COMMENTS ON THE MAINLAND ORIGINS OF THE PRECERAMIC CULTURES OF THE GREATER ANTILLES

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Computer simulations are used to shed light on the probable origins of the earliest Preceramic cultures of the Greater Antilles and to understand the navigation skills necessary for island colonization. These cultures, dating to between ca. 4000 B.C. and 2000 B.C., are found on Cuba, Hispaniola, and possibly Puerto Rico. Two areas, northern South America and northern Central America, have assemblages that bear resemblance to the assemblages of the Greater Antilles, but there are important differences. Chance discovery of the Greater Antilles is possible from three areas: northern South America, northern Central America, and southern Florida. Directed voyages have a high degree of success from all three areas. However, voyages from northern South America require the least navigational skill, making it the most likely source of colonization. From northern Central America, foreknowledge of the islands appears to be required, while directed voyages from southern Florida encounter considerable risk.

Se emplean modelos de simulación por computadora para entender los origenes posibles de las primeras culturas precerámicas de las Antillas Mayores, así como las habilidades necesarias para realizar su colonización. Estas culturas, que tienen fechas entre 4000 a.C. y 2000 a.C., se encuentran en la Cuba, la Española y posiblemente en Puerto Rico. Dos áreas, la parte norte de Sudamérica y la región norte de Centroamérica, tienen conjuntos arqueológicos que presentan semejanzas con aquellos de las Antillas Mayores. Sin embargo existen diferencias importantes, especialmente en las industrias líticas. Los resultados de la simulación indican que hubo posibilidades del descubrimiento de las Antillas Mayores desde tres áreas: el norte de Sudamérica, el norte de Centroamérica y el sur de la Florida. Hay grandes posibilidades de éxito en viajes intencionales desde cualquiera de estas áreas. Sin embargo, los viajes desde Sudamérica requieren menos habilidades para la navegación, haciendo que esta sea la fuente más probable de la colonización. Parece ser necesario tener un conocimiento previo de la existencia de las islas para realizar el viaje desde América Central, y el viaje directo desde el sur de la Florida involucra riesgos considerables. Finalmente, este estudio sugiere que los conjuntos arqueológicos de la Centroamérica, de Sudamérica y de las Antillas Mayores requieren de un análisis comparativo detallado antes de poder sacar una conclusión sólido con respecto al origen de las primeras culturas de las Antillas Mayores.

Virtually every area of the Caribbean and Gulf mainland (Figure 1) has, at some time, been hypothesized to be the origin of the early Preceramic Antillean cultures. Coe (1957) suggested the Yucatan Peninsula, while Hahn (1961:181–182) suggested the Gulf Coast and the southwestern United States. Western Venezuela was suggested by a number of authors (Veloz and Martín 1983; Veloz and Ortega 1973; Veloz and Vega 1982). An origin has also been postulated in the microblade-producing cultures of Louisiana (Febles 1982), and in Nicaragua (Cruxent and Rouse 1969). Currently the Yucatan Peninsula seems to be favored as the most likely source for the earliest populations in the Greater Antilles (Keegan 2000; Wilson et al. 1998). The majority of the suggested origins for the Greater Antillean Preceramic cultures are based on comparisons of a few artifacts, a few artifact types, or manufacturing techniques. Despite calls from scholars such as Rouse, no systematic comparison has been made between the early Preceramic assemblages of the Greater Antilles and any mainland assemblages. Even within the Antillean material, conflicting taxonomies exist (Rouse 1992:58).

I would suggest that the early Preceramic cultures of the Greater Antilles probably had multiple inputs from the surrounding mainland, but some

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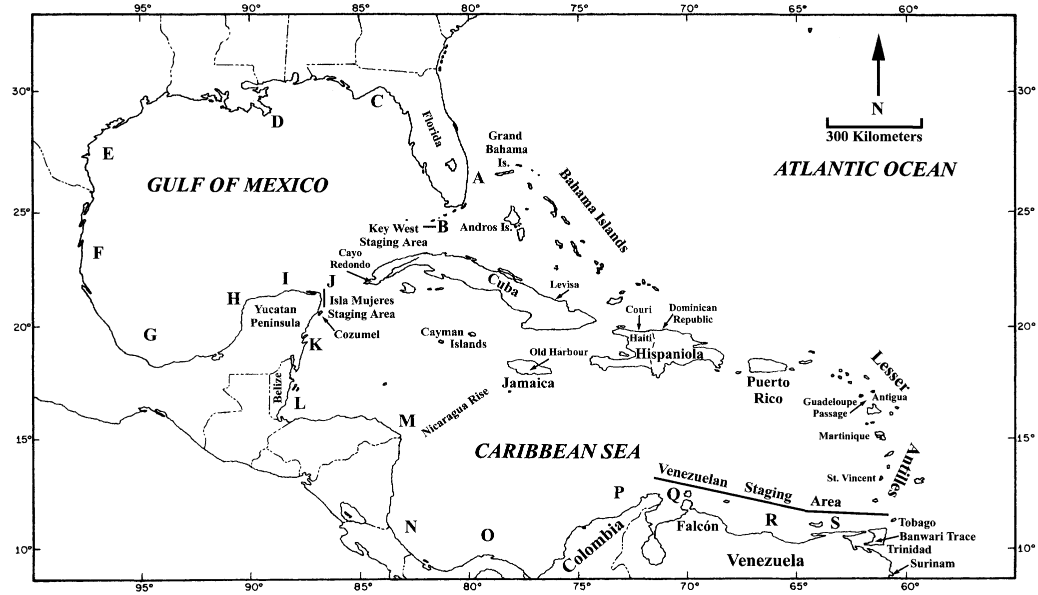

Figure 1. Staging areas for voyages (letters indicate regions of departure considered in this study).

group had to arrive first. This issue of primacy is investigated through the use of computer simulations of both accidental and intentional discovery of the islands from various mainland points of departure. The result is to evaluate the potential for discovery of the islands by mainland peoples and to assess the navigational skills necessary to reach the islands. The simulation program is a more comprehensive version of an earlier work (Callaghan 1999, 2001). The current version has numerous advantages: it is more flexible with respect to the questions that can be asked, it contains more detailed wind and current data, and it incorporates archaeoclimatic modeling factors in climatic variation during the Preceramic period of the Greater Antilles that might be significant.

Once likely places of origin on the mainland are identified, I present a brief discussion of the similarities and differences between the relevant mainland assemblages and those of the Greater Antilles based on previously published work.[1]

The Early Preceramic Period of the Greater Antilles

The earliest human occupations known in the Caribbean islands date to approximately 3000 B.C. for Cuba (Kozlowski 1974:67) and 4000 B.C. for Haiti (Moore 1991). A number of artifact classifications have been proposed for the occupations including those of Kozlowski (1974), Rouse (1992) and Veloz and Vega (1982). Although Rouse's classification has been criticized for masking variability in the assemblages, I use it here as it is the most widely known. Rouse (1992:51) classified the artifacts of the earliest occupants of the Greater Antilles into his Casimiroid Series, for a period lasting from ca. 4000 B.C. to 400 B.C. The series contains three subseries: Casimiran (4000 B.C.–2000 B.C.), Courian (2660 B.C.–A.D. 240), and Redondan, beginning perhaps as early as 2050 B.C. (Rouse 1992:51–61). According to Rouse (1992:51), the early peoples making these artifacts occupied Cuba and Hispaniola and possibly Puerto Rico; the early assemblages found on Antigua may also represent a manifestation of the Casimiroid Series. No similar assemblages are found south of the Guadeloupe Passage in the Lesser Antilles (Figure 1).

