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On the Relative Isolation of a Micronesian Archipelago during the Historic Period: the Palau Case-Study

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Contact between Europeans and Pacific Islanders beginning in the early 1500s was both accidental and intentional. Many factors played a role in determining when contacts occurred, but some islands remained virtually isolated from European influence for decades or even centuries. We use Palau as a case-study for examining why this archipelago was free from direct European contact until 1783, despite repeated attempts by the Spanish to reach it from both the Philippines and Guam. As computer simulations and historical records indicate, seasonally-unfavourable winds and currents account for the Spanish difficulty. This inadvertently spared Palauans from early Spanish missionaries, disease, and rapid cultural change.

Key words: computer simulations, seafaring, Spanish contact, Palau, Caroline Islands, Micronesia.

The first contacts between Europeans and native Pacific Islanders occurred in the early 1500s. This was, of course, a major historical event which ultimately transformed the lives of thousands of people through the spread of new technologies, religious ideologies, diseases, animals and plants, and trade activities. Over the following centuries, European influence grew through direct contact with native groups and indirect movement of various goods such as iron (Hezel, 1972; Hezel, 1983; Descantes, 2001; Fitzpatrick *et al.*, 2006). The acquisition of precious commodities, including spices, copra (dried coconut meat), mother-of-pearl shell, *bêche-de-mer* (sea-cucumber or sea-slug), and metals, and aspirations to convert native peoples to Christianity, became powerful motivators for Europeans to expand their global empires, and seek out new islands to establish trade outposts.

Despite a massive effort by Europeans to discover new islands so that they could develop their economies and extract resources, there are several instances where islands remained largely free from European influence for decades or even centuries. On the surface this may not seem necessarily surprising, for the Pacific is the world's largest ocean and most island groups consist of small, not-very-visible coral atolls. In addition, relatively few European ships made their way into the Pacific in the 16th and 17th centuries, thereby reducing the chances of contact. But it is still curious why some islands remained isolated, especially considering that many were fairly large and that Europeans were intent on taking advantage of these new sources of wealth and increasing their control over critical trade routes.

One of the island groups which remained isolated long after other nearby islands were exposed to European influence was the Palauan archipelago in the Western Caroline Islands of Micronesia (Fig. 1). Contemporary Spanish historical accounts testify to the frequency of drift-voyages from the Carolines (Hezel, 1983) with no fewer than nine different landings between 1664 and 1669 (Hezel, 1972: 28). These voyagers reported to missionaries that numerous islands lay to the east. In December 1696, Father Paul Klein, after meeting on Samar, in the Philippines, 30 Carolinians who had blown off-course while sailing from Lamotrek to Fais, described their experiences in a letter to the Jesuit

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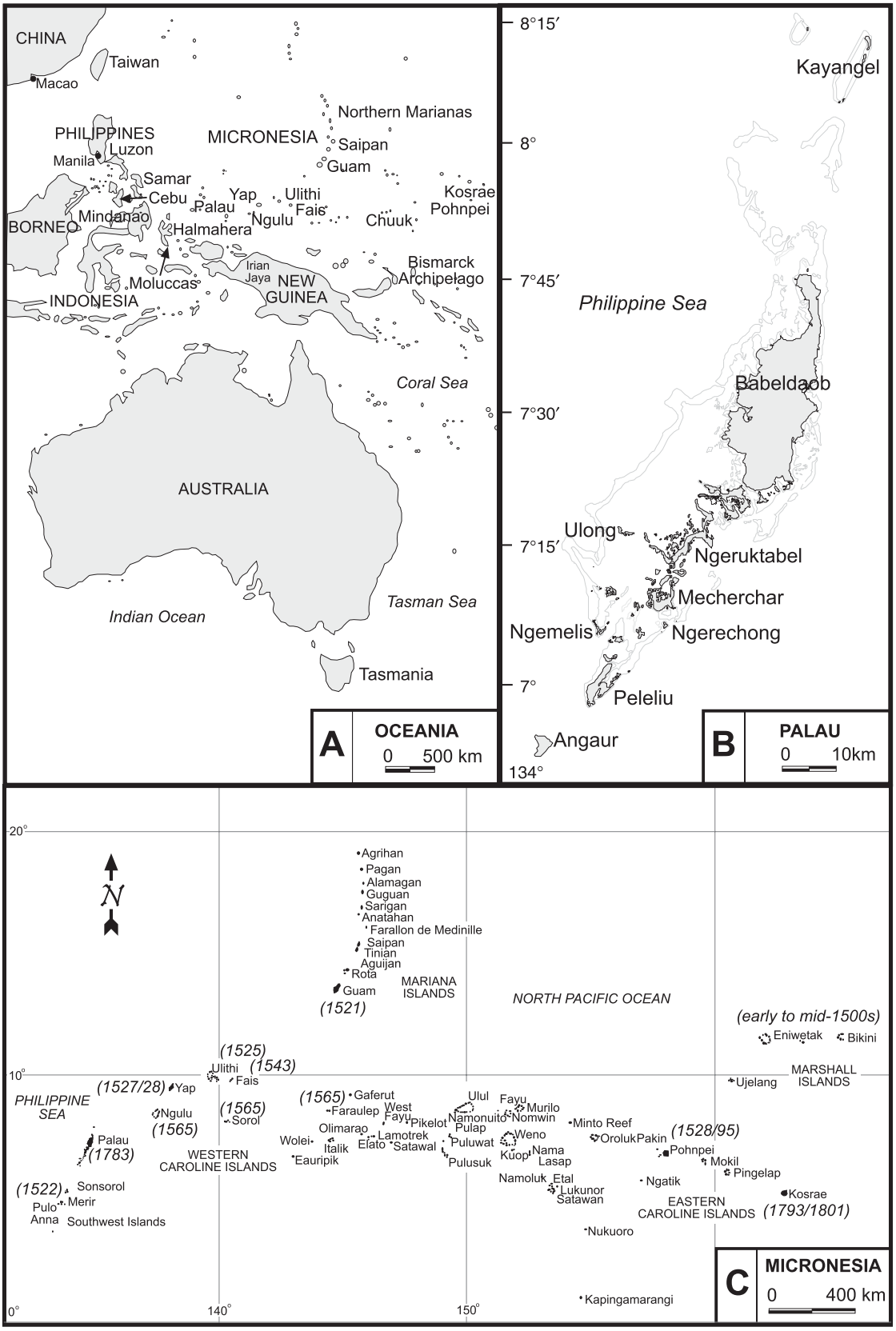

Figure 1. Maps of Oceania (A), western and central Micronesia (C), and Palau (B). Dates in parentheses in map (C) show the earliest probable contact of islands by Europeans (see Hezel, 1972; Hezel, 1983).

