few terns flying around when the canoe was far from land, Nainoa did not set great store in this sighting, but at this point he conceded that these terns might be signs of land nearby. More intriguing was the sight of a lone albatross, for this was the first one he had ever seen flying around Hawai'i. Nainoa recalled in his interview that evening that a colony of these wide-ranging birds had recently become established on Kaua'i and that maybe this bird was from there.

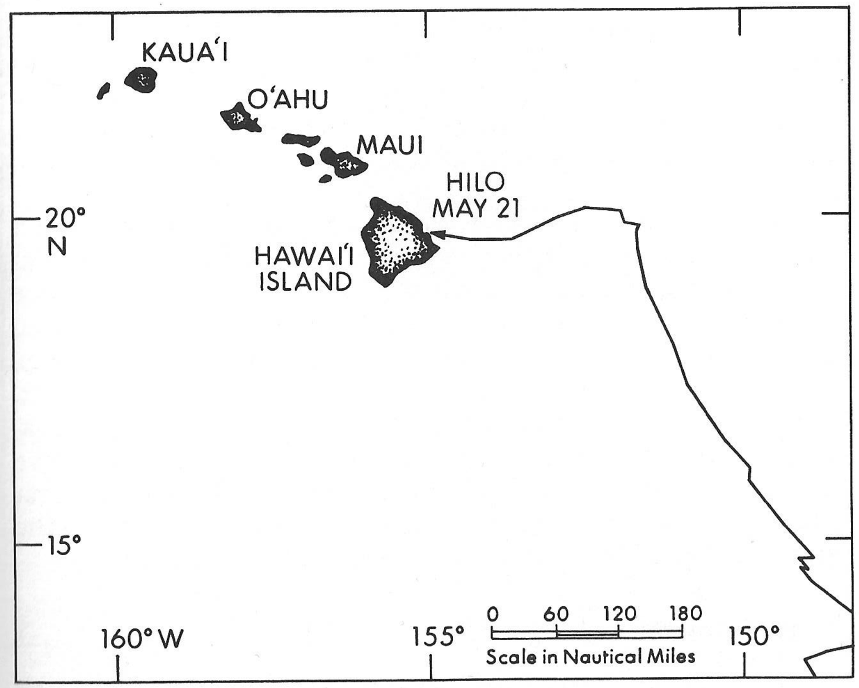


Figure 80. Landfall on the island of Hawai'i, 21 May 1987.

The next day, 20 May, Nainoa began to think that he may have overestimated the latitude and so directed the steersmen to steer a little to the south of west, a heading that in fact made the canoe point almost directly toward Cape Kumukahi. That day, as the canoe slowly sailed along in the light airs, much rubbish floated by, and more sooty terns and big brown albatrosses were seen. More telling as true signs of land, Nainoa thought, was the sight of four *manu-o-Kū*, as everyone on board called the sparkling white fairy terns.

That night, a loom of light was seen ahead, and, despite the extremely poor visibility, the next morning land was sighted ahead under the clouds. *Hōkūle'a* had come home, successfully concluding the navigation experiment (fig. 80). The next priority was to get the canoe to O'ahu in time for the welcoming celebration planned for the 23rd, just two days away. As the winds continued very light, *Hōkūle'a* was taken under tow to Hilo for customs inspection and other formalities before continuing along the island chain toward O'ahu. Late in the afternoon of the

22nd, *Hōkūle'a* anchored off Kalaupapa Peninsula on the north shore of the island of Moloka'i to pick up crew members who had flown in to join the canoe for the final arrival at O'ahu. The crew was given supper ashore by the residents; this quiet re-entry to Hawai'i was a welcome pause before the hectic day to follow.

About midnight the canoe left Kalaupapa, still under tow in the calm, and shortly after dawn arrived off the entrance to Kāne'ohe Bay which leads directly to Kualoa. Just before the canoe was to make its ceremonial entrance, the wind at long last picked up, enabling the canoe to sail majestically into Kāne'ohe Bay, surrounded by a fleet of paddling canoes, yachts, and power craft. Finally, the twin prows of *Hōkūle'a* nosed onto the sands of Kualoa, the same shore where the canoe had been launched twelve years earlier. Just as thousands of people had seen *Hōkūle'a* first take to the sea at Kualoa, so thousands more now welcomed the canoe and her crew home with chants, dances, and orations.