These Casimiroid peoples did not make ceramics or practice agriculture. Initially, their chipped stone tools were made on blades, but these became less frequent in comparison to tools made on flakes over time. Both blade and flake tools are overwhelmingly unifacially retouched and shaped. Retouch on the dorsal surface is usually marginal. Occasionally, a few retouch flakes are removed on the ventral surface, often near the base (Kozlowski

1974). Extensively chipped bifacial stone tools are extremely rare. Kozlowski (1974:70) reported three poorly provenienced bifacially chipped tools from Cuban collections, but doubted that one originated in Cuba.

The Old Harbor collection (Lovén 1935: 219–222) of bifacial points from Jamaica has been suggested as belonging to the first peoples occupying the Greater Antilles (Harris 1991:81). However, the collection is highly problematic. Sven Lovén (1924, 1935) reported that the collection was acquired by Captain A. F. Scholander in 1920 from a Swedish sailor in Jamaica. The collection consisted of 75 bifacial projectile points. The sailor claimed that the points came from a mound at Old Harbour, Jamaica (Lovén 1935:219). Rouse (1960:19) noted that the points are more in keeping with the Florida Archaic period and do not resemble anything found in the Caribbean. Further, Bullen (1976:595) was of the opinion that this collection represented three periods of Florida points, going so far as to state that the material appeared to be Florida chert. Given that these points fit well into a Florida typology, the circumstances of their acquisition, the absence of Preceramic period sites on Jamaica, and a lack of similar tools anywhere else in the Caribbean, I feel it best not to include the collection with Carsimiroid or other Caribbean Preceramic assemblages.

During the later part of the Preceramic period of the Greater Antilles, the time of the Courian and Redondan Subseries, new types of tools appeared in the assemblages. These include intricate ground stone tools such as stone bowls, axes, beads, and items of unknown function (Rouse 1992:51–62). Many of these artifacts bear incised geometric designs. Shell gouges and decorated wooden batons have also been recovered.

The first cultures of the Greater Antilles do not appear to have reached the islands via the Lesser Antilles. Nor do they appear to be related to the Banwari Trace cultures of Trinidad. While some researchers (Sanoja 1987; Veloz 1991) have suggested a connection between the two regions on the basis of *Strombus* shell gouges, Rouse (1992) sees the use of *Strombus* shell gouges as an independent development in the Greater Antilles. Further, as Keegan (1994:266) has noted, Preceramic settlements are not found in the Windward Islands with the exception of two small sites, Boutbois and Le Godinot on Martinique (Allaire and Mattioni 1983), and one very dubious site, Buccament, on St. Vincent (Hackenberger 1991). In fact, there is very little evidence of Preceramic peoples in the islands south of the Guadeloupe Passage until one reaches Trinidad and Tobago. Direct crossings, which bypassed these islands, were possible (Callaghan 2001), but the Banwari Trace site is dated to approximately 5000 B.C. It is in the Redondan period, however, 3,000 years later, that shell gouges appear in Cuba. Even if shell gouges were introduced from Trinidad 3,000 years after the occupation of Banwari Trace, such an origin would still not explain the earliest Preceramic cultures of the Greater Antilles.

Computer Simulations of Voyaging

Computer simulations have been successfully developed to study maritime colonization, primarily in the Pacific. Levison et al. (1973) designed the first experiment of this kind in the late 1960s. The simulation examined the possibility that Polynesia was colonized from Melanesia or from South America, as Heyerdahl (1952) espoused, by drifting with the prevailing winds and currents. The results of 101,016 simulated voyages demonstrated that, with only a few exceptions, undirected drift voyages could not account for the colonization of Polynesia.

A version of their program was then run that assumed the intention of the crew was to try to maintain a general bearing east. This experiment ran 8,052 simulated voyages. It demonstrated that of all the Eastern Polynesian Islands, the Marquesas Islands, would have had the best chance of being colonized first from West Polynesia, despite the fact that the Marquesas are about twice the distance from West Polynesia as the Society Islands, also located in East Polynesia. This finding corresponds remarkably well with linguistic evidence for the pattern of colonization of East Polynesia (Levison et al. 1973:48–50). The results of this model continue to be indirectly supported by ethnographic and experimental observations of the navigational skills and efficient voyaging canoes of the Pacific Islanders (Finney 1977, 1979, 1987, 1991; Gladwin 1970; Goodenough and Thomas 1987; Lewis 1972).

More recently, Geoffry Irwin of the University of Auckland devised a second simulation program (Irwin 1989, 1990, 1992; Irwin et al. 1990). The Auckland team utilized the same wind and current data as Levison et al. 1973, but the canoes in their study were programmed for interactive sailing strategies that permitted navigation by dead reckoning, thus providing the option of return trips either by dead reckoning or by following the Polynesian tradition of latitude sailing.

The results (Irwin et al. 1990) seem to bear out Irwin's earlier conclusions that human expansion across Remote Oceania was not a unidirectional process, despite being characterized by a "bow-wave advance" from west to east, nor can it be justifiably regarded as the cumulative result of countless haphazard, one-way voyages. Rather, the simulation strengthened the evidence for a safer, but much more complicated, multidirectional process of navigation that initially occurred against, then across, and finally down the prevailing winds. This complex pattern suggested that the overriding concern of early colonists was their ability to backtrack to their point of departure, rather than the speed or range of exploration.

A third simulation (Thorne and Raymond 1989), developed at the Australian National University in Canberra, utilized ethnographic data for the performance characteristics of Indonesian bamboo rafts to plot drift voyages from Timor to northern Australia—parameters relevant to the initial colonization of Sahulland, the combined landmass of Australia and New Guinea, in the Late Pleistocene. Given known wind and current patterns, almost all rafts ended up on the Australian coast, most within a week to ten days. When Pleistocene sea levels were considered, it was virtually impossible for a raft to miss Australia.

A fourth, ongoing simulation study (Callaghan 1991a, 1991b, 1995, 1999, 2001; Callaghan and Fremont 1992) deals with the initial colonization of the Caribbean islands and subsequent interaction patterns. The results show that three mainland areas had the potential for chance discovery of the Greater Antilles and that during the Ceramic period there were no technological or environmental barriers requiring navigation to follow a "stepping stone" pattern from island to island.

Structure of the Simulation and Program Modifications

At issue in the present study are two points: (1) how difficult would chance discovery of the Greater Antilles have been from surrounding mainland areas; and (2) once the islands were known, how difficult would it have been to return to them using the type of watercraft likely to have been in existence at the relevant time? Chance discovery includes such events as voyagers being lost at sea during storms while fishing or conducting other activities. Dening (1963:138–153) noted that the limited empirical evidence of known drift voyages in Polynesia suggests a common pattern of behavior. People conclude they are lost early in the voyage and respond by allowing the vessel to drift before the wind with no attempt to navigate in a particular direction. In the second scenario, the voyagers either know the location of the islands or they are deliberately exploring in a particular direction. The fewer the number of course changes required to reach the target, the simpler the navigational skills necessary.

While answering these questions does not automatically tell us from which mainland area the Greater Antilles were first colonized, it does tell us the probability of discovery from specific locations and the level of navigational skill required to intentionally reach the islands from locations on the mainland. An understanding of the navigational problems encountered by prehistoric peoples in the Caribbean can be used to evaluate possible origins of the Preceramic peoples of the Greater Antilles.

The watercraft used in the simulation were canoes from the Upper Orinoco and Maya-style canoes from Central America. Canoes were chosen because they were in use in Florida by 6000 B. P. (Hartmann 1996:90), the approximate time of the earliest evidence for human occupation of the Greater Antilles. Both canoe styles have a wide distribution around the Caribbean, and the Ye'kwana style has been recovered from the Bahamas (Callaghan and Schwabe 2001). Earlier work (Callaghan 1991a:150–203) demonstrated that rafts could not have made these requisite crossings because of slow speed and excessive drifting before the wind. Data regarding how the canoes performed were derived from both on-location experiments and from analysis using naval architecture programs. Performance data for the Maya and Ye'kwana style canoes were entered into a dynamic wind and current simulation. The wind and current information is the same as that used to compile American Navy pilot charts (Defense Mapping Agency Hydrographic/Topographic Center 1982).

