Navigating the Currents

Adapted from "Virtual Voyage: Course Strategy and Departure Time" and other sections of the Polynesian Voyaging Society website at <leahi.kcc.hawaii.edu/org/pvs>, June 2000.

Imagine that you are a wayfinder. Through long years of study and practice, you have learned the traditional art of guiding a Hawaiian voyaging canoe to its destination without using instruments. You have learned to listen to subtle differences in the sound or thrust of the ocean swell on the wooden hulls of the canoe, use the stars and the sun to determine your position and time of day, and estimate the wind speed and direction. You know how to put all of the signs together to interpret where you are in the vast expanses of the Pacific Ocean, and whether you're on course for your destination. While you're underway, you do all of this on as little as two hours of sleep each night, because the success of your journey and the lives of the entire crew depend upon your constant attention to navigating.

You have guided the crew of the *Hōkūle'a*, the first Hawaiian voyaging canoe built in modern times, from Maui to the South Pacific island of Nuku Hiva. Now, after sharing food, fellowship, and traditional dance and song with your Polynesian *'ohana*, you are ready to plan your journey home.

Charting a Course

As wayfinder, your job starts well before the canoe leaves shore. You must design an ideal course for sailing from Nuku Hiva back home to Maui. To do that, you will consider the capabilities of the canoe along with the winds, currents, and weather conditions anticipated along the way. As a modern-day wayfinder, you have a couple of advantages over your ancient counterparts: accurate ocean and current maps, and measured average current and wind conditions for different parts of the ocean and different seasons of the year.

Still the ideal course you chart is only a model of what your course will really look like once the *Hōkūle'a* is under sail. It is called a "reference course" because you will use it as a point of reference during the voyage. This course is based on average wind and current conditions, and on the ocean these conditions are never average. The canoe deviates from its reference course, sailing in whatever direction the winds allow it to sail. During the voyage, as the wind or ocean currents push *Hōkūle'a* off its reference course, you will eventually try to get the canoe back on it or close to it when conditions allow.

Under Sail

Once *Hōkūle'a* leaves the shores of Nuku Hiva, your job as wayfinder is to plot the canoe's position relative to the reference course. Charting the canoe's position is a matter of educated estimation. You plot the position of the vessel by estimating:

1) The speed and direction in which the canoe is traveling,
2) The speed and direction of ocean currents, and

Sightings of seabirds such as this albatross tell Polynesian navigators there is land within about 60 miles. (Photo: Kim Martz and Forest Starr)

3) Latitude (based on measurements of the altitudes of stars crossing the meridian).

In keeping with Polynesian tradition and techniques, you make these estimates without instruments. They can be hampered by poor weather conditions that obscure the sky and make patterns in ocean "swells" (long, crestless waves or successions of waves generated by weather events such as storms) difficult to interpret. Since the speed and direction of ocean currents cannot be estimated without instruments, you, a modern-day wayfinder, use seasonal averages to calculate your position.

Finding Land

Your goal is not to stay on the reference course, but to guide *Hōkūle'a* back home to Maui. The art of wayfinding involves adapting to variable and unexpected conditions of wind and weather while maintaining progress toward the windward side of the Hawaiian Islands.

As repeated landfalls by *Hōkūle'a* in its many journeys since 1976 show, wayfinding does not require exact positions to be successful. The wayfinder will successfully guide the canoe to its destination by keeping track of where the canoe is in relation to the reference course and destina-

A Revival of Polynesian Voyaging

Over a period of some one thousand years, Polynesian navigators explored and settled islands in an area covering over ten million square miles. How they accomplished this has been the subject of much speculation for centuries. Since 1976, the Polynesian Voyaging Society has helped scientists, anthropologists, archaeologists, and others interested in the survival of Polynesian culture understand how that achievement happened. In traditional-style Polynesian voyaging canoes, Hawaiians have traveled throughout the Pacific, navigating using only the constellations, wind, and wave patterns to guide their voyages over thousands of miles of open ocean.

The first Hawaiian voyaging canoe built in modern times was *Hōkūle'a*. Construction on *Hōkūle'a* started in 1973, and the canoe was finished in 1975. Since then, *Hōkūle'a* and its crew have sailed between Hawai'i and the South Pacific, visiting islands including Tahiti, Rapa Nui, Raratonga, and the Marquesas. In 1995, *Hōkūle'a* and another voyaging canoe, *Hawai'iloa*, were shipped to Seattle where they traveled up and down North America's Pacific coast from Juneau, Alaska, to San Diego, California.

