

Research Article

Pacific Nicaraguan Radiocarbon Dates: A New Chronology and Cultural Sequence

Geoffrey McCafferty¹ , Andrés G. Mejía Ramón² and Hector Neff³

¹University of Calgary, Calgary, AB, Canada; ²Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Cerdanyola del Vallès, Barcelona, Catalunya, Spain and ³California State University, Long Beach, CA, USA

Abstract

In 2005, McCafferty and Steinbrenner presented new radiocarbon dates from Santa Isabel to challenge the traditional ceramic sequence for the Postclassic of Pacific Nicaragua. Since then, several projects have generated more data, such that a new chronology and cultural sequence can now be suggested. In this article we present 79 chronometric dates from 19 sites, representing a 1,500-year temporal span. This new scheme is divorced from the existing chronology of the “Greater Nicoya” region that includes both Pacific Nicaragua and northwestern Costa Rica because of perceived distinctions in ceramic types (and other cultural traits). It also facilitates better comparisons with cultural traditions of greater Mesoamerica, especially the development of the Mixteca-Puebla stylistic tradition.

Resumen

En 2005, McCafferty y Steinbrenner presentaron nuevas fechas de radiocarbono de Santa Isabel para cuestionar la secuencia tradicional de la cerámica del Postclásico del Pacífico de Nicaragua. Desde entonces, varios proyectos han producido más información, y ahora es posible sugerir una cronología nueva y secuencia cultural nueva. En esta obra presentamos 75 determinaciones cronométricas que pertenecen a 19 sitios, con una duración temporal de 1,500 años. Este marco nuevo es divorciado de la cronología existente de la región Gran Nicoya, que incluye ambos el Pacífico de Nicaragua y el noroeste de Costa Rica, por diferencias percibidas de tipos de cerámica (y otros rasgos). Además, facilitará comparaciones con tradiciones culturales de Mesoamérica, especialmente el desarrollo de la tradición estilístico Mixteca-Puebla.

Keywords: Pacific Nicaragua; chronology; cultural sequence; ceramics; Mixteca-Puebla stylistic tradition

Palabras clave: Pacífico de Nicaragua; cronología; secuencia cultural; cerámica; tradición estilístico Mixteca-Puebla

Chronology is the backbone of archaeological reconstructions, but it is also a chain of inferences and assumptions—some explicit, many tacit. In practice most chronologies in the Americas rely on culture-historical sequences derived from ceramic seriation and similarities to better studied regions, employing absolute dating and Bayesian modeling in a highly variable manner. Most users of chronologies, however, are not engaging in culture history; they interpret ceramic complexes and their associations to a circumscribed range of dates according to their own research questions often in conflict with the assumptions underlying the chronologies in the first place.

Pacific Nicaragua serves as a case in point. Compared to other regions in Mesoamerica, the region has been heavily understudied. For decades it has been subsumed within the “Gran Nicoya” tradition, an archaeological construct shaped

largely by developments in northwestern Costa Rica. This framing has been convenient but constraining: convenient in its appeal to stylistic affinities—especially in polychrome ceramics—but constraining in its flattening of local cultural trajectories, conflation of temporally disjunct material, and dependence on a chronology generated largely outside of Nicaragua itself. As a result, key assumptions about ceramic phases, cultural affiliations, and the timing of events have been recycled and reinforced with little scrutiny, even as new data increasingly strain interpretations (McCafferty and Steinbrenner 2005a; Steinbrenner and McCafferty 2021).

In this article, we present a framework to build models parsimonious with both contextual and stylistic-morphological data. We begin by briefly introducing Pacific Nicaragua as a culture region, describing previous efforts at establishing a local chronology. To demonstrate how different tolerances to uncertainty affect interpretative outcomes we present a revised chronology and cultural sequence for Pacific Nicaragua built from 79 radiocarbon dates drawn from 19 sites across the region (Figure 1). Rather than rely solely on inherited sequences or heuristic typologies, we employ

Corresponding author: Geoffrey McCafferty; Email: mccaffer@ucalgary.ca
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Figure 1. Map of Pacific Nicaragua indicating sites mentioned in the discussion.

a Bayesian modeling framework that explicitly nests dates within both stratigraphic and stylistic contexts. This allows us to not only refine the temporal distribution of ceramic complexes, but to be transparent about the inferential scaffolding that supports those reconstructions. Importantly, we do not presume a single way of reading the chronology but rather provide a set of inferential tools—a timeline, a Gantt chart, and a stacked area diagram—appropriate for different research questions.

Cultural context for Pacific Nicaragua

Pacific Nicaragua has been recognized as the southern frontier of greater Mesoamerica for the past 100-plus years (McCafferty et al. 2012). At contact in the early sixteenth century the native inhabitants spoke dialects of Nahuatl and Oto-Manguan, both languages originating in central and southern Mexico (Constenla 1994). Colonial period chronicles recounted historical myths of Chorotega and Nicaraog groups arriving along the Pacific coast in the centuries before the Spanish conquest, although the precise timing of the migrations remains ambiguous (Abel-Vidor 1980; Chapman 1974; Fowler 1989). Cultural characteristics such as the religious pantheon and practices, as well as the use of the central Mexican calendar, were reported and have been cited as evidence for the Mesoamerican nature of the colonizing groups. One element that has attracted interest has been the use of polychrome pottery with elements of the Mixteca-Puebla stylistic tradition, including iconography relating to the Mesoamerican “feathered serpent” (Day 1994; Lothrop 1926; Manion and McCafferty 2017; McCafferty 2019; McCafferty

and Steinbrenner 2005b). Less obvious, however, are the cultural characteristics of the autochthonous groups that occupied the region prior to the Mexican migrations. It is likely that these were speakers of a macro-Chibchan language since Chibchan dialects are still spoken in central and eastern Nicaragua (Constenla 1994; Steinbrenner 2021a). Archaeological evidence indicates interaction between these groups and Maya from El Salvador and Honduras, based on the shared use of Usulután-like Negative Resist ceramics during the Formative period (Braswell 1997; Demarest and Sharer 1982; Dennett et al. 2011).