The simulation program in the following discussion is a much more advanced version of the one cited above (Callaghan 1999, 2001). This second generation program is based on the United States Navy Marine Climatic Atlas (US Navy 1995) and has been expanded to include all of the world's seas and oceans with the exception of Arctic waters. The data are organized at the finer resolution of one degree Marsden squares (one degree of longitude by one degree of latitude) rather than two degree Marsden squares as in the previous studies. In particular, this change allows the effects of smaller and more variable currents to be accurately reflected in the outcomes. The advanced program also automatically shifts from the data for an initially selected month to that for the following month after the original interval has expired. This feature better reflects the reality of changing wind and current conditions over long voyages. A conversion to spherical coordinates has been added that increases positional accuracy outside of the tropics. The operator also has the option of defining success in different ways. Success can be defined as sighting an island from a particular distance or as the vessel actually making landfall. Finally, the program allows the operator to change the bearing of a vessel during a voyage to reflect decisions made by the crew. This last feature is important when assessing the level of navigational skill required to reach a selected target.

Past Climate and Water Levels

Although climatic conditions during the period from 6000 B.P. to 4000 B.P. differed from present conditions, it is possible to estimate the nature of these differences and include them in the interpretation of the results. It is also important to consider variation in sea levels.

High-resolution reconstructions of the Caribbean climate are available. Hodell et al. (1991) present such a reconstruction for the last 10,500 years based on $^{18}O/^{16}O$ ratios in Haitian Lake Miragoane ostracod shells that reflect changes in precipitation for the period. From about 6000 B.P. to 4000 B.P., the $^{18}O/^{16}O$ values and variation (1991:Figure 2) were lower than over the last 200 years, the period during which pilot chart data were compiled. The values indicate higher precipitation levels than current conditions (1991:792). There was a slight shift toward drier conditions at approximately 5200 B.P. than just prior to that time, a condition that lasted until approximately 3200 B.P. During this period, conditions resembled the wettest conditions of the last 200 years. Hodell et al. (1995) published a similar study from Lake Chichancanab in the central Yucatan Peninsula. For the period from ~7000 B.P. to 4000 B.P., the climatic history of the two lakes is very similar (1995:375).

Hodell et al. (1991:792) note a correlation between precipitation anomalies and variation in the annual climatic cycle in the Caribbean region. They state: "(e)nhancement of the annual cycle led to years of anomalously high precipitation, whereas a reduction led to a deficient rainy season" (1991:792). Thus reconstruction of variation in precipitation should accurately indicate variation in the annual cycle. The annual cycle itself is controlled by the summer displacement of the North Atlantic subtropical high by the northward movement of the intertropical convergence zone and the reverse movement in winter. Hodell et al. compare their data with annual cycle intensity changes estimated from "the seasonal insolation difference at the top of the atmosphere at 10° N between August and February" (1991:792). Changes in both records for the 10,500-year period are similar (1991:Figure 2). This agreement reinforces the conclusion that while variation from present climatic conditions, including surface wind patterns controlled by the subtropical high, existed during the early Preceramic period, they were not substantial.

Further, data from sea cores and other sources (Bryson 1987:2) indicate that, on a global scale, the boundary between the prevailing westerlies and the trade winds has been at about 20 degrees north latitude throughout the Holocene. This means that the North Atlantic subtropical high pressure cell would

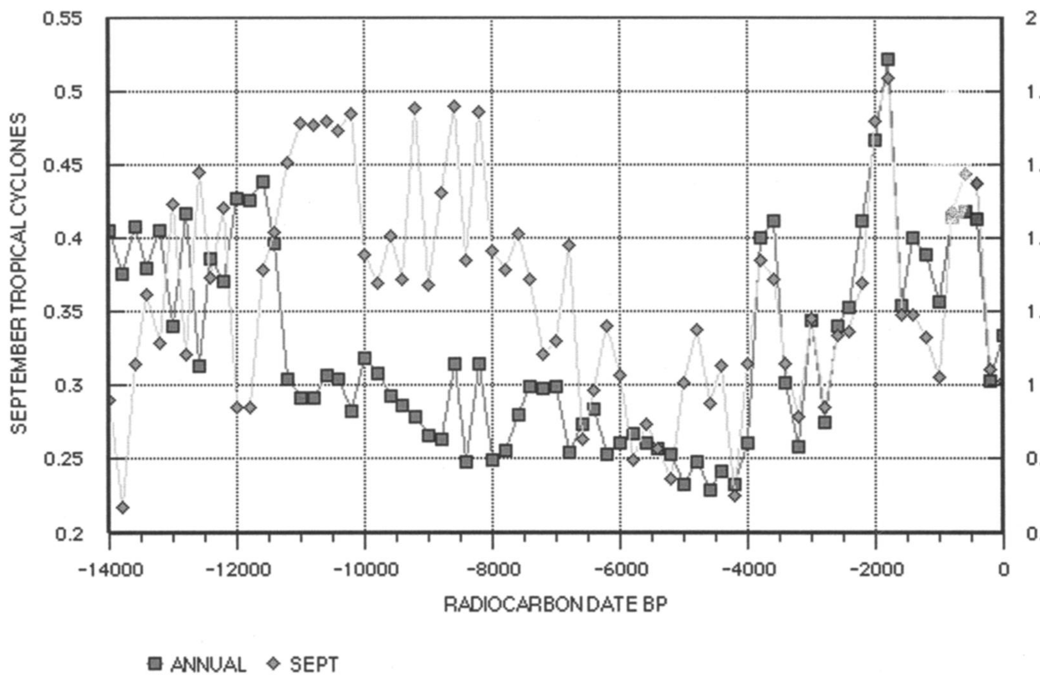

Figure 2. Tropical cyclone history, South Florida (provided by Reid Bryson, Center for Climatic Research, University of Wisconsin).

have been further north in terms of annual mean, but probably not north of its present northern (summer) limit (Lamb 1987:Figure 9.3). Therefore, conditions similar to present summer may have prevailed year round in the study area during the period centered around 6000 B.P. to 4000 B.P.

Bryson and Bryson's (1998) archaeoclimatic modeling indicates very similar patterns of precipitation for a number of areas around the Caribbean and Gulf region. The modeling is based on Milankovitch cycles, geographic information, and modern atmospheric calibration data. Such modeling effectively demonstrates the magnitude of the changes and is used to calculate past positions of the intertropical convergence zone, the subtropical high pressure systems, the jet stream, and other major features of atmospheric circulation. From this modeling, precipitation and temperature can be derived. The results of the modeling show precipitation between ~6000 B.P. and 4000 B.P. for the coast of Venezuela, the Cayman Islands, Key West in Florida, and Isla de Cozumel to be equivalent to, or slightly greater than, that of the period from ~500 B.P. to 100 B.P. (Reid Bryson, personal communication 2002).

Tropical cyclone activity is also an important issue when considering navigation. Figures 2 and 3 (provided by Reid Bryson, Center for Climatic Research, University of Wisconsin) model tropical cyclone activity for the Lesser Antilles and south Florida. For the Lesser Antilles, activity is slightly less from 6000 B.P.–5000 B.P. than from about 500 B.P.–100 B.P., and is significantly less from 5000 B.P. to 4000 B.P. Between 6000 B.P. and 4000 B.P., tropical storm activity for south Florida was roughly half what it was between 500 B.P. and 100 B.P.

Overall, the available data suggest a 6000–4000 B.P. climate very similar to that reflected in the United States Navy Marine Climatic Atlas (US Navy 1995), based on data beginning in the early nineteenth century. The main climatic difference appears to have been a significant reduction in tropical storm activity in the northwestern Caribbean and eastern Gulf region during the period of interest, perhaps making voyaging safer.

