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RESOLVING AMBIVALENCE IN MARSHALLESE NAVIGATION

RELEARNING, REINTERPRETING, AND REVIVING THE "STICK CHART" WAVE MODELS

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Marshallese wave navigation remains one of the least understood systems of traditional spatial orientation in Oceania. A sharp decline in voyaging during the historic era and continuing reluctance to share the surviving family-based knowledge of the waves has led to ambiguous and sometimes contradictory interpretations, encompassing both local and anthropological ambivalence. In this article, I examine the navigational concepts of two acknowledged experts from different navigation schools in the Marshall Islands who modeled their ideas of the dynamic flow of ocean waves in wooden instructional devices, commonly referred to as "stick charts." Of central importance is how a navigator worked toward resolving his ambivalence of these concepts by relearning, reinterpreting, and reviving the stick chart wave models. Theoretically, the selectivity of abstract models during practical engagement in the oceanic environment adds to an already powerful dynamic in the complementarity of information processing modes in Marshallese navigation and other systems of way-finding more generally.

Keywords: Navigation, Stick Charts, Marshall Islands

Introduction

The many forms of inquiry into Pacific navigation and voyaging have led to an increasingly clear understanding of oceanic systems of spatial orientation. Archaeological, genetic, and linguistic studies that have traced the flow of ancient migration routes across the Pacific Ocean continually reinforce the idea that settlement involved intentional, two-way voyages of exploration and colonization (Howe 2007; Kirch 2000, 2010). Experimental voyages (Finney 1979, 1994, 2003), and simulated voyages (Avis et al. 2008; Di Piazza et al. 2007; Evans 2008; Irwin 1992) have demonstrated the seaworthiness of the ancestral double-hulled voyaging canoes and hint at the navigational abilities possessed by the pioneering mariners who first sailed into unknown seas and mentally mapped the locations of distant, newly discovered islands (Irwin 2007, 2008, 2011). Observations recorded by foreign explorers and visitors have provided a glimpse into the sophistication and extent of various navigation traditions at the time of European contact (Finney 1998), and richly detailed ethnographies and studies of the few surviving navigational traditions throughout Oceania have documented non-instrumental navigational techniques and highlighted distinctive regional variation (Ammarell 1999; Feinberg 1988; Gladwin 1970; Lewis 1994 [1972]; Thomas 1987). This has sparked a resurgence and revitalization of voyaging in island cultures that have enjoyed either a strong historic continuity of voyaging (e.g., Satawal) (Flood 2002; McCoy 1976; Metzgar 2006; Ridgell et al. 1994) or a complete cessation and recent rebirth of voyaging (e.g., Hawai'i) (Finney 1979, 1994, 2003, 2007; Low 2013).

Other major voyaging traditions lie somewhere in between these ends of the spectrum, but their systems of spatial orientation remain less well known. These include the voyaging communities of the Santa Cruz Islands of the southeastern Solomons and the Marshall Islands of Micronesia, where a decline and virtual cessation of voyaging by sometime in the twentieth century limited in-depth ethnographic investigations until recently.[1] Current efforts to revitalize inter-island canoe voyaging are now centering on the few surviving elders who remember but no longer regularly practice traditional navigation (Genz and Finney 2006; Vaka Taumako Project 2011). Those elders are providing key insights into such poorly understood navigational techniques as the wind compass (Feinberg and Genz 2012; Pyrek and Feinberg, this issue; Vaka Taumako Project 2016), an enigmatic underwater lightning-like phenomenon called *te lapa* (Feinberg 2011; George 2012), and wave piloting (Genz 2014; Genz et al. 2009). At the same time, they are seeking ways to balance the competing cultural imperatives to simultaneously safeguard knowledge-based positions of identity and revitalize cultural heritage (Genz 2011). Perhaps because of the sharp decline of navigational knowledge, and possibly a reluctance to share knowledge, the emerging understandings of spatial cognition and their representations within the contemporary seafaring communities of the Santa Cruz Islands and Marshall Islands are laced with ambiguous and sometimes incongruous interpretations.

Such understandings encompass both local and anthropological ambivalence (e.g., Feinberg and Genz 2012), which I view as a state of having contradictory ideas about something. In this article, I examine the navigational concepts of two acknowledged experts from different navigation schools in the Marshall Islands who modeled their ideas of the dynamic flow of ocean waves in wooden instructional devices, commonly referred to as "stick charts." Like Pyrek and Feinberg (this issue), my emphasis is on the specialist knowledge of technical idea systems. Traditionally, only a few select individuals within a particular community would have been trained in navigation. Due to the virtual cessation of voyaging in the Marshall Islands, only two surviving experts—Isao Eknilang and Thomas Bokin—know, or are willing to share with others, how to construct and interpret their "stick chart" models.[2] Thomas, who is a titled navigator with extensive sailing experience from a region called Kapinmeto, has a clear, non-ambiguous set of navigation concepts.[3] Isao, who has never attained the status of navigator, represents another group of islands centered on Rongelap atoll. The majority of the contradictory understandings stem from the ethnographic context of Marshallese voyaging and navigation, which is one of cultural revitalization. This is similar to the revitalization of voyaging in the Vaeakau-Taumako region of the Santa Cruz Islands discussed in this issue (Feinberg;

Pyrek and Feinberg, both this issue), and is a key feature of the ambivalence surrounding the "stick chart" models.

The genesis of the cultural revival of wave navigation in the Marshall Islands involved aspiring navigator Korent Joel, commonly and respectfully known as Captain Korent, learning and using the two schools of navigation (the Kapinmeto school through Thomas and the Rongelap school through Isao), an endeavor that was fraught with ambivalence. The two schools allow for contradictory interpretations of the wave patterns, which Captain Korent sought to combine into a single model. Captain Korent's ambivalence stems in part from trying to clarify these conflicting interpretations. This process of seeking comprehension was further complicated by divergent explanations of the waves from the perspective of Western science. Captain Korent sought such an outside scientific perspective to help resolve his own doubts about certain wave patterns. A final layer of ambivalence is anthropological—my own contradictory understandings of how Captain Korent synthesized and shared all of this information.

I describe in this article how Captain Korent Joel worked toward resolving his ambivalence with respect to navigation by relearning, reinterpreting, and reviving the "stick chart" wave models. A particularly insightful experience occurred during an inter-island voyage in 2006 when Captain Korent put the ideas of his teachers and oceanographers to the test. He navigated at sea with both models in mind but invoked certain elements of each depending on the environmental conditions. This selectivity of models resembles the way people of Taumako invoke alternate frames of reference depending on their immediate purpose (Feinberg, this issue). The ambivalence I address is generated within the context of cultural revival and relearning of navigational knowledge with a few select individuals rather than a systemic cultural ambivalence. The ambivalence regarding navigation in the Marshall Islands, generated from the process of cultural revitalization, augments the other contributions in this issue by detailing the routes taken by both anthropologist and local interlocutor (Captain Korent) to resolve that ambivalence. As such, it bears both theoretical and practical implications.

The particular technical aspect of Marshallese navigation—remotely sensing land by recognizing how islands disrupt the flow of swells and currents—is particularly useful in theorizing about cognitive and experiential ways of knowing. Reviewed elsewhere (Feinberg and Genz 2012; Genz 2014), cognition can refer to all modes of mental activity, including visual, haptic, aural, kinesthetic, vestibular, and proprioceptive information processing, as well the complementarity of experience and embodiment. Oceanic systems of navigation involve a process of combining cognitive information in memory with active sensory sources of information about the oceanic environment. The Marshallese "stick charts" serve as core knowledge represented and stored in memory that is used in conjunction with mostly sensory information of wave movements as felt within the body aboard a canoe regarding one's position, motion, and equilibrium.

There are very few words in Marshallese to convey sensations of wave movements. My informants emphasize the use of the waves even if they have difficulty describing them in their own language. Knowing how to use the waves is the same as showing understanding. This reflects a pragmatic theory of meaning, in which comprehension of the waves is primarily action-oriented. Early in the development of cognitive

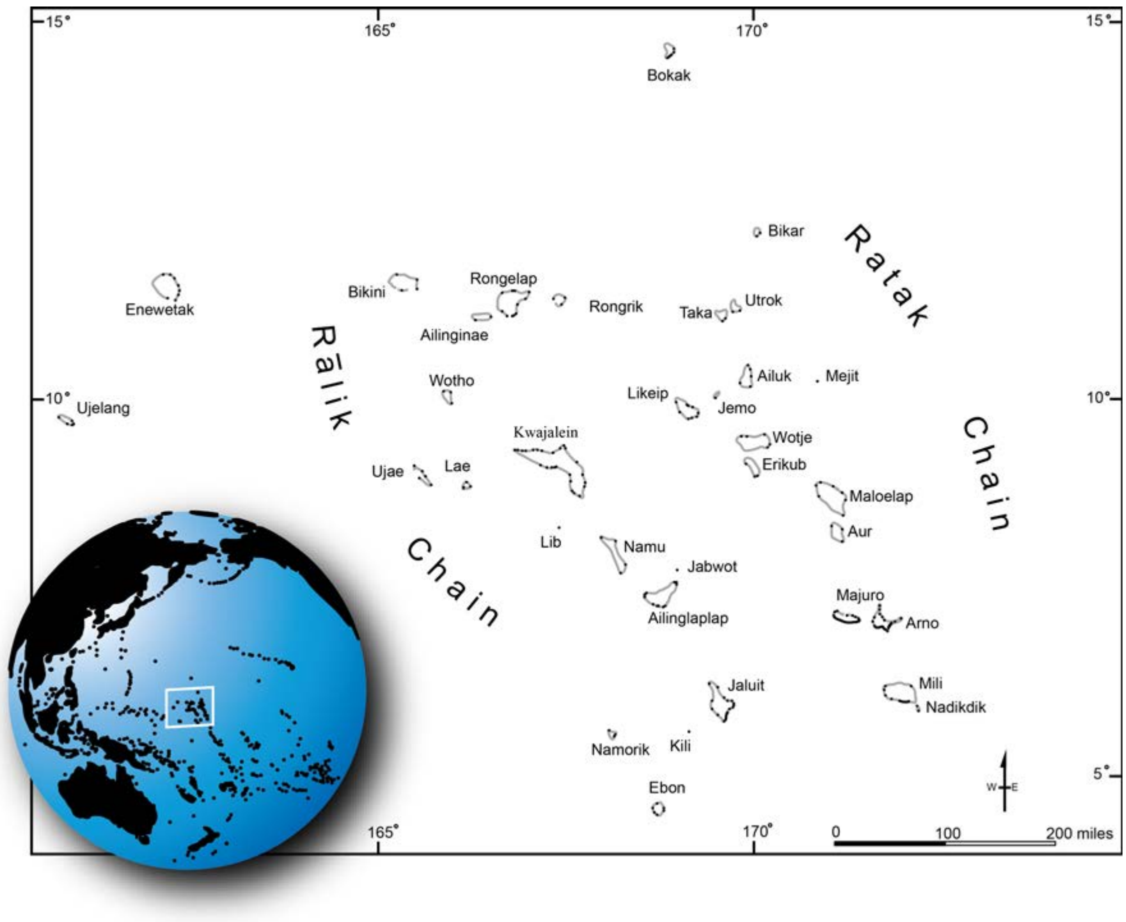

Figure 1. Map of the Marshall Islands.

anthropology, Whorf (1941) discussed the relation between language and habitual behavior. With minimal use of vocabulary in the case of Marshallese navigation, Whorf's emphasis on language can be complemented by non-linguistic representations of thought, namely the "stick chart" models, and ill-described sensory perceptions, especially balance. In this article, I also discuss the relation between the stick charts/sensory perceptions and behavior (navigation), with specific consideration of the relation between habitual or stereotypical navigational practices (the sailing strategy) and actual behavior as observed on the 2006 voyage.