The Longest Leg

The return to Hawai'i took longer than any other leg of the entire Voyage of Rediscovery (fig. 81). Largely because of the enforced stay on Rangiroa, almost two months elapsed between the time the canoe left Tahiti and her arrival at Kualoa. Even the sail from Rangiroa to Hilo took a comparatively long time: twenty-eight days in comparison to the twenty-two days it took in 1976 to sail the greater distance from Tahiti to a point abeam the island of Hawai'i, and the twenty-four days it took to cover that same distance in 1980. The northerly winds, overcast skies, and squally conditions brought on by the El Niño delayed *Hōkūle'a* for weeks in Rangiroa and then made sailing north to the equator tortuously slow, while north of the equator, the lack of strong and consistent northeast trades further lengthened the voyage.

These conditions severely tested Nainoa's navigation as well as the crew's sailing skills and stamina. Although the canoe more or less followed the same course northward as she had on the previous crossings, the 1987 track differed in detail from the other two (fig. 82). On the two previous trips back to Hawai'i, *Hōkūle'a* had sailed fast on the starboard tack for most of the trip, with minimal variations in heading and speed, all of which

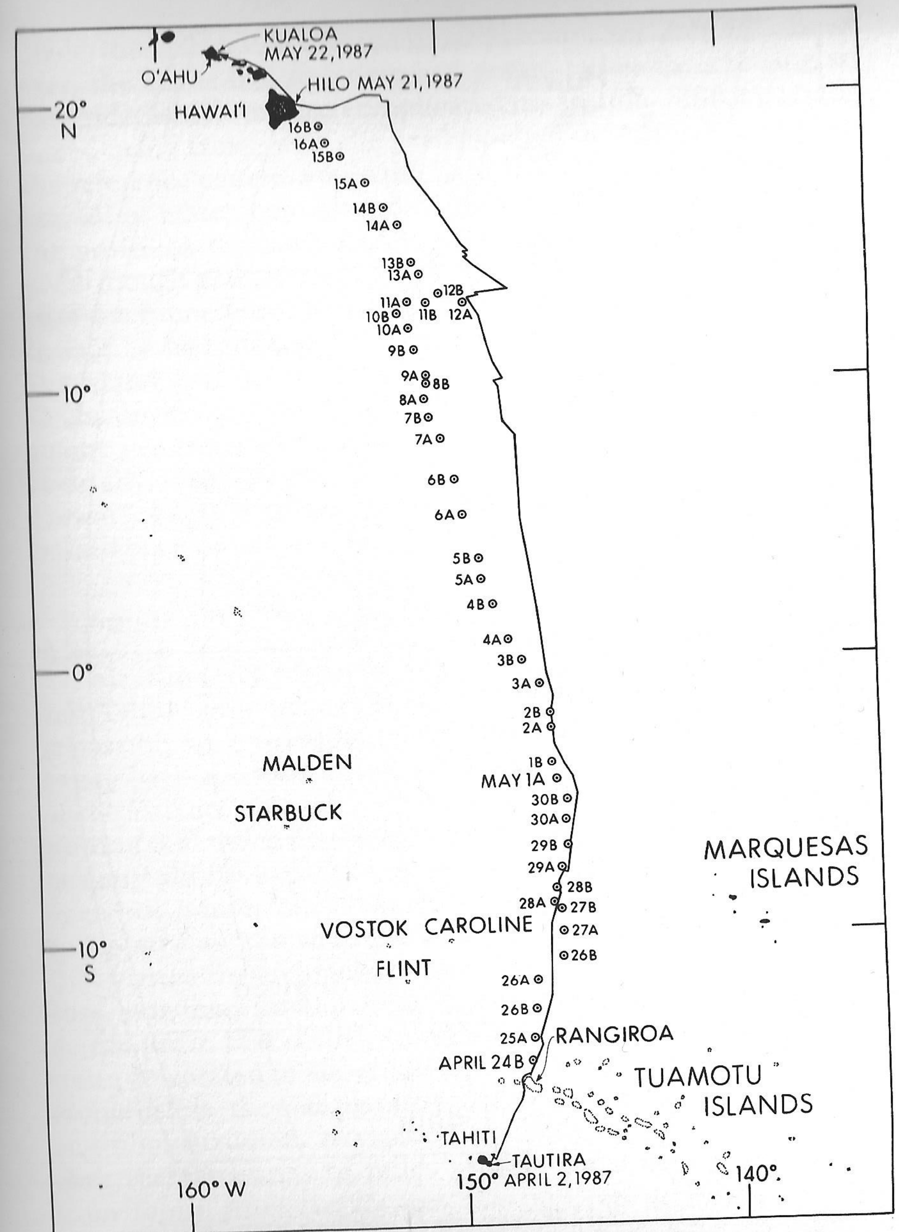


Figure 81. 1987 Voyage of Hōkūle'a *from Tahiti to Hawai'i, showing actual track of the canoe and Nainoa Thompson's dead reckoning (D.R.) positions estimated at sunrise (marked by "A" following the date) and sunset (marked by "B" following the date).*