Many sea areas relevant to this study are very shallow. If any significant land was exposed around 6000 B.P. it might have provided voyagers with intermediate stopping places on their way to the Greater Antilles. Hendry (1993:Figure 7.3) pre-

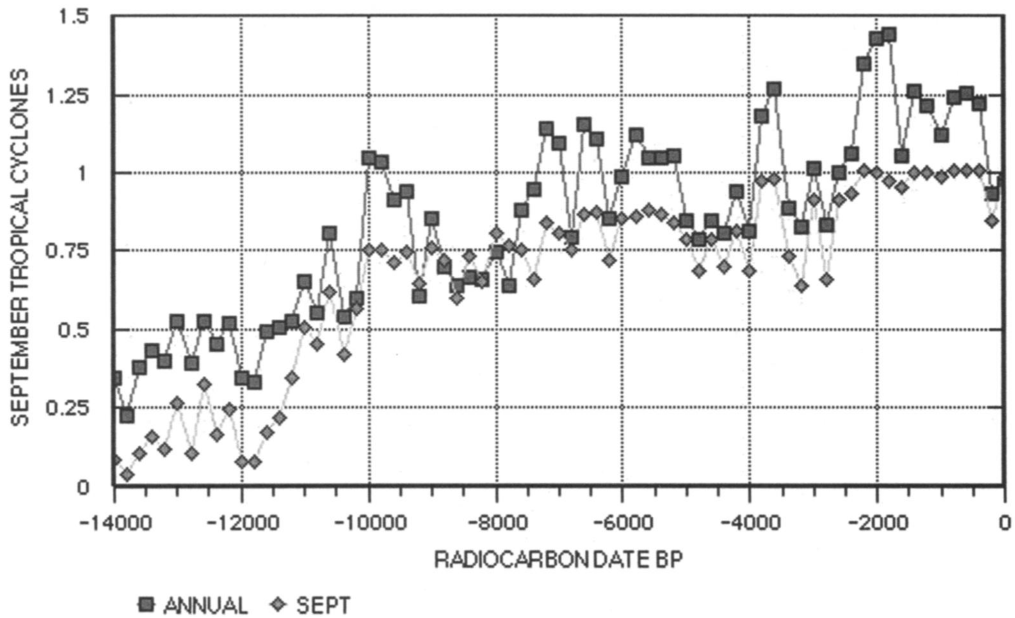

Figure 3. Tropical cyclone history, Lesser Antilles (provided by Reid Bryson, Center for Climatic Research, University of Wisconsin).

sents sea-level curves for a number of areas within the Gulf and the Caribbean region. Those pertinent to this discussion include Surinam, Jamaica, Belize, and Florida. Sea level reached present levels at about 6000 B.P. in Surinam and was about 30 centimeters lower in Belize, 40 centimeters lower in Jamaica, and 50 centimeters lower in Florida by that time. Hendry (1993:115) also points out that tectonic movement generally cannot explain the variation in relative sea level within the Caribbean and Gulf region. Rates of vertical tectonic movement are at least one order of magnitude less than relative sea-level rise, thus giving them little significance in most localities over the last few thousand years. An examination of nautical charts reveals that no significant new land would have been exposed in areas such as the Bahama Banks, the Nicaragua Rise, or southwest Florida.

Simulation Results

Figure 1 shows the 19 areas of departure considered (Callaghan 1991a and 1991b) and then reinvestigated with the current second-generation program. Three thousand voyages were simulated from each area for both drift and directed voyages, totaling 114,000 simulations. With the exception of three regions—south Florida, the Yucatan Peninsula, and Venezuela—there was virtually no possibility of either chance discovery of the Greater Antilles or of directed (paddled) voyages. This is not surprising for the western Caribbean where navigating to the islands is to windward. Columbus, in a letter to Ferdinand and Isabella concerning his disastrous fourth voyage, commented on the problems of sailing to windward in the Indies:

> In the Indies, if ships do not sail except with the wind abaft, it is not because they are ill built or because they are clumsy. The strong currents that are there, together with the wind, bring it about that none can sail with the bowline, for in one day they would lose as much way as they might have made in seven, nor does a carvel serve, even if it be a Portuguese latteen rigged vessel [Columbus 1932:98].

Winds and currents in the Gulf of Mexico are extremely variable for periods extending voyages beyond the five-month limit used in the model. A five-month limit was used because it represents the duration of some of the longest drift voyages recorded (Levison et al. 1973:20).

As the Maya-style canoe and the Ye'kwana-style canoe results are nearly identical, Table 1 pre-

Table 1. Drift Versus Intentional Voyage Landfall Success Rates for Specific Source Points.

Geographic Source Point[a]	Drift Voyage Success Rate	Drift Voyage Avg. Duration	Intentional Voyage Success Rate[b]	Intentional Voyage Avg. Duration
A	0.00%		0.00%	
B	0.10%	15 days	100.00%	
C	0.00%		0.00%	
D	0.00%		0.00%	
E	0.00%		0.00%	
F	0.00%		0.00%	
G	0.00%		0.00%	
H	0.00%		0.00%	
I	0.00%		0.00%	
J	0.10%	4 days	0.20%	2 days
K	0.00%		100.00%	5 days
L	0.00%		100.00%	6 days
M	0.00%		0.00%	
N	0.00%		0.00%	
O	0.00%		0.00%	
P	0.00%		0.00%	
Q	3.00%	39 days	100.00%	7 days
R	5.00%	34 days	100.00%	6 days
S	10.00%	30 days	100.00%	6 days

[a]See Figure 1.
[b]At 3.4 knots per day.

sents only the results of the Maya-style vessel. For more than a 300 nautical mile stretch of the Venezuelan coast, points Q, R, and S, there is a reasonable chance of an undirected vessel successfully reaching the Greater Antilles given fall environmental conditions starting in September. Success was defined in the simulations as making landfall on the islands. The success rate ranges from 3 percent in the western part of the staging area to 10 percent in the east. From the west, landfalls are primarily in western Cuba. As one moves east, landfalls are overwhelmingly on the southwest coast of Hispaniola. Interestingly, because no Preceramic sites have been found on Jamaica, only one of the 9,000 simulated drift voyages made landfall on Jamaica.

For voyages originating from the northern Central American coast, successful drift voyages were limited to a small area east of Isla Mujeres off the northeastern coast of the Yucatan Peninsula. The success rate was .1 percent and was limited to April and September conditions. Moving the starting position as little as ten nautical miles north or south of Isla Mujeres eliminated any chance of success. Results for drift voyages from the southern tip of Florida in the eastern Gulf of Mexico show that success was possible from a point near Key West, Florida. The results from the second generation program show low rates of .1 percent in September and April comparable to those for Isla Mujeres. Similar to the case for Isla Mujeres, moving even 5 nautical miles off this starting point eliminated any chance of success.

In comparing the likelihood of successful drift voyages to the Greater Antilles from the three staging areas, a departure from the Venezuelan coast has a considerably greater chance of success than from northern Central America or southern Florida. However, there are other factors that suggest success from South America was much more likely. First, given the length of the staging areas for the three locations, there is approximately 15 times more coastal area from which success is possible for South America than for northern Central America or southern Florida. Given the presence of dugout canoes along the Venezuelan coast and some time depth for their use, it appears almost inevitable that some people would have found themselves in the Greater Antilles.

The program gives success rates for vessels, but does not include calculations for crew survival. The means of estimating risk to the crew is provided by Levison et al. (1973:Figure 6). Their estimations are derived from the work of McCance et al. (1956), where survival rates were calculated from data gathered on approximately 27,000 persons forced to abandon ship during World War II. In tropical waters, risk is determined largely by length of time at sea. The data show danger to crew for drift voyages as follows: successful drift voyages from the South American coast took from 4 to 6 weeks, with a probable crew loss of 10 to 12 percent. This means that 1 or 2 members (out of a total of 8 to 10) could be expected to die en route. Such a loss could still result in a viable founding population, according to Birdsell (1985), or allow for a return trip (Callaghan 1999). The probability of crew loss in successful drift voyages originating near Isla Mujeres was about 1 percent and therefore insignificant, while the probability from Key West was 5 to 7 percent.