Ethnographic Setting

In contrast to other islanders in Oceania, who guided their canoes primarily by the stars and winds, the Marshallese apparently took the common land-finding technique of detecting how swell and current pattern disruptions can be used to sense land remotely (Lewis 1994) and developed this into a comprehensive system of navigation. Sometime after settlement of the archipelago approximately two thousand years ago, navigators focused their observations for detecting land on one environmental phenomenon—the ocean. The geography of the Marshall Islands helps to account for this emphasis on waves for navigation.

The Marshall Islands is composed of 29 coral atolls and 5 coral islands in two main chains, called Ratak and Rālik, that extend over five hundred nautical miles just north of the equator along a southeast-northwest axis in the western Pacific Ocean (Figure 1). A swell produced by the dominant unobstructed northeast trade wind hits most of the atolls directly in the eastern chain and then in the western chain, transforming through wave reflection to produce windward reflected waves. In addition, through wave refraction it passes by the atolls to produce lee-wave crossing patterns (Genz et al. 2009). The twin chain archipelago also straddles the seasonally fluctuating boundaries between opposing streams of the west-flowing north equatorial current and the east-flowing equatorial counter current (Lagerloef et al. 1999). In addition, swells may transform as they pass through this spatially varying field of currents (Genz et al. 2009:219), and atolls may additionally deflect and accelerate the flow of these current streams (Laubenfels 1950a; Spoehr 1949).

Using the waves as guides, the descendants of the first inhabitants refined their sailing canoe technology to establish and maintain widespread patterns of inter-island and extra-archipelago communication. Voyaging networks documented toward the end of the nineteenth century within and between the Ratak and Rālik chains supported resource extraction and exchange as well as facilitated the consolidation of chiefly power (Spennemann 2005). Then, social disruptions under the German (1885-1914) and Japanese (1914-1944) colonial administrations impacted canoe voyaging and wave navigation. An ideological shift was occurring where the Marshallese began to devalue their traditional culture—especially sailing canoes—in favor of modernity. This, coupled with colonial prohibitions on inter-island canoe travel, resulted in a sharp decline that culminated in a virtual cessation of voyaging with the intrusion of the Pacific theater of World War II. The atoll of Rongelap is one of the few places where the voyaging traditions managed to persist, but this was short-lived.

Immediately after the war, the U.S. detonated sixty-seven nuclear bombs on Bikini and Enewetak atolls as part of its weapons testing program. The consequences of these detonations were most damaging to the residents of Rongelap, who received direct exposure to radioactive fallout from a hydrogen bomb, codenamed Castle Bravo, in 1954 with an unprecedented explosion equivalent to the force of 15,000,000 tons of TNT going off. In addition to immediate radiation burns and subsequent inter-generational birth defects, the Rongelapese suffered from contamination of resources, forced relocation, and treatment as human subjects in biomedical treatments, further damaging their health and psychosocial well-being (Barker 2013[2004]; Johnston and Barker 2008).

After the Rongelapese were told by the U.S. government that it was safe to return to Rongelap in 1957, a young Korent Joel began learning navigation from his grandfather by feeling shallow waves at a particular coral reef. Here, young students of navigation traditionally began their instruction by feeling how the movement of water simulated much larger ocean swells as they approach land. A number of students were eagerly studying traditional navigation until 1954, when the Bravo detonation brought their activities to a halt. Isao Eknilang, who was my main informant for the traditional lore of navigation from Rongelap, had been a student within this last cohort. With the school of navigation essentially no longer operational, the lone, young Korent learned navigation quietly from his grandfather. He lay blindfolded in a canoe while his grandfather towed him to various positions around a coral islet so that he could determine his location based on how the intersections and reflections of incoming waves from the ocean and lagoon affected the motion of the canoe. Since Rongelap remained radioactive, however, this was a fleeting exercise in what would have under normal circumstances been numerous years of rigorous training. Fearful of radiation and distrustful of the U.S. government's declaration that Rongelap was safe, Korent's family sent him, now a teenager, to Honolulu in 1968 to learn how to captain government cargo ships with modern celestial navigation. Twenty years later, the rest of the Rongelap community perceived their homeland as a nuclear wasteland and left, and have yet to resettle.

Captain Korent's time in Hawai'i coincided with a re-birth and renaissance of Polynesian voyaging. My academic advisor, Ben Finny, was pioneering the approach of experimental voyaging to ascertain how ancient seafarers cold have navigated and sailed their voyaging canoes to explore, settle, and discover the Pacific Islands. Assessing the performance capabilities of voyaging canoes led to the construction and sailing of *Hōkūle'a* and other double-hulled Polynesian voyaging canoes over considerable distances of thousands of miles out of sight of land using traditional navigation (Finney 1979). Ethnographic documentation of extant navigation traditions spurred local communities to revitalize their voyaging practices (Lewis 1994). These waves of inspiration rippled throughout the Pacific, including the Marshall Islands. Efforts there to preserve and revitalize the canoe building traditions led to the development of a community project called *Waan Aelon in Majol* (Canoes of the Marshall Islands), with the ultimate goal of voyaging once again with wave navigation (Alessio and Kelen 2004).

Inspired by *Hōkūle'a* and with the community support of *Waan Aelon in Majol,* Captain Korent, now a seasoned sea captain on government cargo ships, initiated a collaborative endeavor in 2005 with University of Hawai'i anthropologists and oceanographers to synergistically research, re-learn, and revitalize Marshallese navigation and voyaging (Genz 2011; Genz and Finney 2006).[4] Alson Kelen of *Waan Aelon in Majol*, who served as my co-researcher and co-facilitator of the revival project, followed a progression of learning that mirrored how Captain Korent and several other navigation informants learned the art as apprentices. Alson and I observed the Rongelap training reef and continued to learn—as Captain Korent had—through explanations of wooden models, commonly called "stick charts," that graphically represent the key navigational concepts. Finally, the research culminated in an inter-island voyage in 2006 that served as a way for Captain Korent to demonstrate his knowledge and use of wave navigation. That voyage also functioned as a test, under traditional chiefly protocols of knowledge transmission, that enabled Captain Korent to become a socially recognized navigator. A successful journey by the traditional methods of wave navigation would enable Captain Korent's chief to bestow upon him the title of navigator. Such a test was necessary, because his youthful training had been disrupted by the myriad social changes wrought by the thermonuclear Bravo test of 1954 (Barker 2013 [2004]; Genz 2011).

In preparation for the monumental 2006 voyage, Captain Korent learned from several elders, especially his uncle, Isao Eknilang. Isao had also learned navigation on Rongelap, undertook his first voyage in his youth, and remembered the stories, chants, and songs surrounding the technical way-finding knowledge. Part of the rationale for the voyage was for Captain Korent to meet with another recognized navigator, Thomas Bokin, who lived on Ujae to the south in a region called Kapinmeto, which was traditionally a separate navigation training area with different ideas about how to use wave patterns for navigation. The resulting ethnographic details of what Captain Korent learned from these two experts, compared to an oceanographic perspective (Genz et al. 2009), have provided a robust understanding of this system of navigation (Genz 2014), while drawing attention to somewhat divergent instructional models between Isao and Thomas. Before embarking on the return voyage, Captain Korent had both of their instructional models in mind, and then during this return voyage Captain Korent worked toward resolving the apparent conflict between these divergent hydrodynamic models.

Marshallese Wave Piloting

Marshallese navigation is a system of wave piloting, in which mariners pilot, or guide, their canoes by reference to swell and current pattern transformations that are used to remotely sense land (Ascher 1995, 2002; Finney 1998; see Ammarell 1999 for discussion of piloting in Bugis navigation). Navigators set an initial course based on the known geographical configuration of atolls and islands and then orient themselves and maintain a course primarily in relation to absolute frames of reference by conceptually dividing the horizon into points and quadrants based on swells, currents, winds, and the rising and setting points of stars and asterisms (Erdland 1910, 1914). In practice, navigators rely almost exclusively on the dominant east tradewind swell and swells from three other quadrants that are coincidentally the same as Western demarcations of west, north, and south. With such an emphasis on an environmental feature (waves) that is in constant motion with changing direction, strength, and frequency, navigators must orient themselves through the practical activity of sailing out of sight of the home island and sensing the shifting configuration of myriad waves. With such a narrowly focused “navigational toolkit” (Pyrek and Feinberg, this issue), the foundation of navigators’ knowledge lies in their embeddedness in the voyage, or their complete immersion and practical engagement (Feinberg and Genz 2012; Ingold 2000:325; Lauer and Aswani 2009), especially their sensory perceptions of the movement of the ocean itself (Genz 2014).

Spatial orientation in Marshallese wave piloting centers on vestibular ways of knowing about the ocean. Rather than articulating the sailing course and actual heading in terms of the swells or other phenomena analogous to the Carolinian star compass (Alkire 1970; Gladwin 1970; Goodenough 1953; Lewis 1994; Sarfert 1911; Thomas 1987) or the wind compasses of the Santa Cruz Islands (Feinberg 1988; Feinberg and Genz 2012; Pyrek and Feinberg, this issue; Vaka Taumako Project 2016), directions for the helmsman are relative without a direct heading, with the primary directions of either *kabbe* ‘downwind’ or *bwābwe* ‘upwind.’ Further, navigators do not employ explicit dead-reckoning procedures for estimating their position once out of sight of land analogous to *etak*, the Carolinian ‘moving island’ concept (Gladwin 1970; Lewis 1994; Thomas 1987). Instead, contemporary Marshallese navigators continuously experience the flow of the waves toward the destination atoll by detecting and following a direct wave path between atolls, gauging the distance traveled on this path through current stream perturbations, and ascertaining the direction and distance toward land, if they do not hit it directly, by sensing wave patterns in particular quadrants surrounding the destination atoll (Genz 2014). This process involves navigators sorting out the different wave patterns and focusing on those heading their way. Navigators perched on the lee platform of the canoe's outrigger complex primarily use their sense of balance to feel how the canoe responds to the waves, and changes in the rhythmic motion of the canoe signify a distinctive "seamark" that indicates the direction and distance toward an island.

The system of Marshallese wave piloting was successfully put to the test by guiding a yacht between two atolls, Kwajalein and Ujae, separated by about 120 nautical miles. Captain Korent maintained that the hull design (a modern mono-hull compared to an outrigger canoe) did not affect his ability to interpret the waves through the motion of the vessel. Yet, this experiential component of navigation is difficult to internalize and even more troublesome to express in words (Feinberg and Genz 2012). Fortunately, Marshallese navigators have developed distinctive teaching devices to convey some of this vestibular knowledge and spatial information. Mentioned earlier, the first method of instruction involves simulating the sensations of movement of disrupted swell patterns for an apprentice by placing him blindfolded lying down in a canoe at various points surrounding a particular coral islet. The other main method of instruction is to model the wave concepts and map the locations of wave patterns in relation to land in the so-called "stick charts," a distinctive cultural representation of spatial relationships (Bennardo 2002).