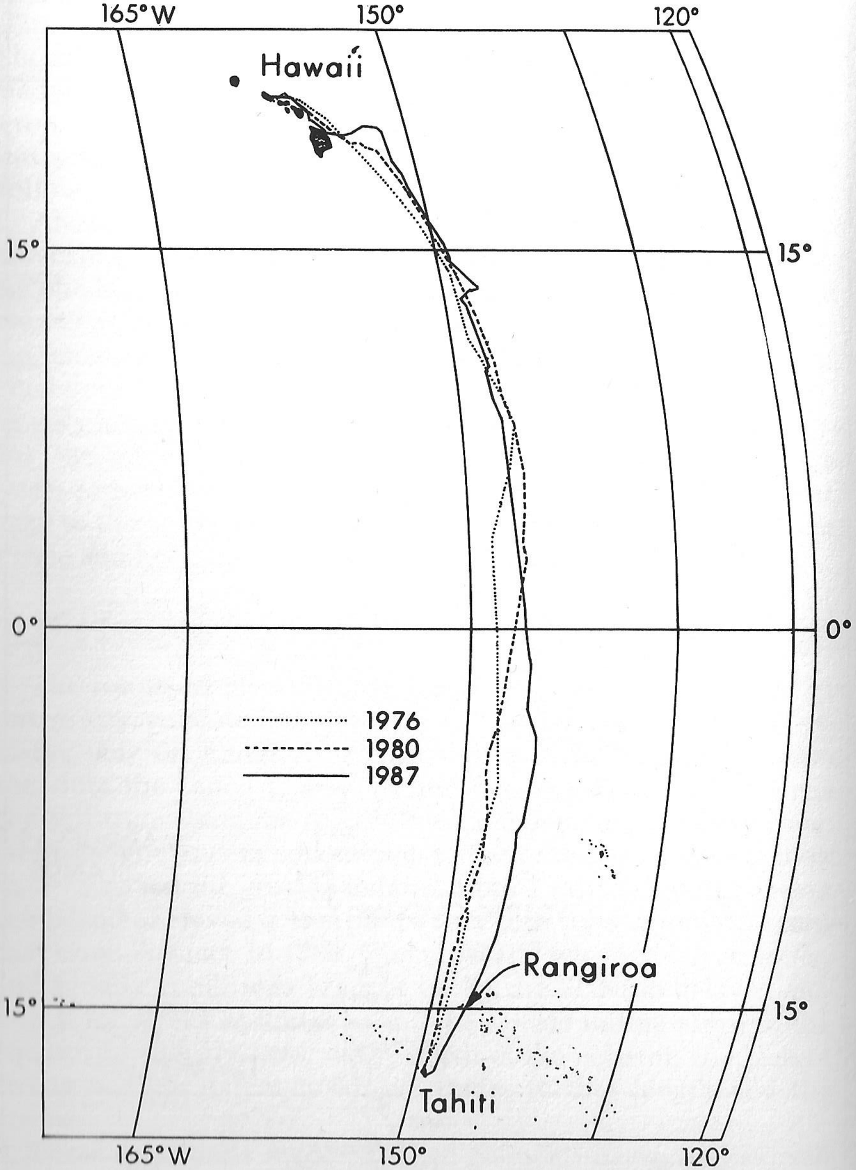


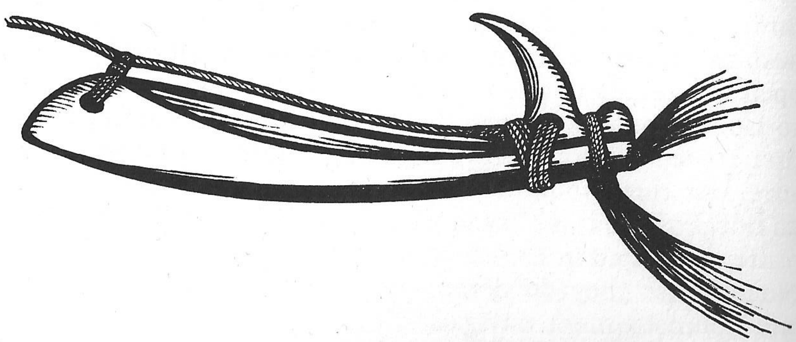
Figure 82. 1976, 1980, and 1987 voyages of Hōkūle'a *from Tahiti to Hawai'i.*

made the navigation relatively straightforward. In 1987, however, the canoe had to be worked north, rather than getting an easy ride, which in turn complicated navigation. Shifting winds forced many tacks, with the heading often departing widely from the reference course, while the light winds extended the time at sea, all of which contributed to skewing Nainoa's dead reckoning positions to leeward of the actual track of the canoe. Yet, even though toward the end of the voyage Nainoa was worried that the canoe was passing to the west of the island of Hawai'i, in fact he had managed to sail the canoe to the eastern side of the island, just as originally planned. When no signs of Maui or O'ahu appeared to the north where his reckoning indicated land might lie, Nainoa was able to quickly readjust his thinking to mentally visualize the canoe's correct position to the east of Hawai'i. In spite of everything, the ultimate test of landfall was passed once more.

