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Exploring and Colonizing the Pacific by Logic and Computer

For years histories of seafaring have focused primarily on Ancient Egypt, the Mediterranean, and Western Europe, tracing human maritime capabilities to the point when western European mariners developed the technology and skills to sail continuously from ocean to ocean over the global sea, an achievement that naval historian Perry called the "discovery of the sea" (1974). Yet any truly global account of our species' development of seafaring would also have to record the nautical achievements of other maritime peoples, which, preceded this globe-girdling stage of maritime development. Examples come to mind such as the expeditions of the early Ming Dynasty, when the Chinese sent huge fleets of ships into the Indian Ocean as far as the shores of Africa; the pre-Columbian pioneering of sea routes along the Pacific coast of South America by Native American raft sailors; and above all the expansion into the Pacific that started in Pleistocene times with the crossing to Greater Australia and culminated in the more recent colonization by Austronesian canoe voyagers of the islands of the deep Pacific.

Over the last thirty or so years anthropologists, archaeologists, linguists, and students of indigenous sailing and navigation have made great progress in roughly outlining the sequence and chronology of Pacific expansion and, in the case of the Austronesian phase, in providing insights based upon contemporary ethnographic and experimental research about canoes, navigational methods, and sailing strategies. Irwin's book represents the most ambitious attempt to date to draw from all this material to come up with a comprehensive model for the exploration and colonization of the Pacific. Using logic and computer simulation, Irwin cuts through the jumble of data, hypotheses, and opinions to brilliantly and economically model this Pacific Ocean phase in humanity's spread over the globe.

In the mid-1960s when David Lewis was beginning his remarkable studies of indigenous Pacific navigation reported in ***We, the Navigators*** (1972), and a team of Hawaiian outrigger-canoe paddlers and I were testing

the performance of ***Nalehia,*** the first of the Polynesian double canoes to be reconstructed for experimental purposes, a group led by geographer Gerard Ward started a project to test by computer simulation Andrew Sharp's then-influential thesis that because of the limitations of their primitive sailing and navigational technology, Polynesians could only have "accidentally" settled their islands through a long series of random and for the most part involuntary drift voyages (Sharp 1956). Ward and his colleagues first loaded their computer with a massive compilation of data on wind and current speed and direction in the Pacific, estimates of the drift speed of canoes pushed by the wind and current and how long crews could survive at sea, and then instructions for subjecting canoes to wind and current drawn from the compilation and for plotting their progress until land was reached or the crews perished. Their simulations of thousands of drift voyages clearly showed the poverty of Sharp's thesis: above all it could not really account for the long crossings by which the whole of the Polynesian triangle was settled, in particular the expansion eastward from West Polynesia to the archipelagoes of central East Polynesia, and the subsequent movements from there north to Hawai'i, southeast to Rapa Nui, and southwest to Aotearoa (Levison, Ward, and Webb 1973). Yet, although they concluded that Polynesia must therefore have been settled intentionally by seafarers deliberately exploring unknown seas and intentionally colonizing the islands they found, Ward and his colleagues did not attempt to simulate how they might have accomplished this.

Some data for such a simulation were then available. Our experiments with ***Nalehia*** had indicated that a double canoe could sail to windward up to about 75 degrees off the wind (Finney 1967), a figure supported by observations of the windward capacity of Micronesian outrigger canoes made by Gladwin (1970) and Lewis (1972). We then plotted how a canoe with such a windward capacity could sail from Hawai'i to Tahiti by making a long, curving slant across and slightly into the westward-flowing trade winds and equatorial currents, a model supported by the 1976 voyage of ***Hokule'a,*** our second reconstructed canoe, and the four subsequent crossings she has made between Hawai'i and Tahiti. In addition, published accounts dating back at least to Cooks times indicated that when indigenous seafarers from Indonesia to Polynesia wanted to sail to the east against the trade-wind direction, they waited for those times when the trades were replaced by spells of westerly winds. Had Ward and his associates, or others following immediately in their wake, injected rules for sailing up to 75 degrees off the wind and for waiting for westerly wind shifts into the simulation program, the resultant trials would have undoubtedly demonstrated how gaps unlikely to have been crossed by drifting could have been closed by sailors who had learned to wait for favorable winds before starting out and who could slant moderately

to windward when necessary. Yet, I doubt if a hasty reprogramming with just these two factors would have resulted in a study as sophisticated as the one under review here.