There is considerable differentiation between mainland staging areas when we consider the question of intentional voyages to the Greater Antilles. First, the configuration of the target area when approached from South America offers a greater width than from the other two areas. There is a target window of 80 degrees from that coast compared to 50 degrees from northern Central America and 75 degrees from the eastern Gulf Coast.

More important is the variation in the paddling speed that had to be maintained to reach the Greater Antilles. Success was possible from all three areas if a speed of 3.4 knots was maintained as a daily average. Nevertheless, from South America, voyagers simply maintaining a northerly bearing and an average daily speed of .5 knots still would have usually made landfall in the Greater Antilles, and maintaining a speed of 3.4 knots could have resulted in landfall in about 6 days (Callaghan 2001). Only .2 percent of attempts to reach Cuba from near Isla Mujeres would have been successful even if a speed of 3.4 knots were maintained without course changes in the open sea. Success also was possible from further south (areas K and L), but voyagers would have needed to maintain a speed of 3.4 knots and have had the knowledge and skill to make course changes in the open sea. If voyagers paddled south from Florida and maintained 3.4 knots, they would have no problem reaching Cuba. However, if speeds dropped below 2.5 knots the voyagers would have been at considerable risk of being swept east and then north into the Atlantic Ocean. For successful intentional voyages from all three areas, the probability of crew loss was less than 1 percent.

The results presented in the current study differ from those of the first generation program for a number of reasons. As noted above, the improved program uses wind and current data at a finer resolution, thus allowing more accurate reflection of smaller currents. Its greatest improved effect is in waters off southwest Florida and along the southern coasts of the Greater Antilles where most of the variation between the two programs occurs. Having the program automatically shift to the next month's database after 30 days also has a significant effect. Because the data were not available in electronic form at the time the initial program was written, that version only contained data for the months of January, April, July, and October. It is the September database, however, that reveals the most variation.

Voyagers from the coast of Venezuela had the greatest likelihood of chance discovery of the Greater Antilles. The probability of such a discovery through intentional exploration and for subsequent trips was also very high. Such voyages would have been well within the technical capabilities of people with dugout canoes and would not have been hampered by the environment of the early Preceramic period. The level of knowledge and navigational skill required was minimal, requiring only that a northward bearing be kept. Unforeseen events that reduced the paddling speed below 3.4 knots usually would not have resulted in missing the Greater Antilles.

Chance discovery of the Greater Antilles was unlikely from northern Central America, given the very limited staging area from which it was possible. Intentional discovery also seems somewhat unlikely given the foreknowledge required to change course in the open sea. However, once knowledge of the Greater Antilles was acquired, the islands could have been reached relatively easily from Central America with little risk, as there was a strong tendency for vessels to be blown back to the mainland if they were unsuccessful. The results here suggest that initial contact between the Yucatan Peninsula and Cuba was likely to have first occurred from Cuba, with the necessary knowledge being transmitted to Central America by people already in the islands.

Figure 4. Sandhill phase artifacts, Belize (courtesy of Richard S. MacNeish).

The possibility of chance discovery from southern Florida was limited in the same manner as from northern Central America. While intentional discovery and subsequent voyages did not require navigational skill beyond keeping a southward bearing, this trip would have involved the highest risk. An inability to maintain a relatively high paddling speed would have resulted in landing far up the eastern Florida coast, continuing out into the Atlantic trapped in the Gulf Stream, or making landfall on either Grand Bahama Island or Andros Island. The Bahamas do not appear to have been occupied until well into the Caribbean ceramic period (Keegan 1992:48; see Seidmann [2001] for an in-depth analysis of the problems of canoe navigation along the southwest coast of Florida). Simulation results

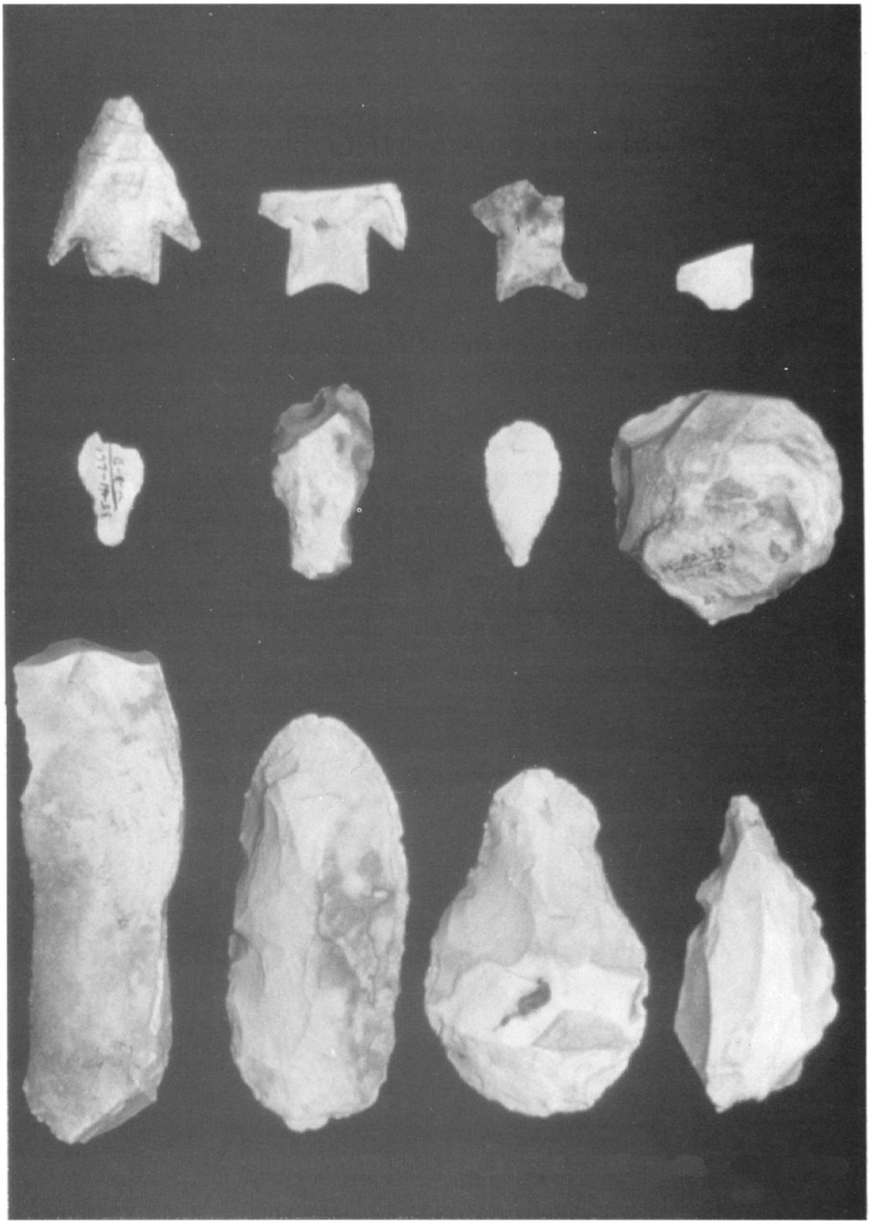

Figure 5. Orange Walk phase artifacts, Belize (courtesy of Richard S. MacNeish).

do not exclude some sporadic contact between Florida and Cuba during the Preceramic period. Kozlowski (1974:71) suggested that one of the three bifaces noted in Cuban collections might represent such a contact during the "Neoindian" period of Florida.