Previous Interpretations of "Stick Charts"

The primary land-based form of navigation instruction with the "stick charts" has been riddled with competing interpretations since its first documentation. The American missionary Gulick (1862) and the German explorer Meinicke (1863:403) observed that Marshallese navigators constructed a variety of latticeworks of straight and curved lines from coconut fronds or aerial roots of pandanus trees, sometimes with the addition of lashed shells. They interpreted these devices as "stick charts" (*Stabkarten* in German), believing they showed the positions of islands, sailing courses, and sea conditions that navigators used while underway. The German ethnographer Schück made an extensive review of the growing number of reports (1884) and museum collections of stick charts (1902), but the clearest understanding first came from a captain of the German navy named Winkler (1901) who learned that the stick charts were not nautical charts or instruments used at sea to indicate sailing courses in relation to islands or currents, but were instead employed as teaching devices, depicting the direction of predominant swells, the bending of swells, their intersection in proximity to land, and the resultant sea conditions.

Importantly, Winkler's historically documented *mattang*, a Marshallese term for one kind of "stick chart," models the conceptual framework underlying Marshallese navigation. As an abstract, allocentrically-framed representation, the *mattang* isolates and idealizes the most important aspects of Marshallese navigation—the swells in relation to wind direction and land —through the geometry of curved lines and their intersections (Ascher 1995, 2002). According to Winkler (1901:493–494), the *mattang* represents

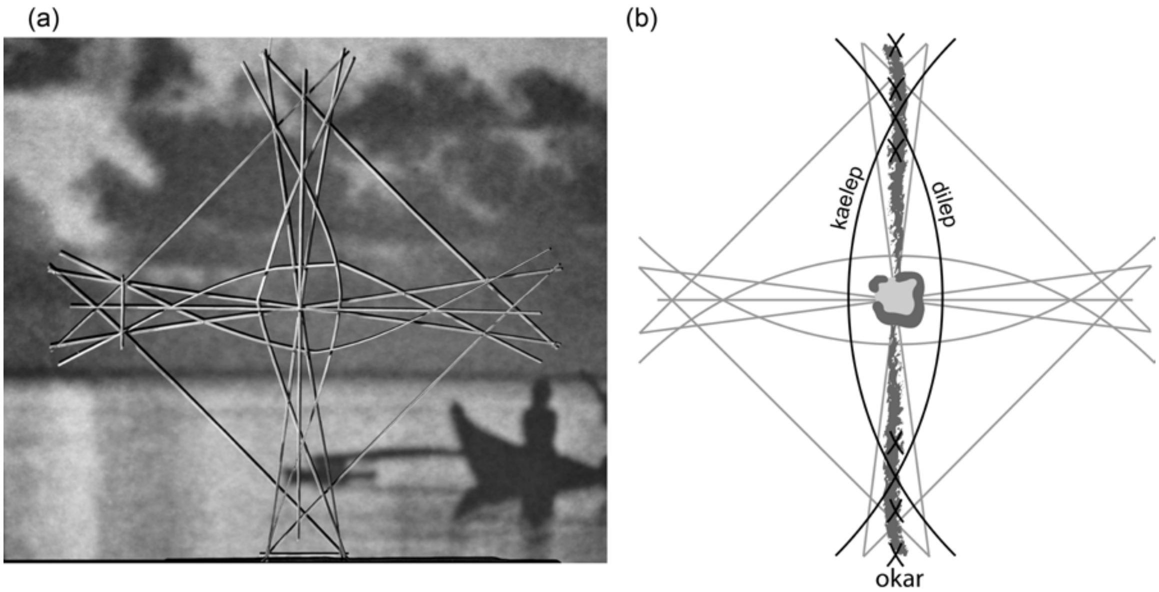

Figure 2. *Mattang* stick chart. An example of a *mattang:* (a) collected by Captain Winkler in 1898 (Catalogue No. E206187-0, photograph courtesy of the Department of Anthropology, Smithsonian Institution) and (b) drawing of the wave patterns (after Winkler 1901: 493).

swells from each of the four cardinal directions, with the eastern swell the strongest (Figure 2(a)). Each swell, or *Dünung* (German for 'dune,' as in a sand dune), bends as it approaches an island or atoll, forming a boundary marker that indicates the position and distance to land. As the four main swells bend around an island, those from opposite directions cross each other to form nodes of intersection called *booj* 'knot,' and the line that forms along these nodes of intersections is called an *okar* 'root.' The crossing of an eastern swell (*dilep*) and western swell (*kaelep*) north and south of island form *okar* that lead a navigator toward the island (Figure 2(b)). According to Winkler's informants (1901: 493), staying on this series of swell intersections to find land is the navigator's highest art: "As the root, if you follow it, leads to the palm tree, so does this lead to the island."

The unique wave-based system of Marshallese navigation enabled widespread interaction within and beyond the two island chains of the Marshall Islands during prehistoric and early historic times (Spennemann 2005; Weisler 2001). Such patterns of movement are inscribed in two other classes of stick charts recorded by Winkler—the *meddo* and *rebbelib*. These are analogical planar representations used for mapping particular regions (Ascher 1995, 2002). They trace the positions of real atolls—represented by lashed shells—and actual swell and current patterns. The *meddo* represents a few atolls from one island chain and the *rebbelib* depicts most of an entire chain or both island chains. One particular *rebbelib* documented by Winkler maps the islands of the western Rālik chain from Ebon in the south to Bikini in the north (Figure 3(a)). Winkler described how the angled chevrons indicate the *booj* along the *okar* from the crossing of the eastern and western swells between Namu and Kwajalein, Kwajalein and Rongerik, Rongerik and Rongelap, and Ailinglaplap and Jaluit (Figure 3(b)). The chevrons between

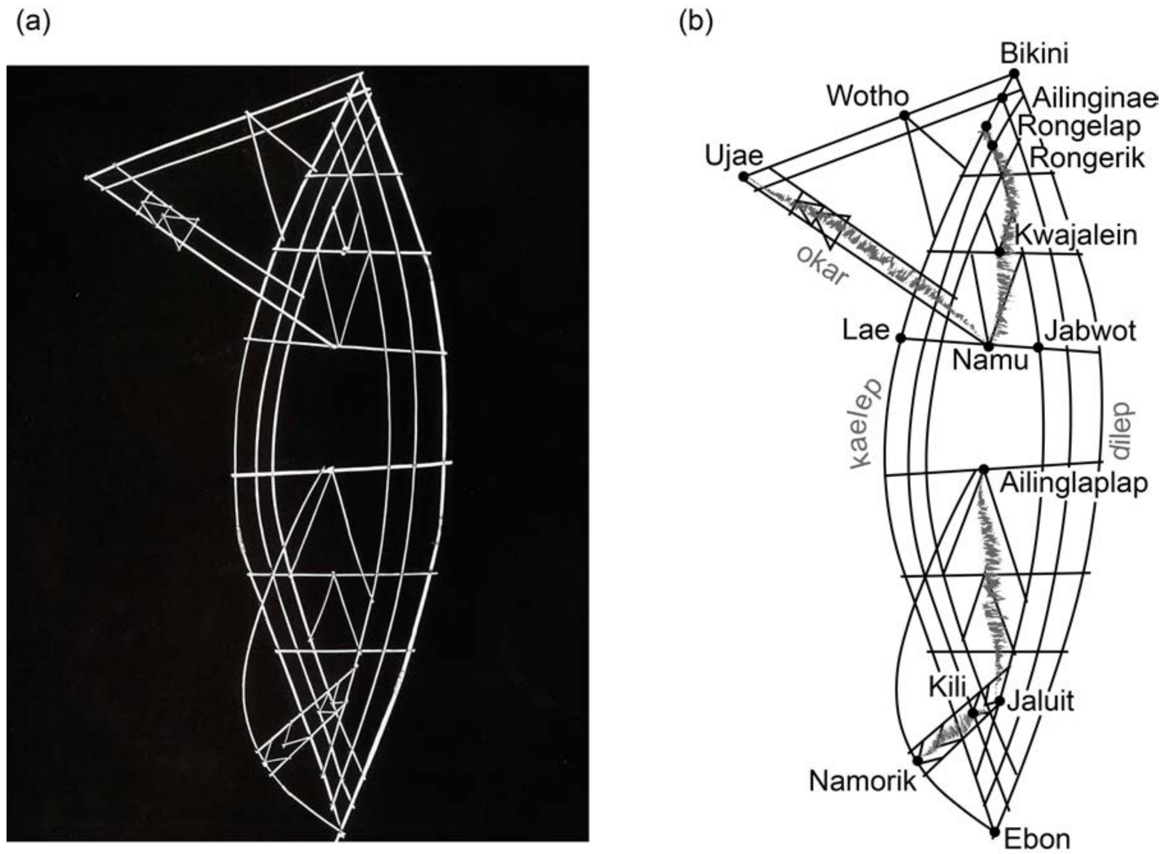

Figure 3. *Rebbelib* stick chart. An example of a *rebbelib:* (a) collected by Captain Winkler in 1898 (Catalogue No. VI 15283, photograph courtesy of the Ethnologisches Museum der Staat-lichen Museen zu Berlin–Preußischer Kulturebesitz), and (b) drawing of mapped locations of islands with *okar* (after Winkler 1901: 501).

Namu and Ujae and between Jaluit and Namorik indicate the *booj* along the *okar* from the crossing of the northern and southern swells. A distinguishing contrast between Winkler's documentation of these examples of *mattang* and *rebbelib* is that the *okar* in the *mattang* is centered on one island or atoll while the *okar* in the *rebbelib* extends between certain pairs of islands like a path.

Voyages of such length as depicted in these wooden cartographies declined dramatically in the late nineteenth and early twentieth centuries for a variety of reasons, including strict protocols of knowledge use and transmission (D'Arcy 2006:94–96), a perception of the prestige of European vessels (D'Arcy 2006:141; Spennemann 2005:33), social disruptions under the German and Japanese colonial administrations (Alkire 1978:141; Hezel 1995:108), a devaluing of traditional knowledge after World War II (Walsh 2003), and the physical and social consequences of the U.S. nuclear weapons testing program (Barker 2013; Johnston and Barker 2008; see Genz 2011 for detailed discussion). Despite the rapid decline of voyaging, some seafaring traditions in the Marshall Islands persisted into the mid-twentieth century and the stick charts continued to attract the attention of ethnographic research (Davenport 1960, 1964; Erdland 1910, 1914; Hambruch 1912; Knight 1999; Krämer 1905, 1906; Krämer and Nevermann 1938; Laubenfels 1950b; Lewis 1994; Spennemann 1993) and local documentation by a naviga-

Table: Marshallese Navigational Terms and English Meanings

Marshallese terms	English literal meaning	English gloss/description
Models		
meto	sea, ocean, navigation	navigational model, "stick chart"
niñeañ kab rōkeañ	northward and southward	navigational model, "stick chart"
wapepe	floating canoe	navigational model, "stick chart"
Swells		
buñtak or *kaeleptak*	swell flowing to the east	west swell
buñto	swell flowing to the west	east swell
buñtokeañ	swell coming from the north	north swell
buñtokrōk	swell coming from the south	south swell
Wave Paths		
dilep or *dileplep*	backbone, spine	wave path (or) east swell (documented by Winkler 1901)
okar	root	wave path (documented by Winkler 1901)
Navigational Signs		
booj	knot	node of intersection of swells
kāāj in rōjep	fishhook	navigational sign to the northeast and southeast of an island
kāāj in rōjep	fly seaward	reflected swell
kōkļaļ	navigation sign	general term for navigational signs
jur in okme	pole for breadfruit harvesting	navigational sign to the east of an island
lutokļo̧kkan	pouring out, away from you	wave pattern leading navigator astray
nit in kōt	pit for bird fighting	navigational sign to the west of an island
reļo̧k or *korteļo̧k*	plunge into the sea	wave pattern leading navigator astray
Currents		
aet	current	current
jukae	going into, crossing into	first zone of currents
rubukae	crossing	second zone of currents
jeljeltae	loosening, unravelling	third zone of currents

tor (de Brum 1961, 1962). Of the numerous documented stick charts and their explanations, the visual rendering of wave concepts in Winkler's historically documented *mattang* and the representation of the *okar* path of waves extending between particular pairs of atolls in the *rebbelib* are most similar to the wave models constructed by present-day navigation experts.