General in Rome (Hezel, 1972: 27). This spurred a keen interest in conducting exploratory voyages into the Western Carolines to locate these 'Enchanted Islands' (Hezel, 1983) with the goal of claiming them for the Spanish Crown. Historical accounts from both passing ships and intentional voyages sent to find Palau often only sighted the Southwest Islands (approximately 400 km away), not the main Palauan archipelago. What can account for the relative isolation of Palau, despite the Spanish attempts to locate it?

To investigate the underlying reasons behind this phenomenon, we examined historical records of voyaging and conducted computer simulations of seafaring to try and determine whether currents and winds may have affected sea-travel and reduced the chances of Europeans reaching Palau. The simulations use ocean conditions recorded by the US Navy to determine how watercraft are likely to move or react to ocean conditions during given times of the year. This type of approach to studying ancient and historical seafaring has increasingly been used to investigate issues relating to colonization, migration, and culture contact (Callaghan, 2001; Callaghan, 2003a; Montenegro *et al.*, 2006), and have proved particularly useful for understanding voyaging throughout the Pacific (Levison *et al.*, 1973; Irwin, 1992; Callaghan, 2003b; Callaghan, 2003c).

Environmental background

The Palauan archipelago comprises several hundred islands in western Micronesia situated at 7°30′ north. The largest is Babeldaob, which is 330 km^2 and the second largest island in Micronesia after Guam. The archipelago is 25 km across at its widest point and stretches over 160 km. Palau is roughly 800 km equidistant from the Philippines to the west and Irian Jaya to the south. The islands of Yap and Guam lie approximately 400 km north and 800 km north-east of Palau and are oriented in a north-east-south-west direction (Fig. 1B).

The main climatic feature in western Micronesia is the equatorial trough of low pressure that induces winds known as the north-east trades (Siedler and Church, 1951; Hazell and Fitzpatrick, 2006). These occur throughout the winter and spring from October to May (Morris, 1988) and are fairly consistent, with a mean speed of *c.*10 knots (18 km/h). With decreasing north-east trade winds in April, east winds become more frequent and become dominant in the region. On average, the mean wind velocity decreases from 10.5 km per hour in January to 5.8 km per hour in June, primarily due to the development of the Australian anticyclone which shifts the prevailing winds (Corwin *et al.*, 1956). From July to October winds are comparatively light, with the mean monthly velocity ranging between 0.5 and 1.5 km per hour.

The north-east trades offer a comparatively consistent velocity and direction. This has two advantages for sailing: a constant wind direction that aids navigation on the open sea, and a constant south-east or north-east ocean swell (depending on the month). Outside the north-east trades, the highest number of days for winds originating from any given direction occurs in September. These 4–7 knot (7.2–12.6 km/h) winds come from the south-west for about seven days (Morris, 1988; US Navy, 1995). Calms (or low wind velocity) are reported for a similar number of days.

Palau is located at the junction of three major ocean currents—the North Equatorial Current (NEC), the Equatorial Counter-Current (ECC), and the South Equatorial Current (SEC). These can produce considerable seasonal current-pattern changes in the region (Gatty, 1944; Jenkins, 1973; Morris, 1988; Irwin, 1992; US Navy, 1995; Rapaport, 1999). Between Yap and Palau, for example, currents are fairly consistent for most of the year, with only minor local variations in and around the various islands and reef systems (Heyen, 1972; Hazell and Fitzpatrick, 2006). The currents flow east to west at around 0.75 to 1.25 knots (2.5 km/h), except through August and October when a variable, weaker north-east set or direction occurs, although a rate of 3 knots has been reported (Morris, 1988). During September, surface currents can have a north-west to south-west set. The variable winds and surface currents also make this and other months with similar conditions difficult periods for sailing.

Historical contacts in western Micronesia

Historical accounts and ships' logs offer insight into when islands in Micronesia were contacted and the difficulties that explorers may have had in seeing, relocating, or landing on them. Guam is especially notable because it was the first island in Remote Oceania discovered by Europeans when Magellan landed there in 1521. The island later became a critical stopover for provisioning

Spanish ships travelling between Mexico and the Philippines. After staying for only a few days on Guam, Magellan traveled south to the Philippines, making his way to the islands of Cebu and Mactan (a small island on the eastern side of Cebu) on the way to the Moluccas, but did not encounter any other islands in Micronesia. Ironically, Magellan never did see the Moluccas which he had tried so hard to find, as he was killed in a skirmish with competing groups on Mactan after befriending a local chief and becoming embroiled in local disputes.