Previous work (Callaghan 1995) investigated the possibilities of reaching various points on the mainland from the Greater Antilles once they were occupied. Return trips from Puerto Rico to northern South America would have been no more difficult than the preceding ones from South America to the north (Callaghan 2001). This also holds true for return trips from Hispaniola and eastern Cuba. From western Cuba, no voyages directly to the South American mainland were successful in the simulation due to the need to proceed into the prevailing winds and currents. However, as noted above and in Callaghan (1995:Figure 3), there was little navigational problem in reaching the Yucatan Peninsula from western Cuba. Reaching Florida from central Cuba (Callaghan 1995:Figure 2) was also a relatively easy proposition.

Comparison of Assemblages from Identified Staging Areas

Simulation programs can be used to direct research in the most profitable direction by identifying the most likely possibilities. The results suggest that voyages from northern South America and the Yucatan Peninsula offered the greatest probability of chance discovery of the Greater Antilles. Although no detailed comparative analysis of material culture has been conducted for any region to evaluate early contact, some comparisons have been noted for the two most probable mainland regions.

Northern South America

Most authors who have suggested similarities between northern South American assemblages and those of the early Preceramic period of the Greater Antilles have worked in Cuba and the Dominican Republic (Febles 1982; Kozlowski 1974; Ortega and Guererro 1981; Veloz and Martín 1983; Veloz and Ortega 1973; Veloz and Vega 1982). Their work tends to give a more complete picture of the early Antillean assemblages through drawings and photographs than sources such as Rouse (1992), in which only a very limited selection of artifacts is illustrated. The more extensive illustrations show greater variation, both geographically and temporally, in the assemblages. Of interest is their finding that the earliest cultural manifestations in the Greater Antilles are concentrated in eastern Cuba and southern and western Hispaniola (Kozlowski 1974:59; Ortega and Guerrero 1981:218).

During the first 2,000 years of occupation, the assemblages include blade, microblade, flake, and Levellois-like technologies. Chipping techniques are largely direct percussion and pressure flaking (Febles 1982:19). Beginning before 5000 B.P., the earliest sites, such as Levisa I in Cuba (Figure 1), primarily contain blades with marginal retouch (Kozlowski 1974). Kozlowski believed that this blade technology arrived in the Antilles fully developed. However, pure blade cores are poorly represented in some sites (Febles 1982). In other sites, there is a progression in core form from blade cores to flake cores (Kozlowski 1974: 40). In Levisa I, Levels VII and VI, dating between roughly 5000 B.P. and 4000 B.P., tools include end-scrapers, burins, retouched blades, side-scrapers, backed implements, notched implements, and triangular flakes resembling Levallois points (1974:55). Kozlowski named other unifacial tools made on blades "tanged," "shouldered," and "leaf shaped" points. While I do not question that at least some of these artifacts are indeed points, the term may be misleading, and the reader is referred to Kozlowski's Figures 10 and 11 (1974:54, 56). Artifacts other than chipped stone do not appear until Level V.

A number of northern South American areas have been suggested as sources of early Antilles populations on the basis of similar technologies, including Colombia and the State of Falcon in western Venezuela. Other localities, such as Louisiana in the United States, were also considered on the basis of microblade technology. These possibilities were eventually rejected, although some of these previously listed authors (Febles 1982; Kozlowski 1974) refer to a perforator type as being a Poverty Point form. The term may have been used descriptively, however, rather than to suggest a connection, as it was introduced by Kozlowski who specifically rejected Florida or the southern coast of the North American Southeast as an origin for the Antillean cultures in his conclusions (Kozlowski 1974:68). Virtually all of these authors acknowledge that the South American mainland assemblages referenced in comparison are poorly known.

Probably the best discussion of the early lithics of the Greater Antilles and their possible origins in northern South America is outlined in the work of Veloz and Martín (1983). They suggest that assemblages primarily in the State of Falcon of western Venezuela are the predecessors. These assemblages contain both unifacial and bifacial tools and are linked by the authors to El Jobo industries. Initially, the unifacial tools were made on flakes, but over time a blade technology developed, particularly in the coastal sites. Kozlowski states that the blade technology developed sometime around 6000

B.C.–5000 B.C. (1974:24). Veloz and Martín (1983:14) list a number of unifacial tools characteristic of these assemblages, including plano-convex perforators, notched scrapers, plano-convex blades with retouch on the dorsal surface, semi-lunate scrapers with dorsal retouch or backed scrapers, bilateral semi-lunate scrapers with dorsal retouch, blades or knives, and scrapers with marginal retouch. The method of manufacture is direct percussion with pressure flaked retouch.

The authors connect these western Venezuelan assemblages to the early Preceramic era of the Greater Antilles while at the same time noting that there is not a complete correspondence. Significantly, bifaces are present in the Venezuelan assemblages while they are virtually absent from the Greater Antilles. The correspondence between the unifacial assemblages of the State of Falcon and the Greater Antilles, as shown in their figures, is more convincing. However, their analysis lacks such basic information as frequencies that would be needed to discriminate among similarly general matches with assemblages from many parts of the world.

The Yucatan Peninsula

Wilson et al. (1998) presented dating for Belize that brought the Preceramic Sand Hill and Orange Walk phases (MacNeish 1982; MacNeish et al. 1980; MacNeish and Nelken-Turner 1983) into line chronologically with the early Preceramic cultures of the Greater Antilles. Work in Belize during the early 1980s (MacNeish 1982; MacNeish et al. 1980; MacNeish and Nelken-Turner 1983) had recovered materials bearing some similarity to early Preceramic artifacts in Cuba and Hispaniola (Callaghan 1990). The most striking similarity between the two regions is the presence of macroblades with little or no retouch. Wilson et al. (1998) presented more recently recovered material of this type and showed that there is a strong correlation in manufacturing technology. However, it should be noted Pantel (1988) demonstrated that differences in chipped stone technology throughout the Greater Antilles are due primarily to variations in the quality of the available raw materials. In short, macroblades occur in conjunction with large nodules of high-quality chert. Further, Parry notes that although this technology is fairly rare and localized in the New World, the nine industries exhibiting it that he studied "appear to be independent developments with no historical connections between them" (1994:87). We should be cautious about making a connection between the Yucatan Peninsula and the Greater Antilles on the basis of manufacturing technology and chronology alone.

However, if such a connection proved to be correct, it would be necessary to question why other aspects of the Belizean assemblages are not found in the Greater Antilles. There are significant differences. Belizean Preceramic sites discussed by Wilson et al. (1998) contain pointed unifaces that resemble some of the unifacially worked macroblades from the Greater Antilles (1998:Figures 4 and 5) but differ in the degree of working. As Pantel states, "It has been clearly demonstrated that secondary flaking is mostly absent from West Indian assemblages" (1988:165). Those from Belize are usually chipped over most, if not all, of the dorsal surface.

The other unifacial tool from Belize discussed by Wilson et al. (1998:Figure 4B), the "constricted uniface," has no counterpart in the Antilles. These constricted unifaces were originally termed "snowshoe shaped end scrapers" by MacNeish (1982:40). Usewear analysis conducted by George Odell (MacNeish and Nelken-Turner 1983:15–24) show these tools to have been used for "adzing, gouging, wedging and chopping hard and soft wood" (1983:46). The only Antillean artifact that could be considered a "constricted uniface" might be a Couri macroblade shown in Wilson et al. (1998:Figure 5A). It is difficult to imagine this tool being used for the above tasks.