Hōkūle'a (Photo: Steve Anderson)

tion, guiding the canoe to the general vicinity of the destination, locating land in that vicinity, and using known landmarks to find the destination.

In class, you will work with a team to create a sailing plan based on the reference course for a voyage of *Hōkūle‘a* from Nuku Hiva in the Marquesas Islands to Hāna on the eastern coast of Maui. In the process, you will learn more about the ocean currents and winds that surround the Hawaiian Islands. And you'll need to know a bit more about the capabilities of *Hōkūle‘a*. Here is some background that will help you as you learn this part of the art of wayfinding.

Sailing *Hōkūle‘a*

Hōkūle‘a has two 19-meter (62-foot) hulls, joined by eight crossbeams. No nails were used in constructing the canoe, so the decking is lashed to the crossbeams, and there are two masts. The 7.25-metric-ton (eight-ton) *Hōkūle‘a* can be loaded with about 4990 kilograms (11,000 pounds), including a crew of 12-16 people, along with their equipment and supplies.

Unlike most modern sailing vessels, Polynesian voyaging canoes like *Hōkūle‘a* have no keels or dagger boards at the bottom of their hulls to stabilize them in the water. This means that their "windward ability"—the ability to sail into the wind—is more limited than many modern craft. Still the canoes can sail in a broad range of wind conditions.

Hokule‘a travels at an average of one-third of the wind speed. Wind speed is measured in "knots." One knot is equal to one "nautical mile" per hour. *Hokule‘a* can make up to 10-12 knots under the best wind conditions. (A nautical mile is based on the length of a minute of arc of a great circle of the earth. According to the international standard, this distance is 1852 meters or 6076.115 feet.)

Crossing the Currents

The Hawaiian Islands are the northernmost and most isolated island group in Polynesia. Voyaging between Nuku Hiva in the South Pacific Ocean and the Hawaiian Islands in the North Pacific, you will pass through several zones characterized by particular current and wind conditions. There are three major current and wind zones (see the map on page 18):

South East Trade Wind Belt

Steady winds from the east/east south east (E/ESE) drive the south equatorial current, which flows westward through the trade wind belt.

Intertropical Convergence Zone

This area, where the southeast and northeast trade wind systems converge, is noted for its heavy cloud cover, squalls, light and variable winds, and dead calms—all of which make sailing and navigating less than ideal. The windless weather, known as the "doldrums," could stall *Hōkūle‘a* for days. The heavy cloud cover hides the stars, so navigating by them is difficult. Under such conditions, you must use the ocean swells to orient the canoe. However, the seas in this area are often "confused." Because the winds (which cause ocean swells) are so variable, there are often no clear swell patterns by which to navigate.