Not long after Magellan's sighting of Guam, Alvaro de Saavedra Ceron on the *Florida* sighted the Yap island group on 1 January 1528. He named it 'Islas de los Reyes' in honour of the feast-day (Hezel, 1983: 14–15). The Yapese were apparently cautious and rarely interacted with the Spaniards during their eight-day stopover before heading to the Philippines. Sixteen years later, Ruy Lopez de Villalobos visited two islands, most likely Fais and Yap, and, much to his surprise, was greeted in Spanish. Whether these western Carolinians had simply remembered the greeting from Villalobos's earlier trip or were in regular contact with the Philippines is unknown (Hezel, 1983: 19). Although numerous islands relatively close to Palau were sighted early on by Europeans, including Guam, Ngulu, Fais, Ulithi, Yap, Cebu, and the Southwest Islands (Fig. 1C), Palau remained virtually unseen by explorers. There were at least a dozen sightings prior to 1783 of islands that today are governed by the Republic of Palau, but only two of these might have been the main archipelago (Table 1). It is important to note that these occurred decades after the more northerly contacts with Guam, Yap, and various smaller atolls such as Ulithi. The first possible sighting was in 1579 by Sir Francis Drake on the *Golden Hind* who, on his way to the Moluccas, encountered natives in canoes who began to trade and then steal things from the ship, causing Drake to refer to it as the 'Island of Thieves' (Lessa, 1975). However, Hezel (1972: 26–7) suggests that Drake's description of the people and their canoes does not equivocally support the notion that this was in fact Palau. Francis Padilla sailed from Guam to Sonsorol in 1710 on the *Santissima Trinidad* and apparently lay off Palau for two days.

With these two possible exceptions, all the other known sightings were of the Southwest Islands. Although politically part of Palau today, these islands are linguistically and culturally different and several hundred kilometres away. It was not until Captain Henry Wilson was wrecked on the reef near Ulong Island on 10 August 1783, while returning from Macao on the *Antelope*, that there began a sustained period of contact between Palauans and Europeans—almost two-and-a-half centuries after European contact with other nearby islands. Although the paucity of sightings of Palau by Europeans may in itself not seem significant, it is curious why it remained undiscovered when smaller and less-visible coral atolls were seen, while the size and configuration of the Palau archipelago presents a highly visible target.

Historical navigation records

Of the historical references which note sightings of the main Palauan archipelago prior to the wreck of the *Antelope* in 1783 (Keate, 1789), several explain the difficulties of navigating in the region, which may help explain why the islands were not contacted until much later. As mentioned previously, the first probable European sighting of Sonsorol (Southwest Islands) was on 6 May 1522 by the *Trinidad* during its attempt to cross the Pacific from the Moluccas to North America (Sharp, 1960: 9–10; Hezel, 1979: 1). Here, adverse winds are cited as a problem for navigating westward. The winds at this time of year are primarily from the east, north-east, and south-east at force 3 on the Beaufort Scale (Defense Mapping Agency, 1994), or 7–10 knots. The second possible sighting, by Sir Francis Drake in the *Golden Hind* in 1579, gives no details of sea-conditions (Lessa, 1975: 54–8).

On 10 April 1710 the *Duke of Bristol*, under the command of Captain Woodes Rogers, travelling from Guam to Ternate (just off of Halmahera). sighted what was probably Tobi (Rogers, 1726: 373; Sharp, 1960: 93–4; Hezel, 1979: 1). The current was described as being strong and setting to the north. Winds at that time of year could be expected to be from the north-east and east at force 3–4 (7–15 knots) (Defense Mapping Agency, 1994). These wind speeds would not have hampered sailing from Guam, but would have been difficult for ships navigating from the Philippines in search of Palau. Also in 1710, on 30 November, the Spanish vessel *Santissima Trinidad*, captained by Francisco Padilla, set out from Manila and found Sonsorol in what turned out to be the only successful attempt by the Spanish Crown to deliberately locate Palau

Table 1. *Sightings of Palau by ships during the historic period (adapted from Hezel, 1983; http://www.micsem.org/pubs/articles/historical/forships/palau.htm)*

1522	Spanish ship *Trinidad* of Magellan's fleet, commanded by Gomez de Espinosa, on its attempt to recross the Pacific. May 6: Sighted two small islands in 5°N which they named 'San Juan'—almost certainly Sonsorol (Sharp, 1960: 9–10).
1579	English ship *Golden Hind*, commanded by Sir Francis Drake, en route to the Moluccas. 30 September: Came upon islands at 8°N. Several canoes came out to the ship and trading was carried on. When the islanders began to steal things, a skirmish broke out and 20 natives were killed. These islands—apparently Palau—were named the 'Islands of Thieves' (Lessa, 1975: 54–8, 250–5).
1710	British privateer *Duke of Bristol*, Captain Woodes Rogers, en route from Guam to Ternate. 10 April: Sighted a low island at 2°54′ N that was probably Tobi (Rogers, 1928: 273; Sharp, 1960: 93–4). Spanish patache *Santissima Trinidad* of Manila, Francisco Padilla, on a voyage to search for the Palaos. 30 November: Found Sonsorol which they named 'San Andreas'. Natives traded peacefully and invited Spanish ashore for a feast. Two priests and several soldiers were landed on the next day, but the ship was driven off by the currents and was unable to make the island again to take them off, despite repeated attempts. 11 December: Sighted Palau and lay off for two days. Several canoes came off with armed natives who came aboard to trade. When some began to pry pieces of iron off the ship, all were ordered off. They hurled spears from their canoes. More canoes came out the next day, but Padilla did not go ashore as they requested. Good descriptive accounts of the people (Eilers, 1936: I, 1–14; Barras de Aragon, 1949: 1076–89; Krämer, 1917: I, 36–67).
1712	Spanish patache *Santo Domingo* commanded by Bernardo de Egui, left Guam to search for Sonsorol and rescue the two priests left there. 15 February: Sighted Palau. A dozen canoes came out, but only one caught up with the ship. Two natives came out on deck while the rest threw food and shell belts up to the ship. The two natives were seized and bound, but one escaped a short time after. Left Palau on 17 February. 19 February: Sighted Sonsorol, but could find no sign of life. The next day the ship was carried away by strong currents and soon after returned to Manila (Krämer, 1917: I, 88–100; Barras de Aragon, 1949: 1089–93).
1761	English merchantmen *Carnarvon*, Captain Norton Hutchinson, *Warwick*, Captain James Dewar, and *Princess Augusta*, Captain Thomas Baddison, on return from Canton. In September sighted island at 434′N, 130°23′E—Pulo Anna. *Carnarvon* also sighted Merir (Stevens, 1808: 636–6).
1763	British merchantman *Governour* sighted Pulo Anna (Stevens, 1808: 636; Robertson, 1791: 104, 1795).
1767	*HMS Swallow*, Captain Philip Cartaret, on exploring expedition of Wallis, discovered islands to southwest of Palau on passage from New Guinea to Manila. 8 September: Sighted a 'very dangerous shout'—Helen's Reef. Saw island that was named 'Hummock' (Tobi). 12 October: Sighted island that was called 'Bird Island' (Pulo Anna). 13 October: Sighted two tiny islands and called them 'Current Islands' or later 'St Andrew Is' (i.e., Sonsorol; Eilers, 1936: 1, 19–20; Wallis, 1965: 1, 200–03).
1769	British indiaman *Ponsborne*, Captain John Payne, en route to China. In February sighted Pulo Anna and Merir (Stevens, 1808: 635–6).
1773	Spanish ship *Nuestra Senora de Consolacion*, piloted by Felipe Tompson, may have sighted Helen's Reef. An old map shows the track of Tompson's ship with a reef drawn in near the position of Helen's Reef (Sharp, 1960: 127–8).
1781	British merchantman *Lord North*, under Captain William Hambly on a return trip to Canton, was driven off course by winds and current. In January sighted Tobi and named it 'Lord North's Is' (Purdy gives as date of discovery 14 July 1728 (Stevens, 1808: 639; Purdy, 1816: 15).
1783	British indiaman *Fox* sighted islands in the Palau group, perhaps Tobi and the Southwest Islands (Dalrymple, 1783: 14). British indiaman *Antelope*, under Captain Henry Wilson, on return passage from Macao. 10 August: Ship went aground on the western reef of Palau in a storm near Ulong. Crew spent three months on Palau and received the assistance of the islanders. Communication was conducted through Malayan interpreters on both sides. Wilson and his men assisted the Ibedul (one of Palau's two high chiefs) in four battles against traditional enemies. The English constructed a small vessel called *Oroolong* and departed on 12 November, leaving one of their men behind and taking the son of the Ibedul (Keate, 1789).