Wave Concepts and Models

My navigation informants represent their concepts of the ocean through models made by weaving and lashing thin strips of the aerial roots of the pandanus tree or the midribs of coconut palms into a latticework, as well as by more ephemeral sketches in the sand. They learned in their youth the explicit swell concepts modeled by these curved designs on their home atolls of Rongelap and Ujae. At his current home on Majuro, Isao Eknilang wove and lashed small pandanus roots to make two models called *niñeañ kab rōkeañ* 'northward and southward' and *wapepe* 'floating canoe.' On Rongelap, Captain Korent also demonstrated his ideas by tracing the main components of the *wapepe* in the sand. Thomas Bokin made a different latticework called meto 'ocean, navigation' at his home on Ujae by placing coconut palm midribs through a woven pandanus mat and setting coral pebbles inside this design. The concepts embedded within Isao's *niñeañ kab rōkeañ* and *wapepe* are similar to Thomas's *meto*, but there are clear differences. One immediate difference is the scale of the model, which is reflected in the terminology. The 'northward and southward' translation of *niñeañ kab* rōkeañ reflects the modeling of a voyage between northern and southern atolls, such as a southern journey of about 120 miles from Rongelap to Kwajalein. This distance is typical of many inter-atoll voyages in the Marshall Islands, which would involve sailing with steady trade winds for about 24 hours in one continuous passage. If the target atoll was farther south in this example, such as Alinglaplap, then Kwajalein would serve as both a (large!) navigational aide and an intervening island for the crew to rest and recuperate. The translation of the other two models as "floating canoe" or "ocean" are more general and reflect the modeling of courses in multiple directions. The Marshallese names, literal English meanings, and English glosses or descriptions of my informants' models and concepts are referenced in the Table.

These three models each represent three perspectives that can be employed anywhere throughout the Marshallese archipelago: (i) the wave field as experienced on a canoe at sea or in relation to an atoll; (ii) the oceanic conditions a navigator experiences between two atolls; and (iii) swell and current transformations in the vicinity of an atoll. Following Ascher (1995, 2002), these stick charts do not map the locations of actual atolls or wave conditions. The main concepts of wave navigation woven into all three of these models include an absolute directional frame of reference that depicts the cardinal directions from which swells emanate (or the directions to which they flow). The four swells that constitute the main field of waves (which is distinct from the current field) are called *buñto* 'east swell,' *buñtak* or *kaeleptak* 'west swell,' *buñtokeañ* 'north swell,' and *buñtokrōk* 'south swell.' My informants envision that these four swells flow continuously regardless of seasonal variations of wind and sea. As a result, this field of swells serves as the foundation for three interrelated concepts of the ocean used in navigation—*dilep* 'backbone,' *kōkļaļ* 'navigation sign,' and *aet* 'zones of currents.' However, my navigation informants lack consensus in attempting to explain these wave concepts.

Wapepe

The *wapepe*, constructed by Isao's weaving and lashing of thin strips of the aerial roots of pandanus (Figure 4(a)), can be interpreted from three perspectives. Of prime importance for spatial orientation is the modeling of the wave field (Figure 4(b)). The intersecting lines at the center of the latticework of the *wapepe* may represent a voyaging canoe or an island or atoll, and the four overlapping curves indicate the range of directions from which swells flow (east, west, north, and south). For instance, a navigator sitting on his canoe in the ocean or gazing out to sea from his home atoll envisions that the dominant swell flows from the east, *buñto*, which includes a range of directions from northeast to southeast, and a weaker swell flows from the north, *buñtokeañ*, extending from northeast to northwest.

The *wapepe* also models sea conditions between atolls, with the four ends of the latticework representing atolls (Figure 4(c)). From this regional perspective, the latticework shows the oceanic conditions a navigator experiences between ideally situated eastern and western atolls, and between northern and southern atolls. In reality, the atolls are not configured in such symmetry, but the navigator mentally adjusts the concepts within this latticework depending on the actual sailing route. The sea conditions between atolls center on *dilep*, which describes the foundation of way-finding as implied by its meaning, 'backbone.' Winkler (1901) previously described the *dilep* quite differently as the eastern swell. But for Isao and my other informants *dilep* is really much closer conceptually to Winkler's *okar*. The straight vertical and horizontal lines of the *wapepe* model such "backbone" waves between northern atolls and southern atolls, and between eastern atolls and western atolls, respectively (Figure 4(c) only labels one *dilep* for clarity). After setting an initial course based on the dominant swell patterns, the navigators search for the *dilep* of the destination island. Previous ethnographic documentation with navigators from Lae by Spennemann (1993) also diagrammed a *wapepe* with the *dilep* extending between islands. According to my informants and reminiscence of Winkler's (1901) *okar* and Spennemann's (1993:91) description, the navigators' highest art is to detect and maintain the canoe on the *dilep* in order to feel their way toward land by staying on this wave "path."[5]

Isao Eknilang, as well as my other Rongelapese informants, explain the *dilep* as primarily as an extension of reflected swells emanating from the destination island. When sailing from a southern to a northern atoll, for example, the navigator feels a pitching motion, where the bow of the canoe first goes up and then down, as the canoe encounters the intersection (*booj*) of an incoming southerly or southeasterly swell and its reflected wave energy. This is similar to a generalized navigational sign called *kāāj in rōjep* 'fly seaward,' or a reflected swell, except that the detection range of *kāāj in rōjep* is about 25 nautical miles and that of the reflected *dilep* waves is so great that it can be detected at the onset of a voyage irrespective of the distance to the target island. Current computer simulations of dominant east and west swells and their transformations, including reflected wave energy, suggests that distinctive wave signatures do in fact form between most islands pairs (Huth 2013:314).

Despite Isao's teachings of the *dilep*, Captain Korent held a completely different model in mind based on the teachings of his grandfather at the training reef on Rongelap

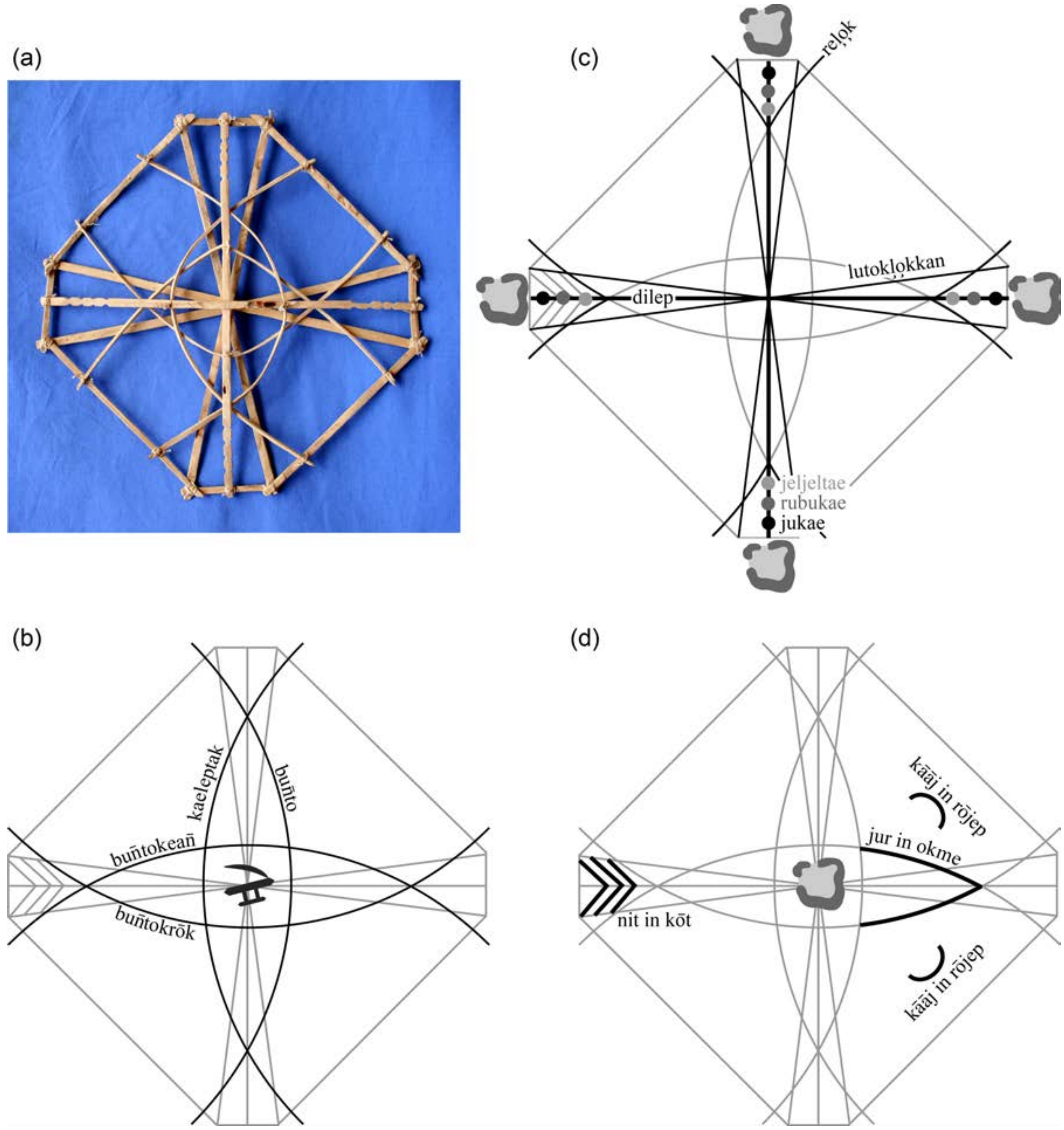

Figure 4. Interpretations of the *wapepe* model constructed by Isao Eknilang. The *wapepe* (a) models (b) the wave field as experienced on a canoe at sea or on an atoll, (c) the wave patterns between atolls, and (d) the wave patterns surrounding an atoll. (Note that the two windward *kāāj in rōjep* and the leeward *nit in kōt* are not represented by pandanus roots, but are depicted graphically.)

and his years of personal observations at sea aboard government cargo ships. Still maintaining that *dilep* are the straight wave paths between atolls as modeled in the *wapepe*, Captain Korent conceptualized *dilep* as the crossing of opposing or nearly opposing swells within a bimodal sea state that forms nodes of intersection (*booj*) between islands. In his youth, Captain Korent felt such a motion while lying on his grandfather's canoe at the training reef, with the intersection of a wave emanating from the ocean after it had broken on the reef and a wave traversing the lagoon from the opposite side of the atoll. The resulting rocking motion from side to side of a canoe is completely different from Isao's pitching motion of reflected wave energy. For example, when sailing from a southern to a northern atoll, the navigator feels how the eastern swell rolls the canoe from side to side, and how the western swell produces a similar motion. When the strength of these opposing, or nearly opposing, swells is equal, the navigator is sailing on the *dilep*. Yet, in situ oceanographic sensing of such a north-south *dilep*, as pointed out by Captain Korent during the field study, only indicated the presence of a strong easterly swell with no data for a westerly swell (Genz et al. 2009).