Irwin titles his last chapter "The Rediscovery of Pacific Exploration." I would foreground that process and assert that Pacific archaeologists had to rediscover the seafaring basis of Pacific colonization before so comprehensive a study as this one could have been undertaken. Although when we began experimenting with sailing canoes some archaeologists were vitally interested in our findings, many others were skeptical of their value. The latter seemed wary of the whole idea of intentional voyaging by competent seafarers. A distrust of oral traditions upon which earlier models of voyaging and settlement had been based, a rejection of the culture history approach in favor of focusing on processes of adaptation and change on assumed island isolates, and an ignorance of sailing and navigation were involved in their skepticism. Many seemed content to assume that each island or archipelago had been settled when somehow one or at the most a few canoes chanced upon it, and that the resultant societies developed thereafter in total or near total isolation from all but nearby islands. However, such least-moves modeling could not stand up in the light of the discoveries that followed in the 1970s and 1980s. For example, the archaeologically revealed evidence of the remarkably swift colonization of islands spread from the Bismarcks to Samoa, and of the exchange of materials along at least major portions of this 2,000-mile-plus stretch of ocean and islands, begged for models featuring intentional exploration and colonization as well as interarchipelago, two-way travel. Then, the documentation by Lewis, Gladwin, and others of the superb skills of surviving navigators in the central Caroline Islands of Micronesia and a few other remote places, plus the realistic insights on navigation and sailing strategy provided by sailing ***Hokule'a*** over the long sea routes of Polynesia, served to demonstrate how stone-age sailors could have intentionally explored and colonized the Pacific and then traveled back and forth between distant outposts. Now, intentional voyaging is certainly "in" among Pacific archaeologists, as witness one of their most exciting research frontiers: investigating long-distance interaction in the Pacific by tracing basalt adze blades and other mineral products that bear a unique chemical signature back to the islands where they had been quarried (Weisler 1997).

Irwin, one of the few archaeologists who owns his own ocean-sailing yacht, writes how one of his most fruitful insights into Pacific colonization came in 1985 while sailing his yacht ***Rhumbline*** westward from Fiji to New Guinea, and, as he puts it, "nursing" his "dissatisfaction with the subject of Pacific colonization" (p. 8). As the yacht slipped downwind with the trades, opposite the generally eastward course followed by the pioneering Austronesian sea-

farers, it occurred to him that he was experiencing the other side of the coin of colonization: "It was what any canoe could choose to do, which had sailed upwind, whether it found land or not. The ease of sailing west is what made sailing east possible!" This insight he later transformed into a formal sailing strategy, which in this study he argues best accounts for the eastward expansion of Austronesian seafarers and shows the highest success and survival rates in his computer simulations: explore to the east on westerly wind shifts, then after finding land or failing to do so after a reasonable time, turn around and sail west before the returning trade winds, first sailing to the latitude of the departure island and then running down that latitude to get home safely. Other nautically informed writers had stated that the ability to exploit westerly wind shifts and the subsequent resumption of easterly trades to explore eastward and then run home to spread the word of a new discovery or in order to survive after a fruitless search must have been crucial to this oceanic expansion. But Irwin has elevated this to a comprehensive strategy and tested it against the archaeological record and by means of computer simulations.

The resultant analysis compellingly models the Austronesian expansion eastward and offers stimulating perspectives on the moves off the main line of advance to eastern Micronesia, Hawai'i and Aotearoa, as well as such issues as the abandonment of the marginal islands and the settlement of the outliers. With text, charts, and diagrams Irwin delights in demonstrating how his analysis leads to new and surprising insights. For example, he argues that plotting the eastward progress of Pacific colonization implies that instead of slowing it was "accelerating at a rate approaching exponential" (p. 81) until the seafarers ran out of uninhabited islands and possibly landed on the shores of an already populated South America (p. 80: fig. 24). He also maintains that both his plotting of archaeological dates and his computer simulations rule out the disputed "long pause" in West Polynesia, arguing that progressive improvements in nautical skills more than matched any difficulties met with as these seafarers moved across the Pacific (pp. 88-89, 208-209).