(Hezel, 1972; Hezel 1979: 1). After spending 'four days fighting the currents and contrary winds, the ship managed to put in there, without however securing anchorage' (Hezel, 1972: 33). On the following day the ship's launch put out to shore again, this time with two Jesuit priests aboard. Before it could return, however, 'the *Trinidad* was driven out of sight of the island by the strong currents that are always so troublesome around Sonsorol, and a few days later Padilla found himself off the Palau group, some 150 miles to the north. All subsequent attempts by the *Trinidad* to regain Sonsorol proved fruitless' (Hezel, 1972: 33).

For that time of the year winds are relatively light from the east half of the compass at force 2–3 (4–10 knots) (Defense Mapping Agency, 1994). There is also a current through the area that sets to the east at one knot, mitigating the contrary winds. In 1712 an attempt was made to rescue those left behind by Padilla on Sonsorol (Hezel, 1972; Hezel, 1979: 1). The *Santo Domingo*, captained by Bernardo de Egui, set out from Guam in January. At that time, expected conditions would be winds from the north-west and west at force 4 (11–15 knots) (Defense Mapping Agency, 1994). Once sailing south of Guam, currents setting to the west and south-west would be encountered and, along with the winds, would be favourable for navigating to Palau. The *Santo Domingo* located Sonsorol on 19 February, but apparently found it abandoned, and were carried away by strong winds and currents, leaving a short time later back to Manila. The current at that time of year sets to the south-west at 0.8 knots and, coupled with a moderate breeze from the north-west and west, would not have been conducive to landing on the small island.

Several sightings of Pulo Anna, to the south of Palau, were recorded in the 1760s (Robertson, 1795: 65, 67: Hezel, 1979: 1–2). The *Carnarvon*, *Warwick*, and *Princess Augusta*, commanded by Captains Norton Hutchinson, James Dewar, and Thomas Baddison respectively, sighted the island in February 1761 as they were returning to Britain from Canton. They were likely to have run into similar conditions as the *Santo Domingo*. In 1763 the British ship *Governour* also sighted Pulo Anna, but no season or conditions are given by Robertson (1795). HMS *Swallow*, captained by Philip Cartaret, sighted Pulo Anna and Sonsorol in October 1767 (Wallis, 1965, 1: 200–203; Hezel, 1979: 2). There they encountered strong south-setting currents and a gale from the south-west. In October, south- and south-eastern-setting currents between Mindanao and Palau average 1.5 knots (Defense Mapping Agency, 1994). *The Ponsbourne*, captained by John Payne, sighted Pulo Anna in February 1769, but Roberts (1795: 67) does not give any details. February conditions are noted above for the *Santo Domingo* sighting.

In 1773 Felipe Thompson, commanding the Spanish vessel *Nuestra Señora da la Consolasion*, sighted what appears to have been Helen's Reef at the extreme south end of the Southwest Islands while sailing from Manila to California via New Guinea (Sharp, 1960: 127–8; Hezel, 1979: 2). Unfortunately no season or description of the conditions was given. Tobi was again sighted by Captain William Hambly of the *Lord North* in 1781 (Robertson, 1795: 66; Hezel, 1979: 2). Hezel (1979: 2) gives the time of year as July, but no sea-conditions are mentioned. The *Fox* sighted the Southwest Islands in 1783 (Dalyrymple, 1786: 14; Hezel, 1979: 2); no further information is given. This is the last reported sighting of the Palau archipelago until the wreck of the British ship *Antelope* in 1783, after which European sighting of or landings on Palau itself become fairly common.

Although these historical accounts provide good evidence for the sea and wind conditions which faced European sailors, they are limited by covering only those times of the year in which they actually sailed. Thus, it remains unclear whether successful contacts with Palau could have been more frequent if voyages had taken place during different months. To help resolve this issue, we conducted simulations of voyaging to estimate the chances that Spanish explorers would have had of finding Palau from Guam and the Philippines both accidentally and intentionally during any given time of the year.