The regional perspective of the *wapepe* also includes a concept of the sea that involves three zones of currents called *jukae*, *rubukae*, and *jeljeltae*. These currents constitute three zones of distinctive wave patterns near islands that indicate relative distance toward land. *Jukae*, *rubukae*, and *jeljeltae* mean 'first zone of currents,' 'second zone of currents,' and 'third zone of currents,' respectively. With the ending of *ae* (current) on each term, *jukae* stems from *juk* (going into or crossing into), *rubukae* derives from *rubuk* (crossing), and *jeljeltae* comes from *jeljelat* (loosening or unravelling). While *dilep* and *kōkḷaḷ* (see below) are wave patterns that result from the transformations of swells, *jukae*, *rubukae*, and *jeljeltae* appear to be current-induced wave patterns. My informants envision that these current streams form regions of choppy waves in an otherwise normal sea state irrespective of localized tidal movements and regional flowing eastward and westward equatorial current streams. The wave characteristics and how they influence the motion of a canoe are the same for each zone of currents, but the sequential ordering of the zones of currents provides the navigator with distance estimates toward land. Isao places the locations of the three currents as radiating outward from every atoll with detection ranges similar to those of the *kōkḷaḷ*, as indicated by the dotted vertical and horizontal lines of the *wapepe*. *Jukae*, *rubukae*, and *jeljeltae* are located about 10, 15, and 20 miles offshore, respectively.

Finally, the *wapepe* models the wave transformations of the easterly trade wind swell near a single atoll (Figure 4(d). In the event that navigators stray from the path of the *dilep*, they remotely sense land by detecting wave-based *kōkḷal*, or navigation signs. Four distinct wave patterns extend seaward from any atoll or island in specific quadrants up to 40 kilometers (25 miles) away. The relative strength of these radiating wave patterns indicates the distance toward land, while the specific wave signatures indicate the direction of land. While Isao describes the similarity of such navigational signs throughout the archipelago, actual wave distances and strengths would depend on oceanic conditions, island size, and underwater topography.

With the predominant wind from the east, superposition of the incoming east trade wind swell and its reflected wave energy produces distinctive wave patterns to the east, or windward, of an atoll. The farthest extent of this reflected wave energy is called *jur in okme,* a term that refers to the curved shape of a particular 'pole used to harvest breadfruit,' and is represented by a portion of a curve in the *wapepe*. The northeast and southeast limits of *jur in okme* are delineated by a series of waves called *kāāj in rōjep*, a term that refers to the 'curve of a fishhook.' If a navigator correctly identifies these windward navigational signs while sailing, he discerns that he is upwind, or to the east of, an atoll.

During a short voyage in 2006 aboard a fishing vessel, Captain Korent detected *jur in okme* to the east of the atoll Arno as well as a southeastern *kāāj in rōjep* about 25 nautical miles offshore that he followed toward land. This was part of an oceanographic study to gather data on the waves (period, direction, height) that Captain Korent identified and used for navigation. We deployed a small free-floating oceanographic data collecting wave buoy at the *jur in okme* and *kāāj in rōjep* at Arno, as well as other locations around other atolls. The wave buoy required one hour to gather sufficient data, and this time—watching the motion of the wave buoy and then feeling the waves aboard the fishing vessel—catalyzed much discussion with Captain Korent. In the case of the eastern *jur in okme*, video footage on the fishing vessel of Captain Korent looking at the wave buoy, which was deployed about a half mile offshore of Arno, clearly shows an incoming easterly swell and a reflected swell flowing back to the ocean, with Captain Korent indicating their intersection as *jur in okme*; however, oceanographic data collected from the wave buoy do not indicate any reflected wave energy. For the southeastern *kāāj in rōjep*, the entire crew—including a University of Hawai'i oceanographer—felt the pitching motion of the vessel as we encountered each reflected *kāāj in rōjep*, but again the wave buoy did not detect any reflected wave energy (Genz et al. 2009).

The easterly trade wind swell then wraps around an atoll and crosses in the direct lee through wave refraction (Genz et al. 2009), creating a confused sea state called *nit in kōt* to the west, or leeward, of an atoll. Literally meaning a 'pit for bird fighting,' *nit in kōt* evokes the image of a cage, which represents the crossing of waves from multiple directions. If a navigator detects this lee wave crossing pattern, he surmises that he is downwind, or to the west of, an atoll. In the *wapepe*, the instructor must indicate the position of *nit in kōt*. During the oceanographic field study, Captain Korent identified *nit in kōt* to the west of Majuro. A series of wave buoy deployments confirmed that this navigational sign formed as the dominant easterly swell refracted around the atoll. Captain Korent named the refracted wave crests as northern and southern swells, suggesting that the formation of the navigational signs is less important than their immediate wave characteristics.

The whole system of navigation is built around creating a situation where the navigator always "knows" where he is in the sense that he can decipher the direction in which he has to guide the canoe to find land. In the event that a navigator misses the target island, the *wapepe* offers a correcting mechanism. From the regional perspective of the *wapepe* (see Figure 4c), the straight vertical and horizontal lines of *dilep* are flanked by angled lines, representing *lutokļǫkkan* 'pouring out, away from you.' These are misleading wave patterns that can lead a navigator astray. An unobservant navigator inadvertently follows the *lutokļǫkkan* waves and may continue past the atoll. The portion of each curve that extends beyond *lutokļǫkkan* represents an additional wave pattern indicative of becoming lost—*reļǫk* (also called *korteļǫk*), 'plunge into the sea.' If a navigator can recognize his navigational errors by eventually reading such waves, he may sail back toward the direction of land. If, on the other hand, the navigator utterly loses his sense of direction, panic sets in. Stories of ancestral navigators describe how, occasionally, a navigator would enter a state of *wiwijet* 'lose the direction of; panic,' a crazed state of mind in which navigators continue to sail in the wrong direction, either sailing toward their death or, even in the event of eventually finding land, remaining dysfunctional as a navigator.

Niñeañ kab rōkeañ

Another type of stick chart demonstrated by Isao is the *niñeañ kab rōkeañ*. The wave concepts modeled in Isao's *niñeañ kab rōkeañ* (Figure 5(a)) and *wapepe* differ only in their level of inclusiveness. The modeling of the *niñeañ kab rōkeañ*, directly translated as 'northward and southward,' is limited to voyages in a north-south direction, while the symmetrical modeling of the *wapepe* can be applied to these as well as east-west voyages. Navigators traditionally used the *niñeañ kab rōkeañ* to teach novices on Rongelap how to guide their canoes southward to Kwajalein and back (see Figure 1).

With a focus on a north-south voyage, Isao only modeled the east and west swells for the wave field with the curved lines (Figure 5(b)). From a regional perspective, the intersection of several pandanus roots at the extreme boundaries of the latticework represents northern and southern atolls (Figure 5(c)). Similar to the *wapepe*, the straight vertical line models *dilep* and *jukae*, *rubukae*, and *jeljeltae*. The three zones of currents are represented as singular points, extending outward from each atoll. The diagonal lines indicate *lutokļọkkan* that lead the navigator past the atoll.

As the east swell (*buñto*) and west swell (*kaeleptak*) approach the atoll, they form the surrounding *kōkļaļ*; however, only a few *kōkļaļ* are represented by the latticework (Figure 5(d)). Aside from *jur in okme* and *nit in kōt* (which Isao drew with pencil due to lack of time to lash additional pandanus roots, see Figure 3(a)), the instructor must indicate the location of the northeast and southeast pair of *kāāj in rōjep*, which again indicates the relatively low importance of these navigational signs compared to *jur in okme*.

Meto

Thomas Bokin similarly interprets his *meto* model (Figure 6(a)) in three ways. From the first perspective, the *meto* shows how the four main swells approach an atoll or a canoe at sea, which is represented by a coral pebble at the center of the woven midribs of coconut palms (Figure 6(b)). The arrangement of the curves is virtually identical to that of Isao's *wapepe*.

Like the *wapepe*, the *meto* also models the sailing conditions between ideally situated eastern and western atolls and between northern and southern atolls (Figure 6(c)). The coral pebbles form an imaginary line between these pairs of atolls, referred to as *dileplep* 'backbone' (similar to the term *dilep*) or *okar*. The exact placement of the coral pebbles also indicates the three zones of currents, located at various distances between atolls rather than, according to Isao's models, radiating outward from each atoll. *Jukae*, the first zone of currents, is located about a third of the way toward the destination island, *rubukae*, the second zone of currents, is located half way between the home and target islands, and *jeljeltae*, the third zone of currents, is located about two-thirds of the distance toward the target island. This relative placement of the three zones of currents is the same for each voyage irrespective of distance. Depending on the direction of the voyage, the coral pebbles are named *jukae*, *rubukae*, and *jeljeltae*. For instance, when sailing north from a southern atoll, the navigator experiences first *jukae*, then *rubukae*, and finally *jeljeltae*, whereas upon the return voyage south, the names given to these three zones of currents is reversed, so that the navigator similarly encounters *jukae*, *rubukae*, and *jeljeltae* in succession. The terms thus designate changes in the surface of the ocean that reflect distance traveled, but none of my informants describe any distinctive differences among the three currents. They simply use hand gestures to supplement their generic description of "choppy water" for each zone of currents.

Several of the *kōkḷaḷ* are represented in the *meto* as the intersection of various swells (Figure 6(d)), a divergence from Isao's emphasis on the importance of reflected and refracted swells. For example, the intersection of the east swell (*buñto*) and north swell (*buñtokeañ*) form the northeast curved wave pattern *kāāj in rōjep*, and the intersection of the east swell and south swell form the southeast curved wave pattern, also called *kāāj in rōjep*. The *meto* includes two leeward *kōkḷaḷ* that are mirror formations of the windward *kāāj in rōjep—nit in kōt eañ* 'northern *nit in kōt*' is formed by the intersection of the west and north swells, and *nit in kōt rōk* 'southern *nit in kōt'* is formed by the intersection of the west and south swells. The meto further shows wave shadow effects in the formation of the wave patterns. The northeast *kāāj in rōjep*, for example, only forms from the east swell and north swell, as the south swell and west swell are "blocked" or "covered," forming wave shadows that extend toward the *kāāj in rōjep*. The blocking effect of the island on the swells is different from Isao's *nit in kōt*, which emphasizes the bending of swells. The difference between the wave concepts of Isao and Thomas are striking—Isao maintains that a navigator can identify how a swell will be distorted by the islands through reflection and refraction while Thomas asserts that the swells are not transformed but blocked by the islands.