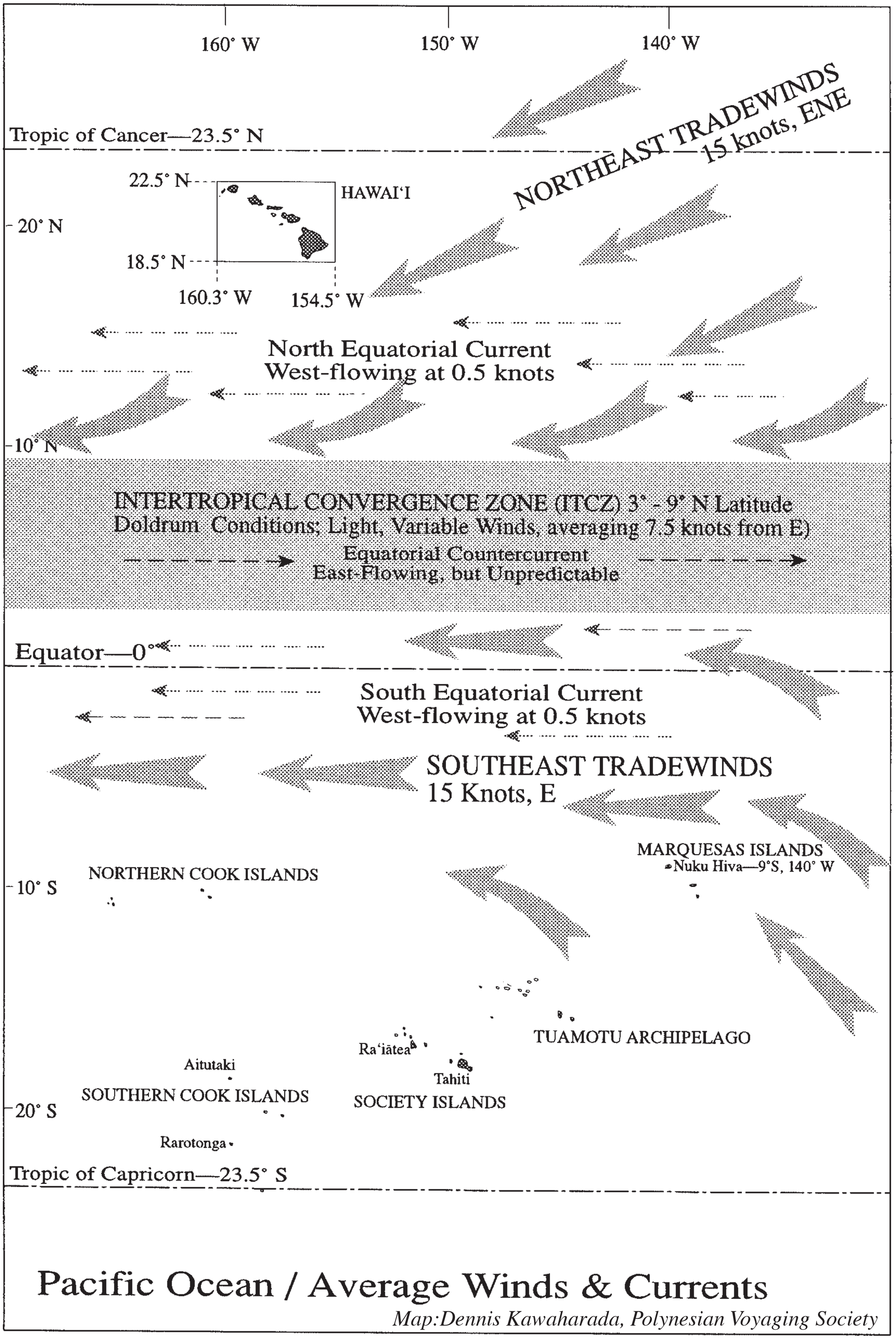
In this zone equatorial countercurrent flows eastward, between the two west-flowing equatorial currents. This countercurrent is formed as the water pushed west by the trade winds flows back east parallel to the equator. Like other conditions in this zone, the countercurrent is sporadic and shifting.

Northeast Tradewind Belt

The winds here are from the east north east (ENE), more reliable in the summer than in the winter. The northeast trade winds drive the north equatorial current, which flows westward.

Heading Home

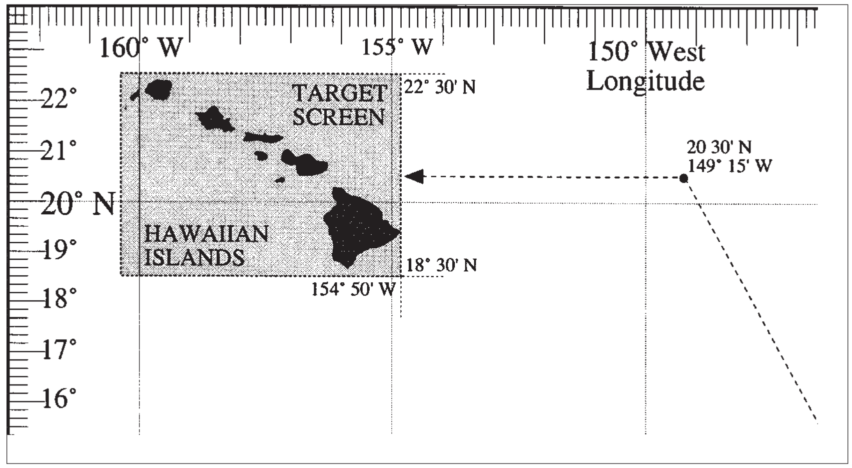
As you navigate through these major current and wind zones, you aim *Hōkūle‘a* to the windward side of the Hawaiian Islands. That way, you



Pacific Ocean / Average Winds & Currents

Map:Dennis Kawaharada, Polynesian Voyaging Society will have the wind with you as you approach land and use landmarks to help guide *Hōkūle'a* to Hāna.