Nevertheless, as in any grand scenario, there is plenty of room for objection and comment. For example, the Austronesian ***drang nach Osten*** does not appear to have smoothly accelerated to the point of going exponential if the starting gate is set back, as many students do, to the Bismarck Archipelago region as opposed to where Irwin models it (p. 80: fig. 24): the Santa Cruz Islands, midway between the Bismarcks and West Polynesia. Take a globe and a piece of string. Place one end of the string at the Bismarck Archipelago and then extend the string eastward to West Polynesia and cut it there, thereby creating a measuring rod representing approximately 2,100 nautical miles. Then stretch the string eastward from West Polynesia, and you will

find that it reaches slightly beyond the Marquesas Islands. If expansion continually accelerated from the Bismarcks, we should therefore expect that it would have taken a significantly shorter time to reach, from West Polynesia, the Marquesas and certainly Tahiti than it took to move from the Bismarcks to West Polynesia. Although Irwin quotes himself on the archaeologically "instantaneous" character of the latter movement--meaning that the time was too short to measure given the uncertainty range in radiocarbon dating, he supposes for purposes of discussion that as much as 500 years might have been involved in moving from the Bismarcks to West Polynesia (p. 39). If, therefore, West Polynesia was reached in 3500 **B.P.** as Irwin charts it in fig. 24 (p. SO), during an accelerating expansion the central East Polynesian islands up to and including the Marquesas should have been reached in significantly less than 500 years, or before 3000 **B.P.** However, this time frame is well before any existing radiocarbon dates, or even Irwin's early settlement estimates graphed in fig. 24, which indicates that at 3000 **B.P.** the frontier of expansion had reached only as far as the Cook Islands, some 700 miles east of Samoa and just halfway to Tahiti. In a perfect archaeological world where the earliest sites are always found and dated without problem, this issue of whether the Austronesian expansion smoothly accelerated throughout its length or was punctuated by bursts and pauses of varying durations could be solved easily. Until then we are stuck with models that depend upon differing estimates of site sampling error, interpretations of radiocarbon dates, and ways of imagining the expansion.

Irwin clearly sets out the computer simulation results in charts, tables, and accompanying text but cautions the reader not to imagine that island navigators ever employed the sailing strategies he tests precisely as he develops them (p. 209). The reader should also be cautious about the virtual environment into which Irwin injects his imagined voyagers, for as he outlines it on pp. 134-136 they sail on a sea without currents, employing wind data from only two months out of the year.

Sailing virtual canoes over a currentless sea may simplify computer simulations but could produce unrealistic results where current counts--such as when, during an eastward passage started with a westerly wind shift, easterly trades come back in strength and require a canoe to tack, or when a canoe makes long slants across steady winds and accompanying currents. A canoe tacking to windward 75 degrees off the wind must travel almost four miles at an angle to make one mile directly to windward. Thus a canoe tacking at four knots would be making only one knot directly to windward, or twenty-four miles in one day. But if that canoe is also sailing directly against a one-half knot current, windward progress would be cut to half a knot, or twelve miles a day. A current of one knot would stop forward progress cold. Even

sailing across the current flow can significantly affect canoe performance, as is evident every time we sail ***Hokule'a*** from Hawai'i to Tahiti. Tahiti lies some 2,250 nautical miles south-southeast of Hawai'i, slightly upwind of the easterly trade winds that flow over most of the route. If there were no currents in the sea, sailing from Hawai'i to Tahiti would be relatively easy. Just put the canoe on a heading sufficiently into trade-wind flow to gain enough miles to the east to reach the longitude of Tahiti, and not end up west of the island. However, except in a narrow band just north of the equator, strong ocean currents generally flow from east to west across the course, requiring us to sail ***Hokule'a*** extra hard into the trades to keep from getting set to the west of Tahiti. Although adding current to computer simulations on this and other routes would not be easy, doing so would enhance the applicability of such virtual voyaging to the conditions actually faced by sailors.