Overall, the *niñeañ kab rōkeañ*, *wapepe*, and *meto* illustrate most of the indigenous concepts with a degree of consistency. They model the wave field as observed from land or from a canoe at sea (*buñto*, *buñtak*, *buñtokean*, *buñtokrōk*), wave conditions that extend between atolls and that can lead navigators astray (*lutokḷọkkan* and *reḷọk*), and some of the *kōkḷaḷ* surrounding an atoll. Of the *kōkḷaḷ*, the latticework of the *wapepe* only portrays *jur in okme*, and the lattice of the *niñeañ kab rōkeañ* portrays *jur in okme* as well as *nit in kōt*, although in this instance it was drawn by hand. The other *kōkḷaḷ* (*kāāj in rōjep)* are indicated graphically where they should be in the spaces between the latticework. This suggests that some *kōkḷaḷ* are more important than others in the navigation system. In addition, none of the models physically represent *kāāj in rōjep*, a generalized reflected wave pattern (cf. Feinberg, this issue, for linguistic absence of terms for windward and leeward in Taumako). This could mean the *kāāj in rōjep* wave pattern is not central to the system of navigation or, more likely, that the concept of reflected waves is so easy to understand that it does not need to be modeled.

The two navigators who constructed the models, Isao and Thomas, generally agree on the relative locations and shapes of the various wave patterns. In each of the models, the four main swells are represented as curves, indicating the range of directions from which they flow. At any point on the curve, a tangent, or the straight line that just touches the curve, represents the possible wave front. The *dilep* are represented as straight lines between atolls; and the windward *kōkḷaḷ* of *jur in okme* and *kāāj in rōjep* are represented (either with "sticks" or drawn by hand) as curves in the same general loca-

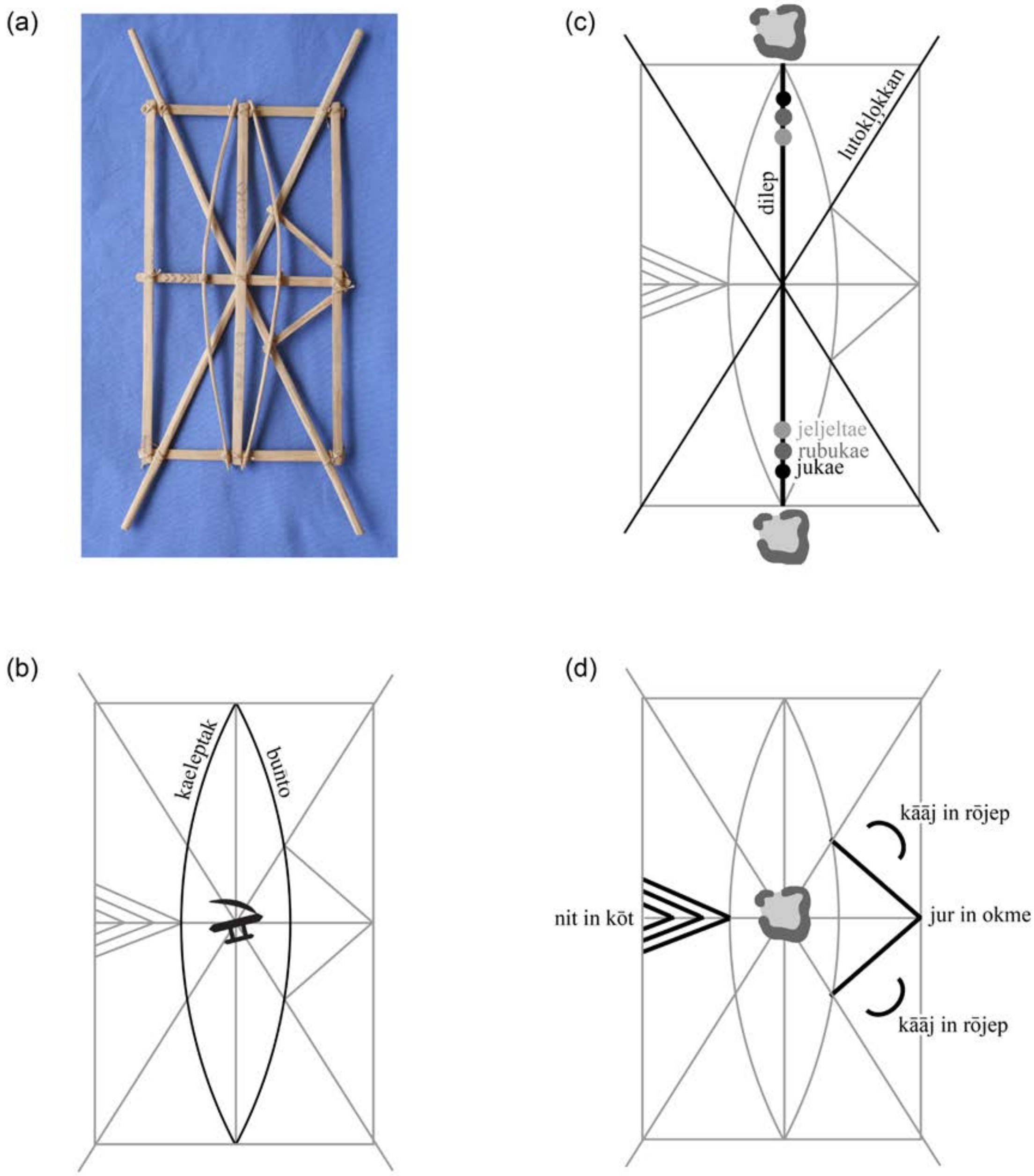

Figure 5. Interpretations of the *nin̄ean̄ kab rōkean̄* model constructed by Ijao Eknilang. The *nin̄ean̄ kab rōkean̄* (a) models the wave field as experienced on a canoe at sea or on an atoll, (c) the wave patterns between northern and southern atolls, and (d) the wave patterns surrounding an atoll (note that the two *kāāj in rōjep* are not represented by pandanus roots, but depicted graphically).

tions, located approximately 40 kilometers (25 miles) offshore. One of the major conceptual differences is the placement of the three zones of currents, with Isao having the currents radiate outward from each atoll, serving as homing devices, while Thomas places

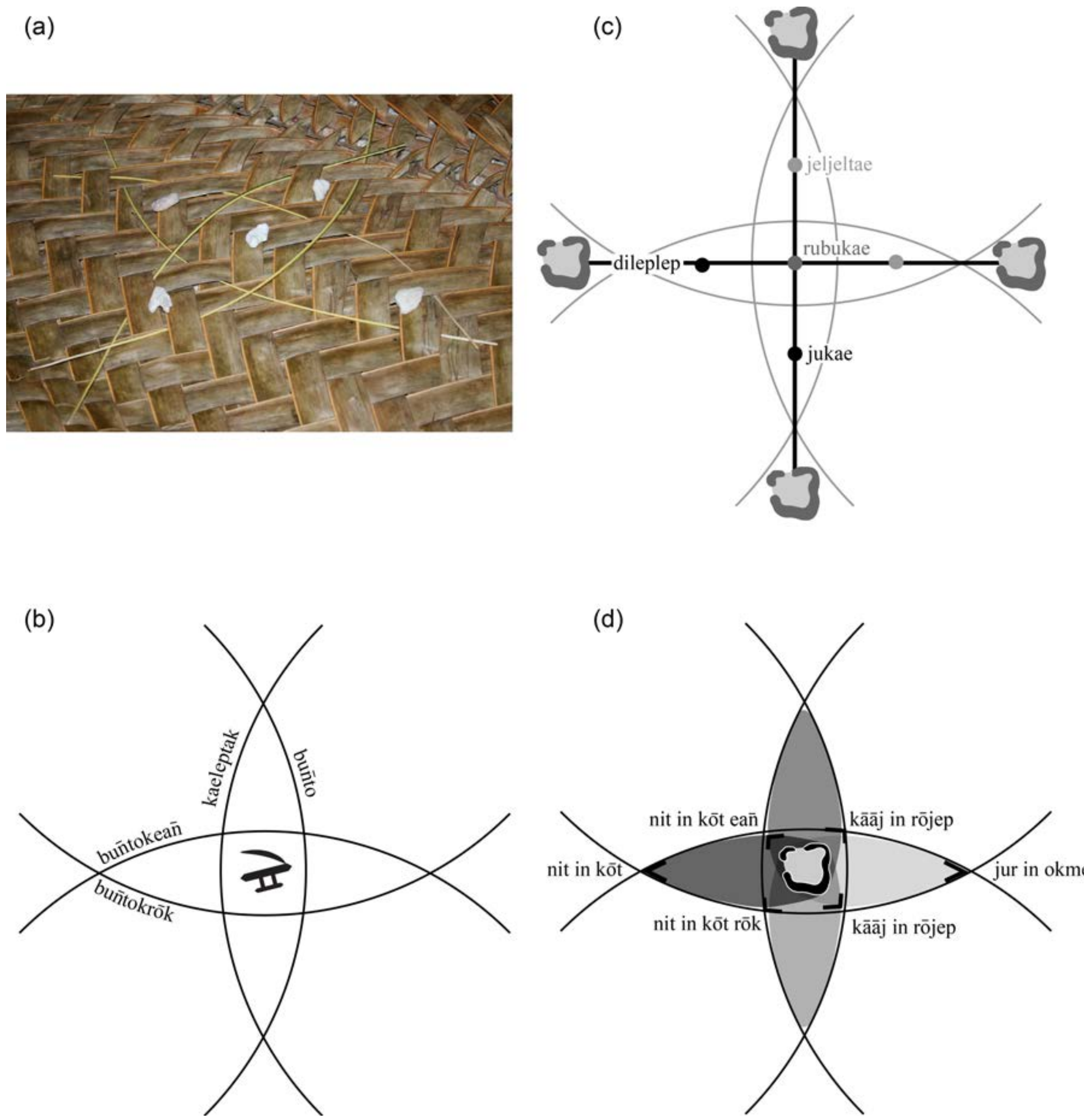

Figure 6: Interpretations of the *meto* model constructed by Thomas Bokin. The *meto* (a) models (b) the wave field as experienced on a canoe at sea or on an atoll, (c) the wave patterns between atolls, and (d) the wave patterns surrounding an atoll, formed by wave shadow effects. A voyage north (c) would encounter (on the *dileplep*) first *jukae*, then *rubukae*, and finally *jeljeltae*, while the names of the currents would be reversed for the return trip, similarly encountering first *jukae,* then *rubukae*, and finally *jeljeltae*.

them between atolls on the *dilep*. Both concepts involve gauging distance away from land, but Isao's zones of currents are essentially *kōkḷaḷ* that expand the detection of islands up to about 25 miles, and Thomas's currents can be followed during the entirety of the voyage similar to the wave path, *dilep*. Unfortunately I did not have the opportunity to have either of these experts demonstrate their understandings.

In addition to representing the locations and shapes of the swell and current patterns in relation to land, the *niñeañ kab rōkeañ*, *wapepe*, and *meto* also model the formation of the swell and current patterns, but with varying interpretations. This ambivalence is significant because the locational information provided by the swells (e.g., distance and direction from land) and visual appearance (e.g., curved or crossed) only provides the navigator at sea with certain components of knowledge. While at times this may be adequate, understanding the physical oceanographic basis of the wave patterns also provides spatial and temporal information that a navigator can draw from when trying to indirectly sense the waves through the movement of the canoe.

An oceanographic perspective developed by Genz et al. (2009) articulates strongly with only one indigenous concept—Isao's *nit in kōt*. Wave displacement data collected from a wave buoy, satellite imagery, and a wave model indicate a lee wave crossing pattern that results from the refraction, or bending, of crests of the easterly trade wind swell at, and past, the sloping sides of islands, extending tens of kilometers downstream. The angled lines of *nit in kōt*, as drawn by hand in Isao's *niñeañ kab rōkeañ*, show that the east swell bifurcates into north and south components as they encounter the island's bathymetry, such that the lee wave field is characterized by diminished southern and northern swells. From the perspective of a vessel at sea, I felt and saw this bifurcation of an easterly swell as it propagated past Majuro. In the lee of the atoll, diminished swells arriving from the north-northeast and the south-southeast rocked the vessel from side to side with equal force. At that moment, I drew from my own knowledge of Isao's *niñeañ kab rōkeañ*, with its crossing diagonal lines representing the southern and northern components of nit in kōt, to reinforce my internalized, embodied knowledge—mostly vestibular knowledge of the rocking motion of the canoe. This was quite different from Thomas's notion of nit in kōt that centers primarily on a wave shadow effect, in which the atoll would block the eastern swell to form a diminished sea, but without any refraction component.