When you plan your reference course, you set an area called a "target screen," which is the area in which the highest points of the destination islands will be visible. During the voyage, as *Hōkūle'a* approaches the middle latitude of this target screen (from the windward side of course!) you make your final major course adjustment, turning west toward the Hawaiian Islands. Turning at the middle latitude of the target screen leaves the most margin for error in estimating the latitude or staying on course in approaching the islands.



Map section showing target screen and course turning for home at mid-latitude. (Map: Dennis Kawaharada, Polynesian Voyaging Society)

You and the crew of *Hōkūle'a* will also rely on other observations to assist you in finding land. For example, seabirds such as the *manu o Kū* (fairy tern or *Gygis alba rothschildi*) and the *noio* (black noddy or *Anous minutus malanogenys*) may indicate the presence of low-elevation islands even before the voyagers can see land. The average range of these seabirds is about 60 miles around each island.

As you develop your sailing plan summary, you will learn how to plan a course to navigate through the wind and current zones to reach your final destination . . . Maui.

From Nuku Hiva to Hawai'i: Charting a Course

Despite the hospitality of your Nuku Hivan hosts, the crew of *Hōkūle'a* is anxious to begin the journey home to Maui. As wayfinder, you are nearing the end of your preparations. You have already mapped a reference course based on average wind and current conditions you are likely to encounter along the way. Now, while the rest of the crew is provisioning the canoe, you must create a more detailed summary of your sailing plan for this trip, using the information and maps given below. The remaining work is divided into three tasks.

Assignment

Work with your team members to complete all three tasks quickly and accurately.

Task #1: Check the Weather

The crew is anxious to return home, but you need to make sure this is a good time of year to be sailing between Nuku Hiva and Hawai'i. Use the information below to determine the safest months in which to make this voyage and explain your reasoning.

- Hurricane seasons: Hurricanes are tropical cyclones with a wind speed exceeding 64 knots. They form in the warm waters of the equator and are steered away from the equator by surface winds. Chances of surviving a hurricane on a voyaging canoe are minimal, so hurricanes must be avoided.
  - The hurricane season in the southern hemisphere is December-February.
  - The hurricane season in the northern hemisphere is June-September.

- Winter storms: There is a greater likelihood of encountering storms during the winter than at other times of the year.
  - Winter season in the southern hemisphere is June-September.
  - Winter season in the northern hemisphere is December-March.

The safest month or months for Hōkūlea to sail:

Task #2: Confirm Your Target Screen

You have already set a “target screen.” This is the general area that you’ll be trying to reach on your voyage. Within this area, you’ll be able to sight land. Once you sight land, you will use familiar landmarks to find your way to Hāna. Double-check how close to some of the major landmarks you would need to be in order to see them. In order to calculate these distances, you will need the following information:

- The formula for calculating the range for sighting land: Square root of h + square root of H = distance in nautical miles from which an object can be seen. (h = height above sea level of the observer in feet, H = height above sea level of the object in feet.)

- The deck of *Hōkūle‘a* is about four feet high.

- The elevations of some these landmarks are:
  Hawai‘i: Mauna Kea, 13,796 feet
  Maui: Haleakalā, 10,023 feet
  Kauai: Kawaikini, 5243 feet

Your answers:

Sighting distance from *Hōkūle‘a* to Mauna Kea:

Sighting distance from *Hōkūle‘a* to Haleakalā:

Sighting distance from *Hōkūle‘a* to Kawaikini:

Given the average range of seabirds such as the *noio* and *manu o Kū*, would you be likely to see these landmarks first, or would seabirds likely give away the presence of islands nearby first? Explain.

Task #3: Finalize Your Sailing Plan

Using the reference course you have already charted, the currents map (from the Student Page "Navigating the Currents"), and the information provided below, fill in the blanks in the sailing plan for the trip from Nuku Hiva to Hāna, Maui.