Computer simulations of voyaging

The simulation programme was used in conjunction with historical documents which recounted the time of year, origin points, and conditions encountered, based on regional sea and wind conditions using the *Pilot Charts of the North Pacific* (Defense Mapping Agency, 1994). The documents we used included Rogers (1726), Dalrymple (1786), Keate (1789), Robertson (1795), Sharp (1960), Wallis (1965), Hezel (1972, 1979), and Lessa (1975). For the simulations we estimated success-rates for drift-voyages, and level of difficulty for intentional voyages. Examining drift-voyages has some advantages as it involves the fewest assumptions possible in the analysis, a strategy that limits decisions for the operator. In virtually all cases, if it is easy to discover point B from point A in a drift-voyage, it will be easier to navigate to point B once its location is known. Directed voyages are better used when evaluating the navigation skill needed when travelling between two points after initial discovery or when there is intent involved in the discovery. When running simulated drift-voyages, four main *variables* are considered: current patterns; wind

patterns; vessel type; and propulsion. The *structure* of the simulation is the actual mechanics of the programme; for example, how data are selected and success as a percentage of all voyages calculated. *Parameters* include such factors as the starting position of the vessel, drift- or directed voyage, duration at sea, and what constitutes a successful voyage.

Currents will affect any objects caught in them in a 1:1 ratio. That is, the object will have the same speed and set as the current unless other forces are operating. Any object floating with an appreciable part above the water will be more affected by wind than by currents unless the current is exceptionally strong. The effect of wind on objects floating high in the water was used by traditional navigators in Kiribati to determine the direction of land when they encountered winds that differed from the flow of the current (Lewis, 1972: 212). The source of wind and current data is the US Navy *Marine Climatic Atlas of the World* (1995). The type of vessel and how it is propelled make up the final variables of the simulation, as the shape of an object both above and below the waterline will dictate wind effects. However, in this problem, multiple types of vessel are being considered and we do not have precise information about the architecture of most, if not all of them. Drawn plans of vessels were not commonly used in Europe until the 17th century and at that time, variation in design became much more prolific. Therefore, speeds at which the vessels used in this simulation can travel under various wind conditions are taken from generalized figures provided by Levison *et al.* (1973).

The programme itself is based on the US Navy (1995) and includes all the world's seas and oceans with the exception of Arctic waters. The data are organized in a resolution of one degree Marsden squares (one degree of longitude by one degree of latitude). This resolution allows the effects of smaller and more variable currents to be accurately reflected in the outcomes. The programme randomly selects wind and current data which are frequency-weighted according to the compiled observations of the *Marine Climatic Atlas*. These forces are then allowed to operate on vessels for a 24-hour period before a new selection is made (see Levison *et al.*, 1973 for a justification of the period length). The actual distance and direction travelled are based on the wind and current data combined with the speeds from Levison *et al.* (1973: 19) and parameters selected by the programme operator. Examples of parameters here include the use of sails, sea-anchors to keep a vessel oriented into the wind during storms, or drogues to slow the vessel and prevent following seas from swamping the vessel. It is also possible to include here changes of heading when under sail. This last feature is important when assessing the level of navigational skill required to reach a selected target during deliberate voyages. The result of the drift-simulations is expressed as the percentage of successes for a particular vessel-type from selected points. For intentional or directed voyages, routes can be evaluated on the duration it takes to reach the goal or target, if at all possible.

Parameters of the simulation are choices made by the operator in order to set up the simulation to answer a particular question. This includes the following information: point of origin and destination; crew strategy; performance characteristics; duration of voyages; time of year; and number of simulations. Four points of origin were used for the drift-voyages with Palau as the destination. These were: east of Samar (central Philippines); south-east of Mindanao (southern Philippines); north of Halmahera; and south of Guam. For the directed voyages, Manila and Guam were used as origin points corresponding with the historical record. The second parameter is the strategy used by the crew. In the drift simulations it was assumed that the crew was lost at sea. Dening (1963: 138–53) notes that the limited empirical evidence of known drift-voyages in Polynesia suggests a common pattern of behaviour in which sailors conclude they are lost early in the voyage and respond by allowing the vessel to drift before the wind with no further attempt to navigate in a particular direction. This strategy allows close to the maximum distance to be covered in a given time when there is no clear indication of relative location. For the purposes of this study, 100 drift-voyages were simulated for every month of the year from each of the starting points.

The strategy for the intentional voyages began with the ships leaving Manila and Guam. In historic searches for Palau, information as to its general location was available. However, without details it is not possible to work this into the simulation. As an alternative, the best possible scenario was assumed—that is, the precise location of Palau was known and headway was optimal. This does not simulate actual historic searches, but it does give information as to the

Table 2. *Success rates for drift voyages to Palau and durations in days*

	January	February	March	April	May	June	July	August	September	October	November	December
Samar	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Mindanao	0%	0%	0%	0%	0%	1% (42)	2% (11, 19)	2% (11, 13)	11% (10–30)	10% (13–56)	1% (22)	0%
Halmahera	0%	0%	0%	0%	0%	10% (15–32)	17% (8–17)	18% (9–28)	35% (9–34)	5% (39–75)	0%	0%
Guam	4% (9–15)	5% (8–11)	3% (9–11)	4% (11)	0%	0%	0%	0%	0%	0%	0%	1% (15)

relative difficulty of routes from different origins and in different seasons. A heading was chosen that would move the ship towards Palau. This was combined with a wind and current direction and force and allowed to operate for 24 hours before a new heading was chosen. The goal was to reach Palau in the shortest time possible. When a particular heading was not successful in moving the vessel towards Palau, the simulation was backed up and another heading chosen. One simulation was done from each origin point for each month of the year. The duration of all voyages was set to 75 days, which would by no means be long even for drift-voyages in open boats due to shipwreck or other misfortunes documented in the Pacific (Howay, 1944; Levison *et al.*, 1973: 20–21). The maximum recorded drift seems to be in the order of seven to eight months, and several of these have been documented in the last few decades. A number of these recorded