The other indigenous concepts of the ocean are presently more difficult to translate into oceanographic terms. The scientific data do not account for the reflected windward wave patterns (*jur in okme* and *kāāj in rōjep*), the three zones of currents (*jukae*, *rubukae*, and *rubukae*), or the wave path between atolls (*dilep*). Further, an oceanographic swell model characterizes the wave field in the Marshall Islands as a dominant eastern swell with intermittent storm events from the southwest instead of four swells of equal strength as envisioned by my informants. The incongruity between these scientific and indigenous explanations of the various wave patterns may reflect discrepancies between low instrument sensitivity and highly refined human perceptions, or alternative ways of conceptualizing the ocean (Genz et al. 2009). On the other hand, refinements to the generation of the swell climatology model by Genz et al. (2009) may lead to a more accurate depiction of the various swells that flow through the Marshall Islands, possibly characterizing more than just the eastern swell.

The apparent discrepancies between indigenous and Western scientific concepts may also reflect partial representations of the wave field, which is quite possible given the status of rejuvenating nearly lost skills. Triangulating these different emic and etic perspectives may allow for a more holistic understanding of navigation. The indigenous system gives navigators the security that they know where they are and thus "works" even if my informants cannot fully explain—or disagree about—the wave patterns, and the oceanographic perspective may help to fill in those gaps of understanding. Yet the seemingly contradictory assertions (e.g., local knowledge claiming four constantly flowing swells versus current Western scientific knowledge claiming only one) call into question the idea that the two schools and the oceanographic model are each providing a piece of the total picture of the wave field and how it varies in relation to the location of atolls, winds, and ocean currents. Instead, there appear to be substantial conflicting interpretations between traditional navigational arts and modern science, as well as between the two navigational schools. These differences may be resolved with refinements to the wave climatology models generated by Genz et al. (2009). Ultimately, the local importance of resolving these differences lies in the practical ability to navigate safely across the open sea.

The Stern Test of Landfall

Captain Korent, on his quest to become socially recognized as a *ri-meto* 'person of the ocean' or 'navigator,' undertook his first traditionally navigated oceanic voyage by guiding a yacht 220 kilometers (140 miles) on an east-west course between the atolls of Kwajalein and Ujae (Genz 2011). Since the community's 35-foot outrigger voyaging canoe was undergoing maintenance, a 35-foot sloop-rigged monohull yacht, with navigational instruments stowed out of sight, served as the sailing vessel. Captain Korent explained that he could detect the wave patterns equally well on either a relatively stable outrigger complex or a single-hull vessel with its severe rocking motion. Like the outrigger canoe, the yacht required wind to keep it on course, but it also had a diesel engine which allowed us to motor into the direction of the wind for part of the voyage, as described below. Serendipitously, this "stern test of landfall" (Lewis 1994) afforded Captain Korent an opportunity to evaluate and validate the concepts embedded within both Isao's *wapepe* and Thomas's *meto* (but not the *niñeañ kab rōkeañ*, which only models north-south courses), since up to this point Captain Korent's instruction had paralleled that of his Rongelapese uncle, Isao, while Thomas, with a slightly different interpretation, resided on Ujae in the western seas of Kapinmeto.

Upon leaving Kwajalein en route to Ujae to meet with Thomas, Captain Korent had planned to use the full repertoire of Isao's teachings, which centered on detecting and staying on the *dilep*, gauging progress by the radiating zones of currents, and expanding the detection range by using the *kōkḷaḷ* of an intermediate island, Lae, and later the *kōkḷaḷ* of Ujae (Figure 7(a)). However, strong 20-knot winds from the west drove 5-6 foot swells against us and forced us to motor toward Ujae. Heavy rain accompanied the wind, and the sky remained overcast for the entire duration of the voyage. Celestial referents were not visible and the westerly wind-driven swell masked the subtler wave conditions. This intermittent storm event with westerly winds is consistent with the oceanographic model of the wave field, mentioned earlier. Captain Korent completed the outward voyage by sailing 200 nautical miles in 48 hours through his own means of dead-reckoning without confidently identifying any salient swell or current patterns and without sighting any stars, but he did sight the small island of Lae on the distant horizon, which allowed him to confirm his dead-reckoning and adjust his course toward Ujae.

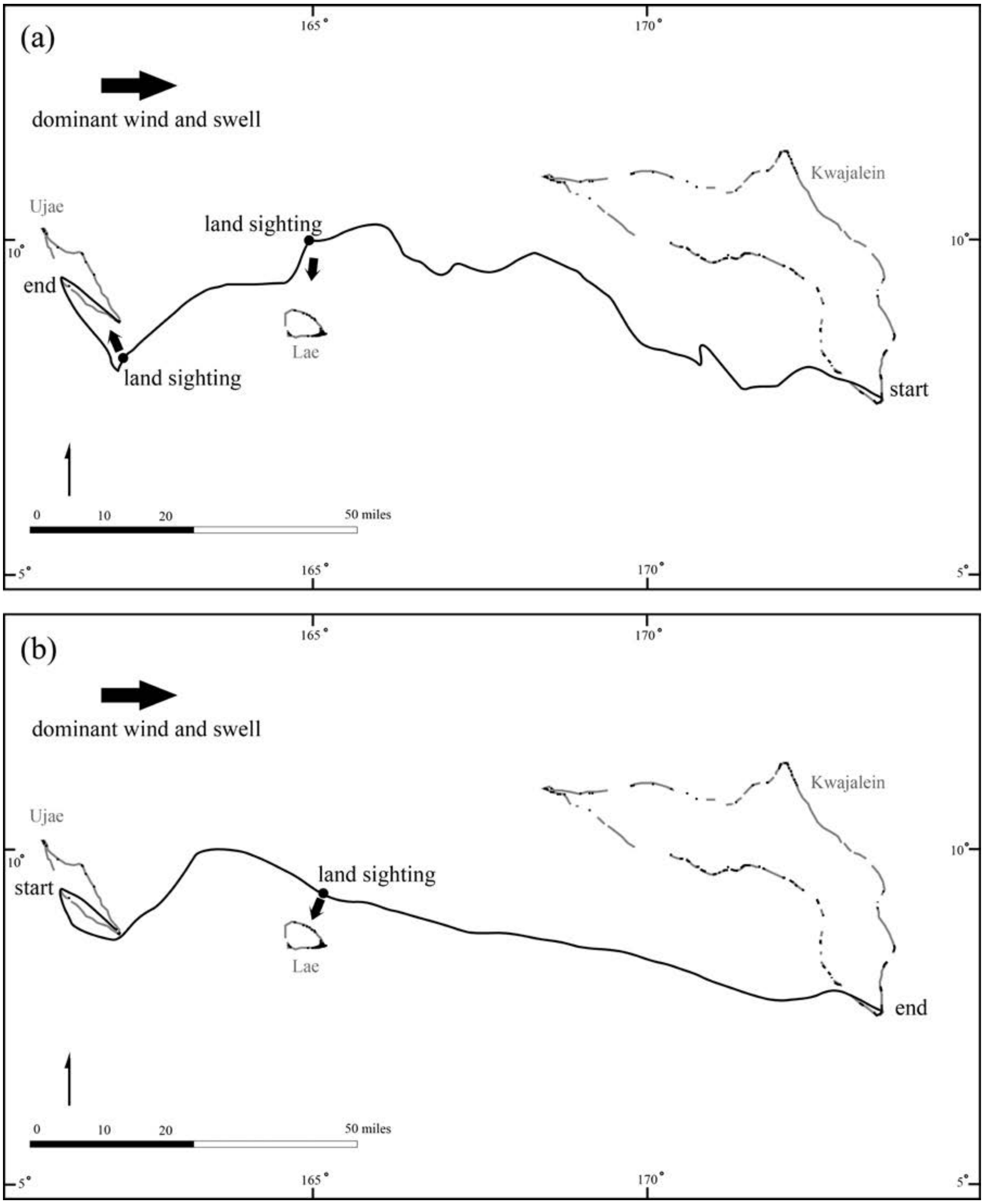

Figure 7. Voyage between Kwajalein and Ujae. GPS tracks for (a) the outward voyage from Kwajalein to Ujae and (b) the return voyage from Ujae to Kwajalein.

Once safely on Ujae, Captain Korent sought out Thomas, who shared with Captain Korent his navigational concepts by weaving the *meto* through his sitting mat. After a few days, Captain Korent had both Isao's *wapepe* and Thomas's *meto* in mind as he embarked on the return voyage to Kwajalein. At this time, he was aware of the differences between the two models, notably the placement of the three zones of currents between islands (Isao) or radiating outward from islands (Thomas), and the emphasis on either reflection and refraction (Isao) or wave shadow effects (Thomas) in the formation of *kōkḷaḷ*. Upon leaving, his navigational strategy was to draw from each model selectively depending on the weather and ocean conditions, summarizing his thoughts with a casual, "We'll see." Yet the most fundamental concept, *dilep*, remained unchanged after Captain Korent learned from Thomas that he should be able to sail on this wave path, detected by balancing the roll of the vessel from northern and southern swells, directly toward Kwajalein.

As we departed Ujae, the weather and sea conditions were more favorable than on the outward voyage (Figure 7(b)). Although the sky remained mostly overcast such that it only permitted the intermittent sighting of a few lone stars, the westerly winds remained at our stern for an enjoyable downwind easterly sail. Overall, Captain Korent completed the return voyage by sailing 160 nautical miles in 35 hours, primarily by detecting wave shadow effects. The storm-driven west swell was dramatically reduced in the lee of Ujae and Lae, and Captain Korent used these diminished seas to gauge his distance and location. As he could interpret the sea conditions much more easily on this return voyage, Captain Korent remotely detected Lae by feeling the diminished leeward seas. As the voyage progressed past Lae, Captain Korent continued to gauge our progress through successive zones of currents and remotely sensed the location of Kwajalein by feeling how a series of reflected swells pitched the yacht forward.

Overall, the return voyage validates that Marshallese navigation is a system of wave piloting, since Captain Korent gauged our progress entirely with reference to wave patterns rather than the intermittent star sightings. It also supports several concepts within both Isao's *wapepe* and Thomas's *meto*. The return course followed the ideal path of the *dilep* (or *dileplep*), as represented in both models, although Captain Korent, who conceptualized this as the crossing of opposing swells (as opposed to Isao's reflected swells) could not identify this wave pattern with certainty. Instead, Captain Korent followed the wave shadow effects in the lee of Ujae and Lae, since the westerly wind created a zone of diminished seas to the east of these land masses. This clearly fits with Thomas's "blocking" of the west swell in the *meto*. But it also fits somewhat with Isao's formation of *nit in kōt*. The *wapepe* is designed to model the *kōkḷaḷ* transformations of the dominant easterly swell, but if the model were transposed 180 degrees from left to right, the dominant westerly swell would result in the same *kōkḷaḷ* but in mirrored quadrants. In this case, now with the dominant westerly wind-driven swell, the *jur in okme* (normally located to the east) would be located to the west of an atoll and the *nit in kōt* (normally located to the west) would be located to the east of an atoll. In effect, Captain Korent followed the *nit in kōt* wave shadow effect eastward, although he did not detect the crossing of wave crests as depicted in Isao's models.