Information You Will Need

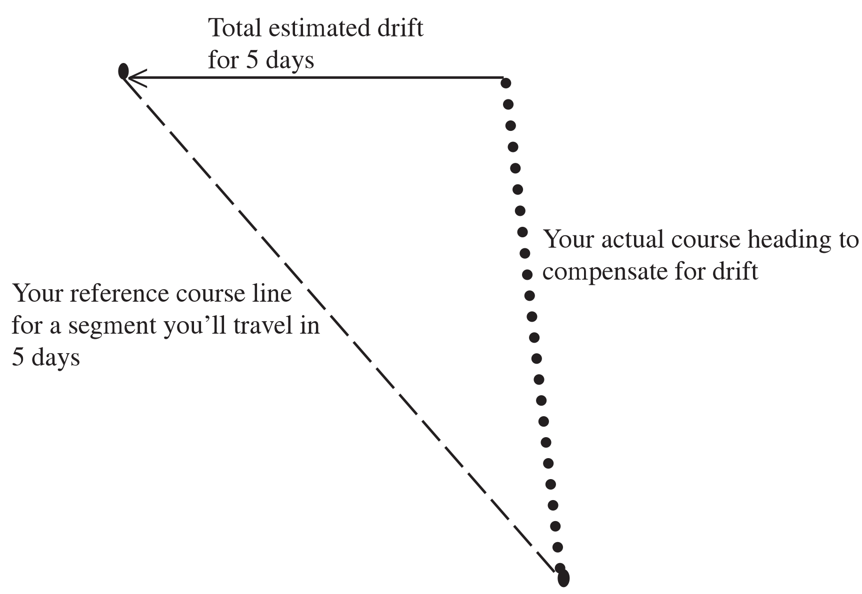
- The sailing plan is broken up into segments corresponding to each of the different wind and current zones you'll cross during the voyage:

  Southeast Trade Wind Belt (Nuku Hiva to 3°N latitude)
  Average wind speed: 15 knots (nautical miles per hour) from the east
  Average current speed: West-flowing at .5 knots

  Intertropical Convergence Zone (3°N latitude to 9°N latitude)
  Average winds: Doldrum conditions—light and variable winds averaging 7.5 knots from the east
  Average current: Unpredictable, cannot be factored into your course line

  Northeast Trade Wind Belt (9°N latitude to Hawai‘i)
  Average wind speed: 15 knots from the ENE
  Average current speed: West-flowing at .5 knots

- The average speed of *Hōkūle‘a* is 1/3 the wind speed. Wind speed is measured in knots. A knot is one nautical mile per hour.
- All distances are measured in nautical miles. One nautical mile = 6076 feet = one minute of latitude or longitude. Latitude and longitude are measured in degrees (°) and minutes ('). There are 60 minutes in a degree longitude or latitude.
- When you plot the actual heading, factoring in the total distance and direction of drift due to the current for the entire segment, you'll need to plot the distance and direction of the drift for the entire segment and adjust the actual heading accordingly. For example:



Sailing Plan Summary *Nuku Hiva to Hāna, Maui*

Write your sailing plan below. Include your calculations.

Segment 1: In the Southeast Tradewinds

Latitudes: __________ to ____________

Average canoe speed:

Average distance traveled per day:

Total distance to be traveled: 710.6 miles
Total number of days for this segment:

Expected total distance and direction of drift due to the current:

Heading: NNW
Determine the actual heading with current factored in and draw it on the reference course map (p. 27).

Segment 2: In the Intertropical Convergence Zone

Latitudes: __________ to ____________

Average canoe speed:

Average distance traveled per day:

Total distance to be traveled: 368.1 miles
Total number of days for this segment:

Expected total distance and direction of drift due to the current:

Heading: NNW
Determine the actual heading with current factored in and draw it on the reference course map (p. 27).

Segment 3: In the Northeast Tradewinds

Latitudes: __________ to ____________

Average canoe speed:

Average distance traveled per day:

Total distance to be traveled: 785.3 miles
Total number of days for this segment:

Expected total distance and direction of drift due to the current:

Heading: Between N by W and NNW
Determine the actual heading with current factored in and draw it on the reference course map (p. 27).