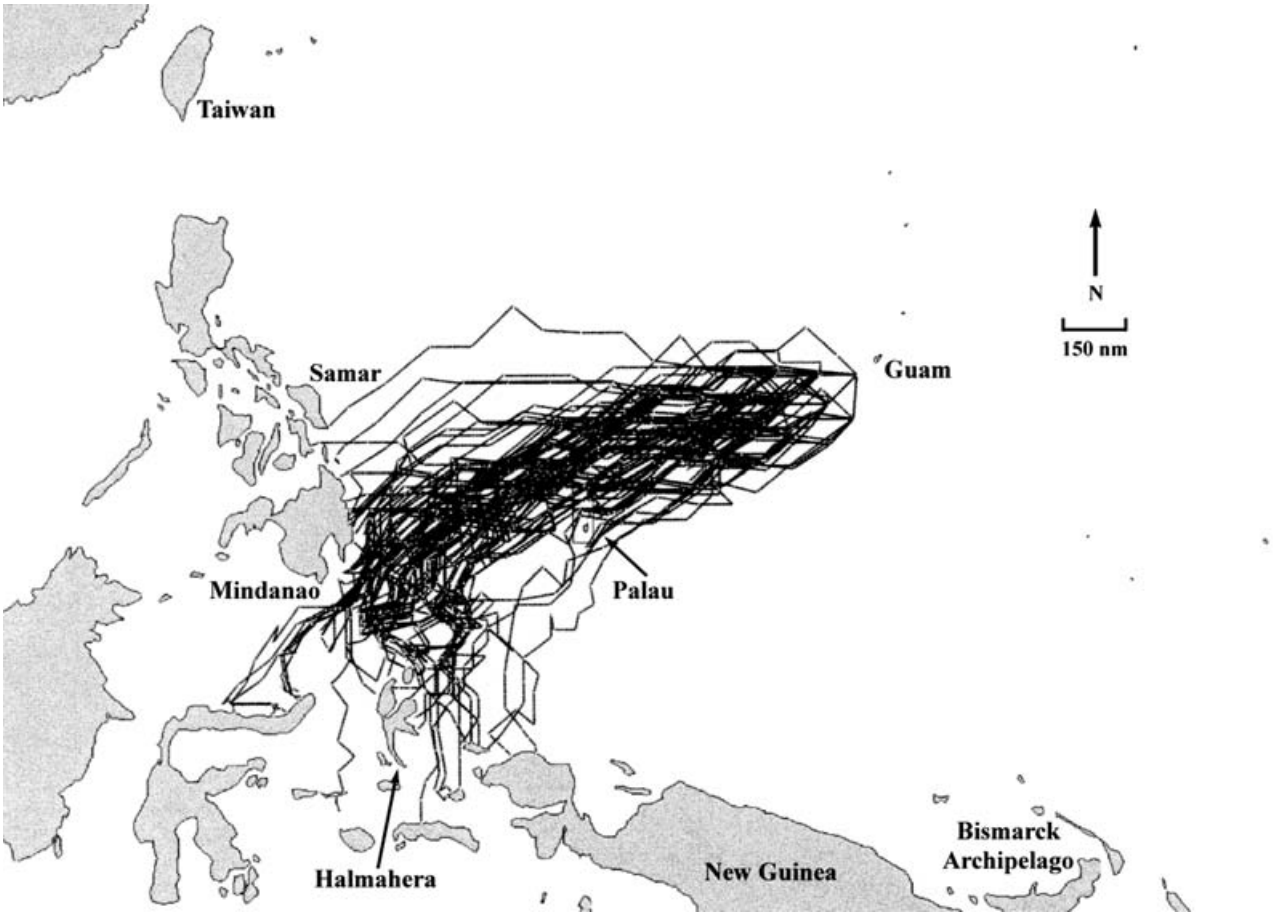

Figure 2. Simulations of voyages from Guam to Palau in February.