Both of the chipped stone tool types discussed above were considered diagnostic of the Sand Hill and Orange Walk phases in Belize (MacNeish and Nelken-Turner 1983:Figure 4). While the dating of these phases was problematic at the time of the study, the associations with other artifact types were not. In the three years I was associated with the Belize Archaic Archaeological Reconnaissance project directed by MacNeish, I observed Sand Hill and Orange Walk phase living floors and activity areas in primary context. There were many tool types with no counterparts in the Antilles (MacNeish and Nelken-Tuner 1983:Figures 4 and 5), including bifacial projectile points and a variety of distinctive scrapers, choppers, and scraping planes (MacNeish and Nelken-Turner 1983:43–51). Bifacial tools are not common in the Belizean assemblages, but those that do exist show considerable skill in manufacture (MacNeish and Nelken-Turner 1983:Figures 6 and 7). Bifacial tools other than blades showing a few flake scars on the ventral surface are not found in the early Antillean assemblages. If there is a direct connection between the Archaic period in Belize and the early Preceramic cultures of the Antilles, it is important to explain why all the distinctive chipped stone tools of the Belizean cultures were deleted, leaving primarily lightly retouched macroblades.

Conclusions

Simulations of navigation problems can be used to rank mainland regions as possible sources for island colonization. Analysis of chance discovery of the Greater Antilles via undirected voyaging shows that trips with any chance of success could have originated from only three areas of the Gulf and Caribbean mainland: northern South America, the Yucatan Peninsula, and south Florida. Vessels drifting off the coast of northern South America had a reasonable chance of reaching Cuba and Hispaniola, while those from the latter two areas had a much lower probability of success. Further, the length of the South American coast from which successful voyages were possible is about 300 nautical miles, as compared to 5 to 10 nautical miles for the Yucatan Peninsula and for Key West off southern Florida. The rate of crew survival was high for all three areas. Interestingly, successful drift voyages from northern South America usually made landfall in southwestern Hispaniola, which, along with eastern Cuba, has the earliest dated occupations in the Greater Antilles.

Analysis of directed voyaging where the crew paddles on a bearing to the islands showed a landfall success rate of 100 percent from all three areas within a reasonable time frame. While even very low paddling speeds and a simple north bearing resulted in success when departing from South America, similar voyages from northern Central America and southern Florida demonstrated only a qualified success. For northern Central America, voyagers would have had to maintain top speeds for canoes and have had the knowledge to change course in the open sea. Assuming these criteria, contact between northern Central America and the Greater Antilles may then have followed two scenarios. One posits a determined effort to discover the islands. This scenario would not be too hazardous, as the majority of unsuccessful vessels would have returned to the mainland. The second scenario posits that the necessary navigational knowledge was obtained from people already in the islands who would have had little problem reaching northern Central America, either accidentally or intentionally. From southern Florida, a 100 percent success rate was possible if a simple south bearing and high paddling speeds were maintained. The risks were high in that lower paddling speeds could have resulted in canoes being swept into the open Atlantic. For successful intentional voyages from all three areas, the probability of crew loss was minimal.

Of the three potential staging areas, northern South America and northern Central America have assemblages that share more similarities with those of the early Preceramic in the Greater Antilles. Assemblages from both mainland areas also exhibit significant differences that will only be understood when detailed comparative analyses have been conducted. Florida also may have contributed to the early Preceramic cultures of the Greater Antilles but, given the hazards of the voyage, it is likely that contact was extremely sporadic.

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References Cited

Allaire, Louis, and Mario Mattioni
1983 Boutbois et Le Godinot: Deux gisements acéramiques de la Martinique. *Proceedings of the IX International Con-*

gress for the Study of the Pre-Columbian Cultures of the Lesser Antilles, pp. 27–38. Centre de Recherches Caraibes, Montreal, Quebec.

Birdsell, James B.
1985 Biological Dimensions of Small, Human Founding Populations. In *Interstellar Migration and the Human Experience,* edited by Ben R. Finney and Eric M. Jones, pp. 110–119. University of California Press, Berkeley.

Bryson, Reid A.
1987 On Climates of the Holocene. *Proceedings of the 17th Annual Chacmool Conference* 1984:1–13, Calgary, Alberta.

Bryson, Reid A., and Robert U. Bryson
1998 *An Archaeoclimatology Workbook: High-Resolution, Site-Specific Climate Modeling for Field Scientists.* Center for Climatic Research, University of Wisconsin-Madison and Department of Geology and Geophysics, University of Minnesota. University of Wisconsin, Madison.

Bullen, Ripley P.
1976 Did Palaeolithic, Archaic, and Formative Man Enter the Antilles from Florida? *XLI International Congress of Americanists* 1974 3:592–599, Mexico City.

Callaghan, Richard T.
1990 Possible Preceramic Connections between Central America and the Greater Antilles. *Proceedings of the XI International Congress for Caribbean Archaeology* 1985:65–67. University of Puerto Rico, Recinto de Rio Piedras.
1991a *Mainland Origins of the Preceramic Cultures of the Greater Antilles.* Ph.D. dissertation, University of Calgary. University Microfilms, Ann Arbor.
1991b Passages to the Greater Antilles: An Analysis of Watercraft and the Marine Environment. *Proceedings of the XIV Congress of the International Association for Caribbean Archaeology* 1991:33–39. Barbados.
1995 Antillean Cultural Contacts with Mainland Regions as a Navigation Problem. *Proceedings of the Fifteenth Congress of the International Association for Caribbean Archaeology* 1993:181–189. San Juan, Puerto Rico.
1999 Computer Simulations of Ancient Voyaging. *The Northern Mariner/Le Marin Du Nord* 1:24–33.
2001 Analysis of Ceramic Age Seafaring and Interaction Potential in the Antilles. *Current Anthropology* 42(2):308–313.

Callaghan, Richard T., and Donna Fremont
1992 A Computer Simulation of Routes of Passage in the Caribbean and Gulf of Mexico. Paper presented at the 57th Annual Meeting of the Society for American Archaeology, Pittsburgh.

Callaghan, Richard T., and Stephanie J. Schwabe
2001 Watercraft of the Islands. *Proceedings of the 18th Congress of the International Association for Caribbean Archaeology* 1999: 231–242. Grenada.

Coe, William R., II
1957 A Distinctive Artifact Common to Haiti and Central America. *American Antiquity* 22:280–282.

Columbus, Christopher
1932 Fourth Voyage of Columbus. In *Select Documents Illustrating the Four Voyages of Columbus.* Vol. II, second series, No. LXX. Hakluyt Society, London.

Cruxent, James M., and Irving Rouse
1969 Early Man in the West Indies. *Scientific American* 221(5):42–52.

Defence Mapping Agency Hydrographic/Topographic Center
1982 *Publication 106. Pilot Charts of Central American Waters.* US Defense Mapping Agency Hydrographic/Topographic Center, Washington, D.C.

Dening, Greg M.
1963 The Geographical Knowledge of the Polynesians and the Nature of Inter-Island Contact. In *Polynesian Navigation,* edited by Jack Golson, pp. 138–153. Polynesian Society Memoir No. 34, Wellington.

Febles D., Jorge
1982 *Estudio tipologico y tecnologico del material de piedra tallada del sitio arqueologico Canimar 1, Matanzas, Cuba.* Academia de Ciencias, Habana.

Finney, Ben R.
1977 Voyaging Canoes and the Settlement of Polynesia. *Science* 196:1277–1285.
1979 Voyaging. In *The Prehistory of Polynesia,* edited by Jesse David Jennings, pp. 323–350. Harvard University Press, Cambridge.
1987 Anomalous Westerlies, El Niño, and the Colonization of Polynesia. *American Anthropologist* 87:9–26.
1991 Myth, Experiment, and the Reinvention of Polynesian Voyaging. *American Anthropologist* 93:383–404.

Gladwin, Thomas
1970 *East is a Big Bird.* Harvard University Press, Cambridge

Goodenough, Ward H., and Stephen D. Thomas
1987 Traditional Navigation in the Western Pacific: A Search for Pattern. *Expedition* 29(3):3–14.

Hackenberger, Steven
1991 Archaeological Test Excavation of Buccament Valley Rockshelter, St. Vincent: Preceramic Stone Tools in the Windward Islands, and the Early Peopling of the Eastern Caribbean. *Proceedings of the XIII International Congress for Caribbean Archaeology,* pp. 86–91. Curaçao.