Segment 4: Westward to Hāna

Latitudes: 20° 30’ N to 20° 45’N

Average canoe speed based on wind speed:

Expected HOURLY distance and direction of drift due to the current:

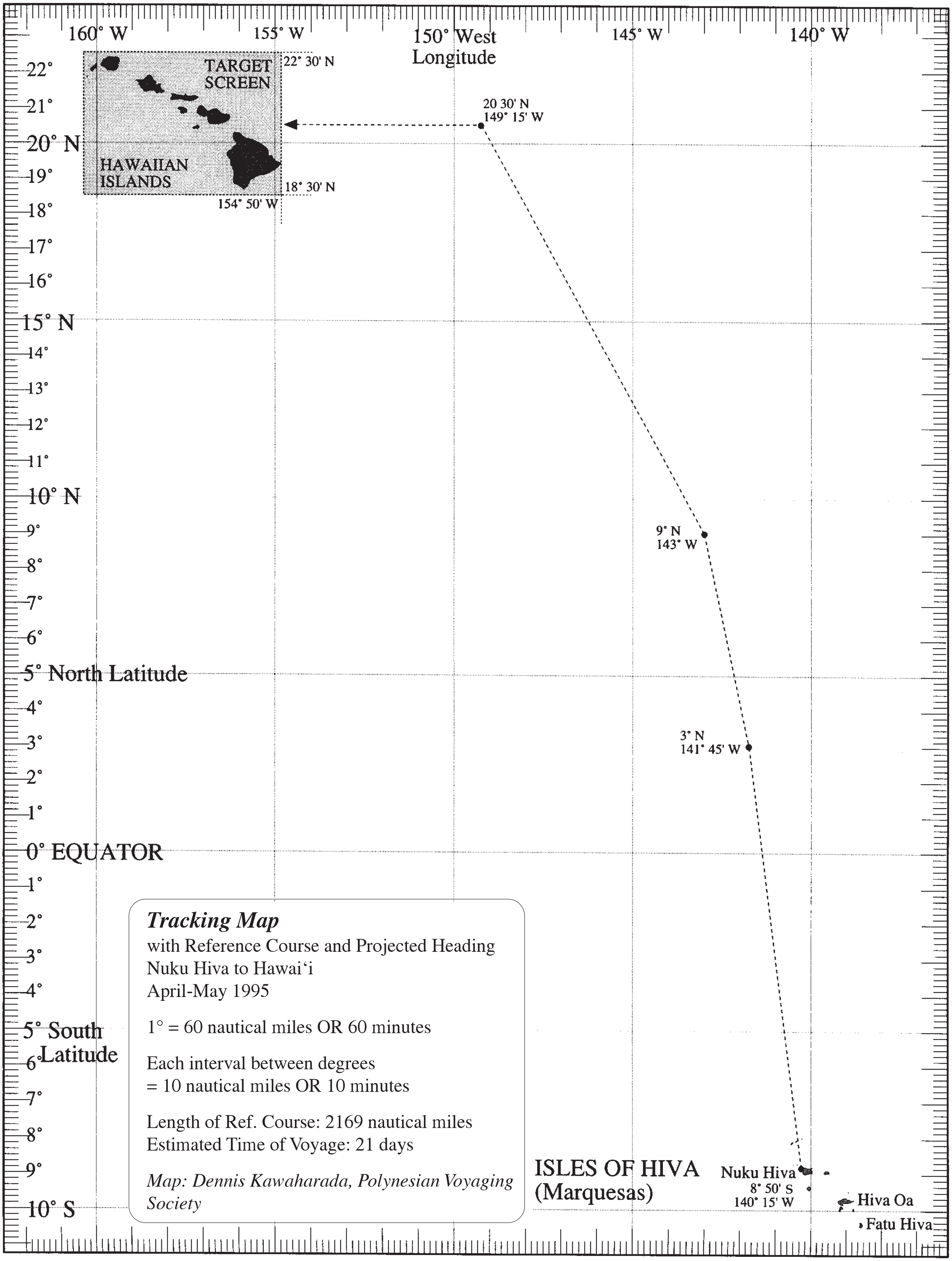
Expected actual performance of the canoe (add speed based on wind and current together):

Average distance traveled per day:

Total distance to be traveled: 405.3 miles
Total number of days for this segment:

Expected total distance and direction of drift due to the current:

Heading: W
Determine the actual heading with current factored in and draw it on the reference course map (p. 27).



Tracking Map
with Reference Course and Projected Heading
Nuku Hiva to Hawaiʻi
April-May 1995

1° = 60 nautical miles OR 60 minutes

Each interval between degrees
= 10 nautical miles OR 10 minutes

Length of Ref. Course: 2169 nautical miles
Estimated Time of Voyage: 21 days

Map: Dennis Kawaharada, Polynesian Voyaging Society