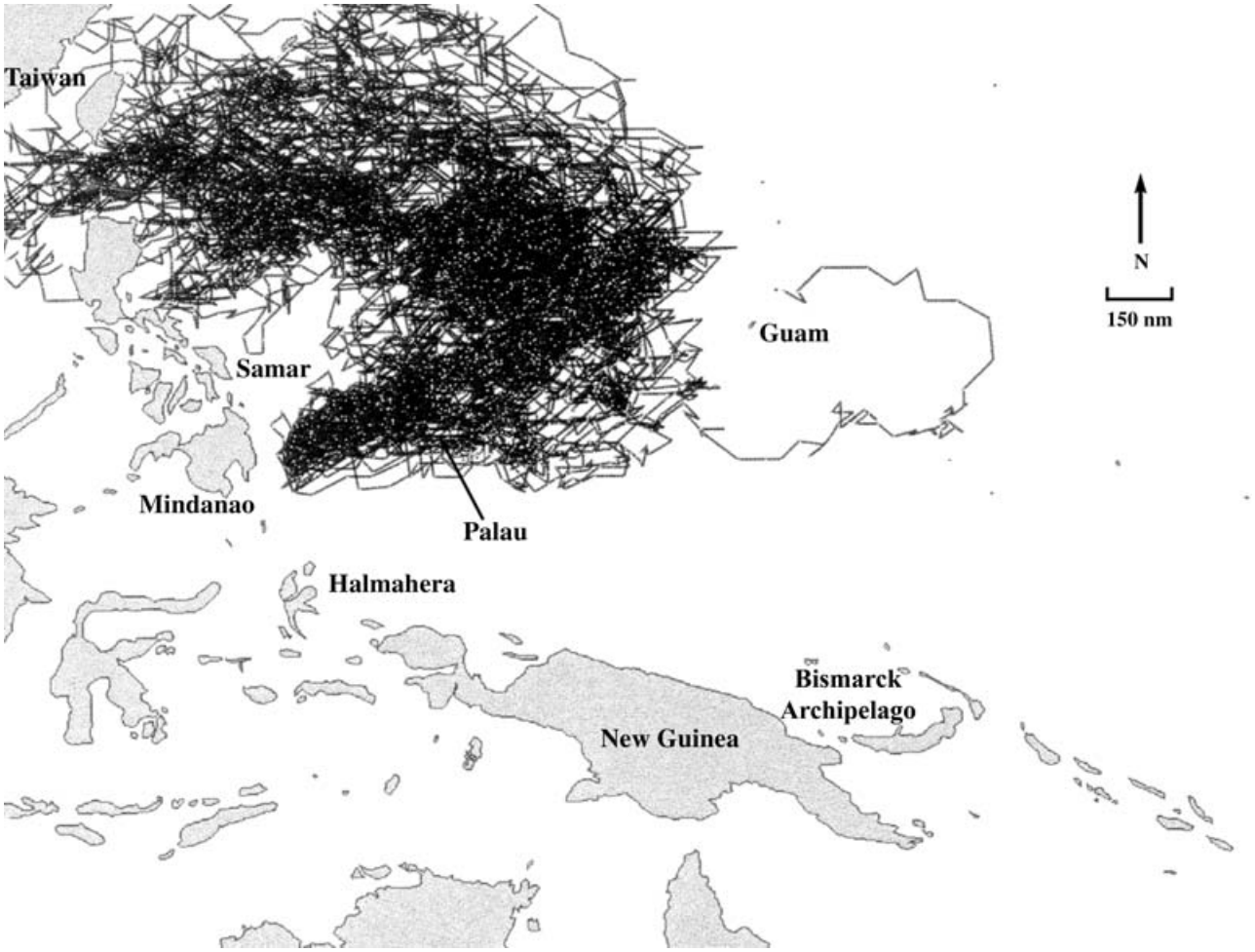

Figure 3. Simulations of voyages from Mindanao to Palau in September.

voyages covered distances of around 5500 km over a period of six to ten weeks, and even more travelled slightly shorter distances.

Drift-voyage simulations

Table 2 gives the success rates for drift-voyages to Palau from the Philippines (both Samar and Mindanao), Guam, and Halmahera along with the duration in number of days. Drift-voyages from Guam were successful from December to April. Success rates were relatively low, however, from 1% to 5%. Durations of voyages were from 8–15 days with an average of about 10.5 days. Drift-voyages were most successful with February conditions and are shown in Fig. 2. From Mindanao, drift-voyages were successful under June to November conditions. Success rates were from 1% to 11% with durations of 10–56 days. The average number of days successful voyages took was 23. Voyages starting in September (Fig. 3) had the highest rate of success (11%). Voyages originating off Halmahera had by far the greatest chance of success from June to October, from 5% to 35%. Voyages beginning under September conditions had the highest

Table 3. *Intentional voyages to Palau from Manila and Guam by month with durations in days*

	January	February	March	April	May	June	July	August	September	October	November	December
Manila	20	25	25	15	18	13	10	13	10	10	16	16
Guam	9	11	11	21	0	0	0	0	0	10	16	16

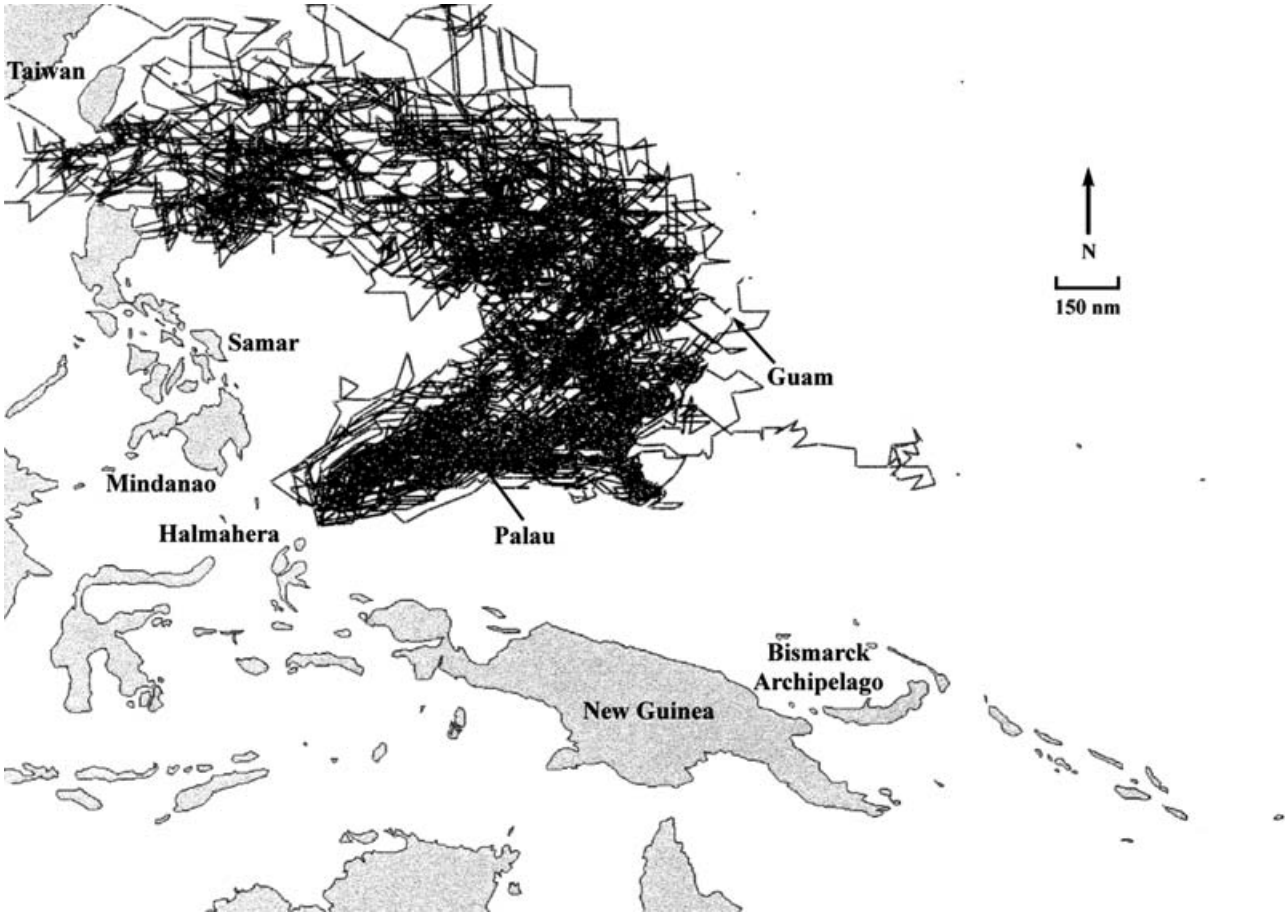

Figure 4. Simulations of voyages from Halmahera to Palau in September.

success rate (Fig. 4). Durations ranged from eight to 75 days with an average of 26 days. It should be noted that under October conditions, the average durations were 62 days which somewhat biases the overall average. No drift-voyages were successful from Samar (see Callaghan and Fitzpatrick, 2007, for further details regarding prehistoric drift-voyages to Palau).