Long-range, Two-way Voyaging

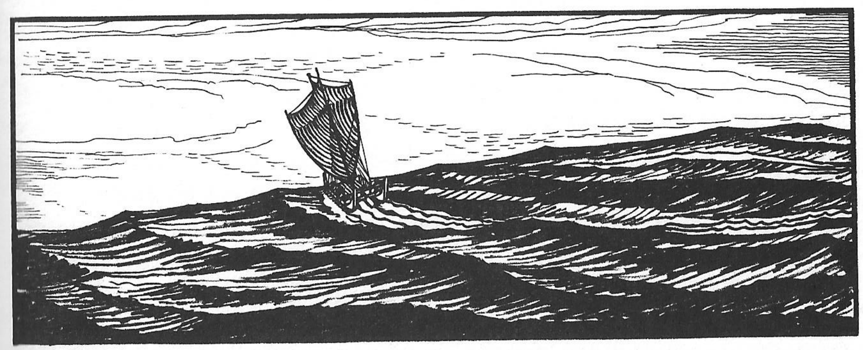
This third roundtrip voyage of *Hōkūle'a* between Hawai'i and Tahiti demonstrates how even under adverse conditions it is possible for a voyaging canoe, navigated without instruments, to sail back and forth between these distantly separated outposts of the Polynesian nation. Not only, therefore, can we forget the limit of 300 miles that Sharp so arbitrarily imposed on the Polynesians' ability to make intentional voyages, but we should also open our minds to the possibility that Hawai'i was not always so isolated as was apparently the case when European voyagers first visited the archipelago in the late eighteenth century. To be sure, our three roundtrip voyages between Hawai'i and Tahiti do not prove that the legendary voyages back and forth over this route celebrated in Hawaiian oral traditions actually took place. Nonetheless they do demonstrate how well the double canoe and noninstrument navigation methods are adapted for sailing over the thousands of miles of blue water separating Hawai'i from Tahiti. After our voyages, it is no longer possible to assume that the great stretches of ocean which lie between Hawai'i and the other Polynesian islands necessarily barred two-way communication between Hawaiians and their kinsmen in the South Pacific.

Yet, that we have made three roundtrips between Hawai'i and Tahiti cannot be taken to mean that Polynesians could have sailed freely back and forth between virtually any set of islands in their oceanic realm. Strictly speaking, our experimental findings gained in sailing around Polynesia are highly specific to particular routes and their characteristic wind conditions, to particular seasons of the year or to weather cycles of shorter or longer periods, and to the size of the destination formed by the target island and any surrounding or screening islands. For example, the alignment of Hawai'i and Tahiti across the trade wind field, and the extensive navigational targets presented by the great length of the Hawaiian chain and the even wider east-to-west spread of the Society and Tuamotu chains, work together to greatly enhance the prospects for voyaging back and forth over this route. Conditions over some other interarchipelago routes in Polynesia are even more conducive to two-way communication, whereas over others they are much less favorable. Voyaging possibilities over each of the sea ways between the many islands and archipelagos of Polynesia must be separately assessed in order to develop realistic models of the degree to which interaction and isolation may have shaped the evolution of the many constituent cultures of the widespread Polynesian nation.



8

PUTTING VOYAGING BACK INTO POLYNESIAN PREHISTORY



When we began experimenting with reconstructed double canoes in the mid-1960s, a new generation of archaeologists then applying modern excavation and interpretative methods in the Pacific were questioning long-held ideas about Polynesian migration and voyaging. Many of these archaeologists rejected assumptions about intentional exploration and settlement, followed by widespread voyaging thereafter, in favor of the view that each island had somehow been fortuitously settled by a canoe-load or two of Polynesians and that the resultant colonies had developed in relative if not total isolation from all but their nearest neighbors.

Such minimalist thinking about Polynesian voyaging and settlement was in part a reaction to the extreme "migration mentality" of earlier students of Polynesian prehistory who pictured canoes sailing freely back and forth across the Pacific and sought to explain the development of each island society in terms of the diffusion of cultural traits brought in by voyagers from various islands, or by the overlayering of one migratory wave over another. But it also reflected a major shift in archaeological thinking brought into the Pacific by researchers trained in the United States and Britain where the longstanding culture history para-