Hahn, Paul G.
1961 The Cayo Redondo Culture and its Chronology. Ph.D. dissertation, Yale University. University Microfilms, Ann Arbor.

Harris, Peter O.
1991 A Paleo-Indian Stemmed Point from Trinidad, West Indies. *Proceedings of the XIV Congress of the International Association for Caribbean Archaeology,* 1991:33–39. Barbados.

Hartmann, Mark J.
1996 *The Development of Watercraft in the Prehistoric Southeastern United States.* Ph.D. dissertation, Texas A & M University. University Microfilms, Ann Arbor.

Hendry, Malcolm
1993 Sea-Level Movements and Shoreline Change. In *Climate Change in the Intra-Americas Sea,* edited by George A. Maul, pp. 115–161. Edward Arnold, London.

Heyerdahl, Thor
1952 *American Indians in the Pacific.* Allen & Unwin, London.

Hodell, David A., Jason H. Curtis, Glen A. Jones, Antonia Higuera-Gundy, Mark Brenner, Michael W. Binford, and Kathleen T. Dorsey
1991 Reconstruction of Caribbean Climate Change over the past 10,500 Years. *Nature* 352:790–793.

Hodell, David A., Jason H. Curtis, and Mark Brenner
1995 Possible Role of Climate in the Collapse of Classic Maya Civilization. *Nature* 375:391–394.

Irwin, Geoffry
1989 Against, Across, and Down the Wind: A Case for the Systematic Colonization of the Remote Pacific Islands. *Journal of the Polynesian Society* 98:167–206.
1990 Human Colonization and Change in the Remote Pacific. *Current Anthropology* 31:90–94.

1992 *The Prehistoric Exploration and Colonization of the Pacific*. Cambridge University Press, Cambridge.
Irwin, Geoffry, Simon Bickler, and Philip Quirke
1990 Voyaging by Canoe and Computer: Experiments in the Settlement of the Pacific Ocean. *Antiquity* 64:34–50.
Keegan, William F.
1992 *The People Who Discovered Columbus: The Prehistory of the Bahamas*. University Press of Florida, Gainesville.
1994 West Indian Archaeology. 1. Overview and Foragers. *Journal of Archaeological Research* 2: 255–284.
2000 West Indian Archaeology. 3. Ceramic Age. *Journal of Archaeological Research* 8(2):135–167.
Kozlowski, Janusz K.
1974 *Preceramic Cultures in the Caribbean.* Zeszyty naukowe Uniwersytetu Jagiellonskiego. Prace archeologicyne; zesz. 20. Panstwowe Wydawn Naukowe, Krakow.
Lalueza-Fox, C., M. T. P. Gilbert, A. J. Martíez-Fuentes, F. Calafell, and J. Bertranpetit
2003 Mitochondrial DNA from Pre-Columbian Ciboneys from Cuba and the Prehistoric Colonization of the Caribbean. *American Journal of Physical Anthropology* 121:97–108.
Lamb, Hubert H.
1987 *Weather, Climate and Human Affairs*. Methuen, London.
Levison, Michael, R. Gerard Ward, and John W. Webb
1973 *The Settlement of Polynesia: A Computer Simulation.* University of Minnesota Press, Minneapolis.
Lewis, David
1972 *We, the Navigators*. University Press of Hawaii, Honolulu.
Lovén, Sven
1924 *Über Die Wurzeln Der Tainischen Kulture.* Elanders Boktryckeri Aktiebolag, Goteborg.
1935 *Origins of the Tainan Culture, West Indies.* Elanders Boktryckeri Aktiebolag,Goteborg.
McCance, Robert A., Colin C. Ungley, James W. L. Crosfill, and Elsie M. Widdowson
1956 *The Hazards to Men Lost at Sea, 1940–44.* Medical Research Council, Special Report No. 291. London, Medical Research Council.
MacNeish, Richard S.
1982 *Third Annual Report of the Belize Archaic Archaeological Reconnaissance*. Center for Archaeological Studies, Boston University, Boston.
MacNeish, Richard S., S. Jeffrey K. Wilkerson, and Antoinette Nelken-Turner
1980 *First Annual Report of the Belize Archaic Archaeological Reconnaissance.* Philips Academy, Andover.
MacNeish, Richard S., and Antoinette Nelkin-Turner
1983 *Final Report of the Belize Archaic Archaeological Reconnaissance.* Center for Archaeological Studies, Boston University, Boston.
Moore, Clark
1991 Cabaret: Lithic Workshop Sites in Haiti. In *Proceedings of the Thirteenth Congress of the International Association for Caribbean Archaeology,* edited by Edwin N. Ayubi and Jay B. Haviser, pp. 92–104. Reports of the Archaeological-Anthropological Institute of the Netherlands Antilles, No. 9. Willemstad, Curaçao.
Ortega, Elipidio, and José Guerrero
1981 *Estudio de 4 nuevos sitios paleoarcaicos en la isla de Santo Domingo.* Museo del Hombre Dominicano, Santo Domingo.
Pantel, Agamemnon Gus
1988 *Precolumbian Flaked Stone Assemblages in the West Indies*. Ph.D. dissertation, University of Tennessee. University Microfilms, Ann Arbor.
Parry, William J.
1994 Prismatic Blade Technologies in North America. In *The Organization of North American Prehistoric Chipped Stone Tool Technologies,* edited by Philip J. Carr, pp. 87–98. Archaeological Series 7. International Monographs in Prehistory, Ann Arbor.
Rouse, Irving
1960 *The Entry of Man Into The West Indies.* Yale University Publications in Anthropology, No. 61. New Haven.
1992 *The Tainos: Rise and Decline of the People Who Greeted Columbus*. Yale University Press, New Haven.
Sanoja O., Mario
1987 Ecología y asentamientos humanos en el noreste de Venezuela. In *Actas del Tercer Simposio de la Fundatión Arqueología del Caribe*, edited by O. M. Sanoja, pp. 1–10. Washington, D.C.
Seidmann, Rayan. M.
2001 The Bahamian Problem in Florida Archaeology: Oceanographic Perspectives on the Issue of Pre-Columbian Contact. *Florida Anthropologist* 54:9–23.
Thorne, Alan G., and Robert Raymond
1989 *Man on the Rim: The Peopling of the Pacific*. Angus and Robertson, Sydney.
US Navy
1995 *Marine Climatic Atlas of the World.* National Climatic Data Center, Asheville, North Carolina.
Veloz, Marcio, M.
1991 *Panorama historico del Caribe precolombino.* Banco Central de la Republica Dominicana, Santo Domingo.
Veloz, Marcio, M., and Carlos A. Martín
1973 Las technicas unifaciales de los yacimientos el Jobo, sus similitudes con el paleo-arcaico anillano. In *Boletin del Museo del Hombre Dominicano* 11(18):13–39. Museo del Hombre Dominicano, Santo Domingo.
Veloz, Marcio, M. and Elipidio Ortega
1983 *El preceramico de Santo Domingo, nuevos lugares, y su posible relacion con otros puntos del area antillana.* Museo Del Hombre Dominicano, Papeles Ocasionales, No. 1.
Veloz Marcio, M., and Bernardo Vega
1982 The Antillean Preceramic: A New Approximation. *Journal of New World Archaeology*: 33–44.
Wilson, Samuel M., Harry B. Iceland, and Thomas R. Hester
1998 Preceramic Connections between the Caribbean and the Yucatán Peninsula. *Latin American Antiquity* 9:342–352.

Notes

1. DNA analysis of early human skeletal remains from Cuba with comparisons to DNA from North, South, and Central American have recently been published (Lalueza-Fox et al. 2003). The results are significant to this work but were not available in time to include in the discussion.

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