The return voyage validates some additional concepts from Isao's *wapepe* and Thomas's *meto*. Captain Korent described how he gauged the voyage with the three zones of currents located near Ujae, between the Ujae and Kwajalein, and close to Kwajalein. This aligns with Thomas's conceptualization of the zones of currents that are located between atolls rather than Isao's idea of currents radiating outward from an atoll.

On the other hand, closer to Kwajalein, the main navigational sign used to indicate proximity to land was *kāāj in rōjep*, a series of reflected waves that caused the yacht to pitch forward slightly. Both Thomas and Isao described these generalized wave patterns, but the movement of this wave pattern fits with Isao's windward reflected wave *jur in okme* (if the *wapepe* were transposed to accommodate the wind-driven dominant westerly swell), as well as the formation of the *dilep* between Ujae and Kwajalein. Yet, Captain Korent only referred to this reflected wave as *kāāj in rōjep* rather than the more specific *jur in okme*, and certainly did not describe it as *dilep* since he was operating with the model of *dilep* as crossing swells.

With both of the navigational models in mind, as learned from the teachings of Isao and Thomas, it appears that Captain Korent did not necessarily choose between the two, but rather drew from each one based on the weather and sea conditions. If we had not faced the remnants of a severe storm with a wind-shift, the expected wave refraction may have produced a leeward crossing pattern similar to that documented during the oceanographic studies. But the storm-driven conditions likely masked those subtler wave patterns, such that Captain Korent could only detect the dominant wave shadow effects. Thus, Captain Korent operated with both models in mind, but invoked that which best articulated with the conditions extant at that moment.

In the context of the cultural revival of voyaging currently underway in the Marshall Islands and Captain Korent's process of learning from other navigation experts, his selective use of models from two different schools of thought (Isao's *wapepe* and Thomas's *meto*) is not surprising. However, Captain Korent had not completed his training before his exodus as a nuclear refugee from Rongelap. If he had been a fully trained and qualified navigator during the 2006 voyage, it is unlikely he would have operated with two models in mind. He would have been thoroughly trained in the Rongelapese school of navigation, which would have likely included techniques for adjusting to the westerly wind shift. Precedents among other traditional voyaging cultures in Oceania suggest that as a fully trained and qualified Rongelapese navigator, Captain Korent would not have deviated from what he had been taught.

Accounting for Ambivalence

Captain Korent's ambivalence with respect to wave piloting as interpreted through Isao's *wapepe* and Thomas's *meto* is compounded by historical changes and regional variation. Some of the differences between previous accounts and the current synthesis can be attributed to generational knowledge loss. Lewis (1994:223-245) observed that knowledge could dramatically change within one generation. For example, my informants acknowledge that they no longer remember or had never learned the hidden, metaphorical meanings of the *ikid* 'song-stories' and *roro* 'chants' performed by their teachers. The relative importance of astronomical knowledge has also apparently declined. Navigators at the turn of the twentieth century recalled for Erdland (1910, 1914) the names of 66 stars and their use as guides when sailing to specific atolls, but my informants only remembered a few guiding stars, and Captain Korent did not rely on them at sea.

Other differences between historic and contemporary navigation are conceptual rather than merely a loss of knowledge, and likely reflect a combination of regional differences, a lack of scholarly research and historic observations on Rongelap and other relatively isolated northwest atolls, and idiosyncratic variation. Previous studies highlight the importance of wave patterns surrounding atolls (e.g., Winkler 1901; Davenport 1960; 1964; Lewis 1994), while my informants conceptualize the *dilep* as wave extensions or "paths" between atolls. Conceptually, Winkler's (1901) *okar* radiates seaward from an atoll while my informants' *dilep* extends between atolls.

The greatest divergence among my informants lies in the explanation of *dilep*—with Isao and others citing reflected wave energy from a dominant incoming swell and with Captain Korent and Thomas referencing opposing swells, despite the fact that both Isao and Captain Korent learned at the same training reef on Rongelap, viewing opposing waves strike the coral islet from both the ocean and the lagoon. It is possible that this training reef simulates the feeling of the real ocean *dilep* but not how it forms. Perhaps, reflected wave energy is largely responsible for the formation of *dilep*, but the naming of these reflected waves describes the direction in which they are flowing (e.g., 'north swell' rather than 'reflected wave'), just as Captain Korent had named the swells contributing to *nit in kōt* as 'north swell' and 'south swell' rather than a bifurcated or curved east swell.

As tantalizing as it is to reconcile the difference between these two models of *dilep*, Lapedpedin, a former Rongelapese navigator and teacher of Isao, both indicates the importance of opposing swells and insists that swells do not curve. As documented by Gerald Knight (1999), Lapedpedin shares the same conceptualization of the *dilep* as Captain Korent (balancing of opposing swells) but not Isao (reflected swells). Lapedpedin described to Knight the balancing motion of opposing swells as the navigator follows the *dilep* toward land:

> …now you look for boj [*booj*]. Do you know what boj is? That knot in rope—just one loop. And when you pull both end loop begin to get smaller and smaller. And one wave roll from left and one from right, just like that knot.
>
> So you keep sailing south but you make eye red again and look hard at ocean and watch to see which wave is getting strong and which one weak. If wave on right [from the west] is strong then you lie northwest. If wave on left [from the east] is strong then you lie northeast. If they fall with *equal* strength then you lie directly north [emphasis added].
>
> If wave on your right [from the west] is getting strong—we call that wave kalibtak [*kaeleptak*]—you turn bow southeast [away from the wave so the wave is coming more from the stern] and that'll put both buntokean and kalibtak to fall from right and left of your stern. Like that know you pull—one wave roll from left and one from right. And they'll push you down perfect path toward island. ... like that knot you pull—one wave roll from left and one from right. And they push you down perfect path toward island. [Knight 1999:108]

The idea of a balance motion of easterly and westerly waves "push[ing] you down perfect path toward island" speaks to continuity of knowledge on Rongelap between generations (Lapedpedin and Captain Korent) and attests to surviving traditional knowledge. The relative isolation of the northwest atolls most likely worked to maintain the transmission of knowledge until the nuclear testing in the mid-twentieth century; it also restricted historical observations and scholarly research. Even within the relatively isolated region of the northwest atolls, however, there is variation in knowledge. While Isao and Captain Korent learned on Rongelap, Thomas Bokin learned in the Kapinmeto region, which my informants identified as a distinct regional training center.

Such regional variation could stem from the oceanographic and geographical features of those seas and islands. Bathymetry data for the Marshall Islands indicates dramatically steep drop offs within just a few hundred feet from shore, resulting in small but noticeable amounts of refraction of incoming swells, and, due to the breaking of those swells on the reef, little wave reflection (Genz et al. 2009). A close inspection of the underwater contours of the island and atolls may reveal differences throughout the archipelago that could have led to various regions in the Marshalls focusing on different types of swell and wave conditions.

Yet, Rongelapese navigator Lapedpedin explained to Knight (1999:65) that atolls metaphorically "eat" the swell by blocking it, which is similar to Thomas Bokin's metaphor of atolls "covering" and "blocking" swells (*penjak*). Lapedpedin, like Thomas, adamantly asserted that swells do not curve as they pass by an atoll:

> …Now I've heard some say wave bend around an island. Alright, I want to tell you right away that is not true. No swell of this world know how to bend. They just roll in one direction and keep going. Now secret is that when you're close to one island that balance of these four wave is broken 'cause that island eat up one of them. So, if you're sailing toward an island from north that island eat up wave from south. So your boat start lunging forward. You're riding on wave falling from north. [Knight 1999:64]

This alignment of knowledge between former Rongelapese navigator Lapedpedin and surviving Kapinmeto navigator Thomas Bokin speaks to a close similarity between these two schools of navigation. Whether the two models currently held by Isao and Thomas derive from generational knowledge loss, regional variation, or idiosyncratic differences, it is clear that Captain Korent, in the middle of his monumental voyage that would prove to launch his status as a true 'person of the ocean,' simultaneously held and operated within these two models, but invoked the necessary elements from each based on the immediate weather and sea conditions to successfully locate land.

Theoretical And Practical Implications

In summary, degrees of ambivalence, conflicting interpretations, and uncertainty in Marshallese navigational concepts exist between the two surviving model builders, Isao Eknilang and Thomas Bokin. The wave concepts embedded within the latticeworks of Isao's *wapepe* and *niñeañ kab rōkeañ*, and Thomas's *meto* share a common basis with some generational continuity (e.g., Lapedpedin) in how they model the flow of swells in relation to land. The models also reinforce the idea that Marshallese navigation is a system of wave piloting, even if the physical oceanographic basis of most of the wave patterns has yet to be completely validated. However, my informants' models also diverge from previously documented models (e.g., Winkler 1901) and from each other in several respects. Whether these differences stem from regional variation in knowledge, lack of scholarly research in those areas, generational knowledge loss, or idiosyncratic differences, my informants' models are in fact sufficiently similar that Captain Korent was able to navigate with both models in mind and invoke a particular model based on immediate conditions with enough accuracy to interpret the ocean surface and find land. This has both theoretical and practical implications.

Theoretically, the selectivity of abstract models during practical engagement in the environment adds to an already powerful dynamic in the complementarity of information processing modes in Marshallese navigation and other systems of way-finding more generally. Elaborated elsewhere (Genz 2014), a successful sea journey involves an ability to shift back and forth strategically among cognitive and experiential ways of knowing. This complex process of combining egocentric sensing of environmental phenomena with allocentrically-framed representations (the "stick chart" models) stored in memory is further complicated by the emergent, selective invoking of those abstract models from slightly different navigational schools.

Practically, the fact that Captain Korent made landfall and, in the process, became socially recognized as a 'person of the ocean,' while operating under two contrasting theories of ocean waves stands as a testament to his perseverance and should give hope to the continuing community efforts to revitalize this endangered knowledge system. Additional voyages at sea, ideally on a newly re-built 35-foot outrigger voyaging canoe, will help Captain Korent to finish resolving the lingering inconsistencies among his elders as he begins to teach a new generation of navigators. And yet, the immediate forging of unknown routes to knowledge recovery may entail building from those multiple and individually incomplete perspectives.

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[1] Vaeakau-Taumako voyaging continued until around 1960 with canoe building and voyaging emerging again in the 1980s. The last long-distance voyages in the Marshall Islands stopped after the era of nuclear testing, with the geographically isolated Enewetak community voyaging throughout their seas in the 1980s.

[2] With the expressed wishes of my Marshallese collaborators, here and throughout the article I use their real names.

[3] I follow the new orthography of the Marshallese dictionary (Abo et al. 1976) for the spellings of Marshallese but use the older spellings of place names for ease of recognition.

[4] Due to the collaborative development of the research design and undertaking of fieldwork, I emphasize, at times, the collective voice of myself, Alson Kelen, and Captain Korent Joel in this study.

[5] The term "path" is my portrayal of how Captain Korent and my other navigation informants explain and demonstrate through gestures how they move through the ocean along the successive nodes of intersection of the *dilep*; these wave patterns are described as *iaļ*, the Marshallese word for "path."

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