The ways in which Irwin employs wind data in his simulations also raise questions about their application. He appears to use only two months of wind data: those for January and July, to represent midsummer and midwinter conditions. What about sailing in April, November, or other times of the year when conditions are most likely to be favorable in particular regions? Although Irwin gives little detail about his simulation programs, it also appears that for his virtual sailors the computer probabilistically selects a wind for "each new day" (p. 135). Both from ethnographic information and experience we have learned to sail by exploiting favorable spells of wind, such as the brief episodes of westerlies that enabled ***Hokule'a*** to be sailed from Samoa to Tahiti--against the direction from which the trade winds usually, but not always, blow. Does Irwin's program effectively simulate these and other spells of winds that are so crucial to actual sailing strategy? Or, as Irwin's wording would seem to indicate, is the wind for each day a separate probabilistic event?

One of the main strengths of this book is its inclusiveness. Irwin does not confine himself to only one phase of Oceanic expansion but begins the story of Pacific settlement with the very early expansion into Greater Australia and the voyaging conditions around New Guinea, and also includes an interesting chapter on Micronesia, which, since the advent of the Lapita discoveries, has come to be considered off the main line of advance. This inclusive approach stimulates such comparative questions as why the expansion (whether smoothly accelerating or punctuated) eastward by Austronesian voyagers from south of the equator continued so far across the Pacific, in contrast to the apparently truncated eastward thrust to Micronesia by their cousins from north of the equator. During the same era Austronesian sea-

farers were striking out into the Pacific, other Austronesian sailors, perhaps sailing from the Philippines, reached the Marianas, and perhaps Belau and Yap. However, these North Pacific Austronesians apparently did not keep expanding to the east like their South Pacific cousins. Primarily from linguistic evidence, it appears that the Micronesian islands farther to the east were settled first and/or primarily by southern voyagers who split off from the Lapita trail, headed north across the equator, and then to the west to populate the earlier settled islands along Micronesia's western margin. Why didn't the initial thrust to Micronesia from the west carry farther into the ocean?

Might it have been, as Irwin suggests, because 3,000 or so years ago the Carolinian atolls immediately to the east of the western edge of Micronesia were still just below the surface of the sea, or only barely awash, and therefore provided little incentive for expanding eastward? Perhaps, but as Irwin admits, we can't really be sure these atolls were not already above the surface then. Furthermore, even if they were still submerged, it could be argued that seas filled with shoaling atolls would have encouraged truly expansive seafarers to keep probing eastward to find and settle the handful of high islands and upraised atolls beyond, and then perhaps to dip southeastward and cross the equator to the more island-filled seas there. A more fruitful tack to take in trying to explain this contrast between the two eastward movements might be to emphasize those factors explored by Irwin that appear to have been crucial to the advance of Austronesian voyagers through the islands south of the equator. In apparent contrast to the seas north of the equator from whence sailed the colonizers of western Micronesia, the "voyaging corridor" running from northern Indonesian-southern Philippine waters eastward along the northern shore of New Guinea was truly a nursery for adventurous seafaring. Its alternating regime of easterlies and westerlies, lack of tropical cyclones, and abundance of island landfalls seem to have honed the seafaring skills of early Austronesian sailors (who may also have benefited in some degree from the local knowledge of indigenous sailors and farmers descended from the Pleistocene seafarers who first colonized this region). Then the chains of islands to windward with respect to the trades apparently beckoned these fledgling explorers farther and farther to the east, particularly when they reached the point where the islands were empty of other humans. The resultant expansion across the Pacific stands as one of the most remarkable nautical achievements in humanity's spread over the planet. By so clearly and resolutely modeling this expansion, Irwin's book puts archaeologists firmly back on board the endeavor to understand how the open Pacific was first explored and colonized.

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