Intentional voyage simulations

The results of the simulations of intentional voyages to Palau from Manila and Guam are shown in Table 3. These show that, at least under ideal conditions, it is possible to reach Palau in any month of the year from Manila. However, in reality these voyages would have been much longer because when an unfavourable combination of heading, winds, and currents occurred, the simulation was simply backed up and another heading chosen. In all cases, the real time to reach Palau is probably double the simulated figures. Voyages in January, February, and March required the longest time of 20–25 days. The months with voyages of the shortest duration, 10 days, were July, September, and October. June and August had the next shortest durations of 13 days, while May and June voyages lasted 15 and 18 days respectively. November and December had voyages that lasted 16 days. These are also the most interesting months historically, as it was during this time that Francisco Padilla in the *Santissima Trinidad* began his search in what turned out to be the only successful attempt by the Spanish Crown to reach Palau.

From Guam, the simulated voyages revealed that from May to September it is nearly impossible to sail to Palau even knowing its exact location. No amount of manipulating headings could achieve success. Ultimately some successful route could have been found, but it would have required unrealistic decisions in choosing headings and very lengthy voyages. From October to April, voyages out of Guam were successful, ranging

from nine days in January to 21 days in April (Table 3).

Discussion and conclusions

It is quite apparent that the Spanish were very eager to find Palau after hearing reports of Carolinian sailors who had drifted to the Philippines. In 1664 alone, Jesuit missionaries recorded some 30 Carolinian canoes which had accidentally drifted to the Philippines and whose members spoke of inhabited islands to the east. But, despite repeated efforts, Palau still remained outside the grasp of direct European influence for centuries. Hezel (1972) notes that there were eight recorded Spanish attempts to locate the archipelago between 1697 and 1711. Of these, only the *Santissima Trinidad* under Padilla was successful, although they never actually set foot on land. The ship set out from Manila in November, the month with some of the most favourable wind and current conditions according to the Pilot Charts (Defense Mapping Agency, 1994). The second successful Spanish attempt to locate Palau in 1712, by the *Santo Domingo* under Bernardo de Egui, set out from Guam in January. As noted, this was an extremely favourable time of year for this voyage.

Adverse wind and current patterns, at least seasonally, are undoubtedly the main reason why the Spanish were unsuccessful in locating Palau. South- and south-east-setting currents between Mindanao and the Palau, particularly from July to September, are generally towards Palau, but tend to pass Palau and swing east around the south end of the archipelago. It is not surprising, therefore, that Sonsorol, Pulo Anna, Tobi, and Helen's Reef were the most frequently sighted islands, due to the currents passing eastward and to the south of the Southwest Group. It must also be remembered that Harrison's marine chronometer, which enabled sailors to make accurate determinations of longitude, was not available until after Cook used it in 1772 (Bricker, 1989: 37–40). It is significant to note that of the 23 total sightings made of the Southwest Islands or the main archipelago of Palau from 1784 to 1799, all were British ships (Hezel, 1979: 2–4), because of this new technology.

The computer simulations we conducted, coupled with historical accounts of sailing conditions, suggest that voyagers drifting from Mindanao and Halmahera to Palau would have had the most chance of a successful landfall. The high rate of success at finding Palau from Halmahera (35%) is explained by the higher than normal winds coming from the south-west during September (Morris, 1988). This was one reason why various ships were able to venture so close to the Southwest Islands of Palau—their voyages left the Moluccas just as favourable winds began blowing northward. In addition, sailors departing from the southern Philippines, even if they were unable to reach Palau, would have had a good chance of returning home. This, in part, also helps to explain the significant number of Carolinian canoes which ended up drifting there.

Because Spanish accounts report repeated, but unsuccessful, attempts to discover Palau from Guam, we also investigated this route; based on these data, the probability of finding Palau by drift-voyages is small due to seasonally-unfavourable winds and currents. These computer-simulated drift-voyages suggest that excursions leaving from the southern end of the Philippines, if allowed to drift, would have had the highest rate of success in finding Palau (see also Callaghan and Fitzpatrick, 2007).

The intentional and directed voyages resulted in some interesting outcomes which correspond to the historical record. From Manila, voyages setting out in the early months of the year would have been very long, even knowing the exact location of Palau. If we double the durations of voyages at this time of year to reflect reality better, it is not surprising that searches would have been abandoned. While the successful voyage of the *Santissima Trinidad* under Padilla did not take place at the most propitious time in terms of sea-conditions, it still left Manila with a reasonable chance of success according to the simulated intentional voyages. The directed voyages from Guam indicate that in some seasons sea-conditions would have made it virtually impossible to locate Palau. The *Santo Domingo* under Bernardo de Egui left Guam in January, the month with the most favourable conditions for success. It seems likely that this choice of departure time had to do with information supplied by the native inhabitants of Guam.

Overall, the simulations we conducted, in conjunction with historical records of seafaring, give us a better sense of the difficulties encountered by Europeans when attempting to find Palau, demonstrating just how influential sea-conditions can be in preventing contact with island groups. Future research will be directed towards investigating the degree to which these same conditions may have hampered efforts by Europeans to locate islands elsewhere in the Pacific.

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