Interest in this cultural dynamic of Mesoamerican contact in Pacific Nicaragua has generated much research, especially in the past 25 years, including an intensive research program based at the University of Calgary (McCafferty 2021). Results from excavation projects at several major sites along the shore of Lake Cocibolca, as well as from other projects, have greatly enhanced knowledge of the pre-Columbian occupation of the region, albeit with mixed results as to the nature of Mesoamerican integration (McCafferty 2015). Some characteristics, such as the polychrome imagery, strongly suggest contact, whereas other elements argue against Mexican culture. For example, evidence of ancient foodways does not indicate an important role for staples such as maize, dog, or turkey in the diet. As is typical of archaeological reconstructions, with more evidence interpretations become more complex, and more research is always needed to clarify inconsistencies.

An overarching problem with interpretation is the question of the “Greater Nicoya” culture area, a concept introduced in the 1960s (Lange 1984, 1992–1993; Norweb 1964;

Steinbrenner 2021b). As initially presented, Greater Nicoya included Pacific Nicaragua and northwestern Costa Rica and was considered the Mesoamerican frontier (Coe 1962; Creamer 1989). Similarities in the polychrome pottery were interpreted as evidence of a homogeneous cultural tradition, especially during the Postclassic period. Recently, a comparative analysis of ceramics from the Nicoya peninsula of Costa Rica and sites along the shore of Lake Cocibolca in Nicaragua have demonstrated considerable differences. These, plus significant variations in settlement and mortuary patterns call into question the utility of the “Greater Nicoya” model (Ibarra Rojas 2021).

The existing chronology for Greater Nicoya was developed using primarily Costa Rican data in the early 1990s (Bonilla et al. 1990; Vázquez et al. 1994) with relatively little input from Nicaragua. Archaeological investigations over the past 30 years, however, have generated 79 useable radiocarbon dates relating to well-documented archaeological contexts. For this reason, we believe that a reconsideration of regional chronologies is relevant, with Pacific Nicaragua considered separately from the cultural traditions of southern “Greater Nicoya.”

Chronological considerations

The archaeology of Nicaragua has a relatively long history, stretching back into the mid-1800s with North American and European explorers visiting pre-Columbian sites and sending back descriptions as well as actual artifacts (Bovallius 1886; Bransford 1881; Squier 1993[1853]; Whisnant 1995). They took particular note of the beautiful polychrome pottery, which led to interpretations of long-distance interaction with cultures from Central America and Mexico. In 1926, Samuel Lothrop published two volumes on the ceramics of Nicaragua and Costa Rica, including color plates of the vibrant iconography. Comparisons with pottery from other regions allowed a relative sequence of the different styles while suggesting cultural interactions.

The first formal chronology was suggested in 1961 by Michael Coe and Claude Baudez based on their excavations in northwestern Costa Rica (Geurds 2017). They divided the cultural sequence into four periods: Zoned Bichrome, Early Polychrome, Middle Polychrome, and Late Polychrome. Specific time periods were suggested in a subsequent publication (Baudez and Coe 1962), roughly correlating these periods with those of the Maya region. This chronology continued to be used into the 1990s, when a conference on Greater Nicoya archaeology presented 90 radiocarbon dates that were used to suggest a new chronological terminology (Vázquez et al. 1994):

Orosi	2000 B.C. to 500 B.C.
Tempisque	500 B.C. to A.D. 300
Bagaces	A.D. 300 to A.D. 800
Sapoa	A.D. 800 A.D. to A.D. 1350
Ometepe	A.D. 1350 to A.D. 1550

This sequence is still in use, both in Costa Rica and Nicaragua, although the diagnostic ceramics used to identify the different periods vary by region (Niemeel et al. 1998). Due to the abundance of absolute dates from northwestern Costa Rica, plus the large number of Costa Rican archaeologists involved in the conference, the period names were generally taken from Costa Rica with little reference to archaeological contexts.

In addition to these overarching chronological sequences, several scholars suggested more localized sequences to better fit the excavated data from Pacific Nicaragua. For example, Wolfgang Haberland (1992), suggested a local sequence for Ometepe Island, as did Paul Healy (1980) for the Rivas region and Silvia Salgado (1996a; Salgado González and Zambrana Fernández 1994) for Granada.

Haberland and Paul Schmidt investigated 10 sites on Ometepe Island (in Lake Cocibolca) during the early 1960s (Haberland 1992). Based on comparisons with the material culture of Costa Rica and several radiocarbon dates, nine phases were suggested for the Ometepe sequence: Dinarte (2000–500 B.C.); Angeles (800–300 B.C.); Sinacapa (200 B.C.–A.D. 1); Manantial (A.D. 1–500); San Roque (A.D. 500–950); Gato (A.D. 1000–1200); La Paloma (A.D. 1100–1300); San Lazaro (A.D. 1300–1400); and Santa Ana (A.D. 1400–1550). Interestingly, Haberland (1992:115–116) mentioned that the culture history of Ometepe included elements from both northern and southern sectors of Greater Nicoya, as well as additional unrelated characteristics. Especially for the final Santa Ana phase, he cited Ciudad Real’s sixteenth-century account that the inhabitants spoke neither Chorotega nor Nicarao languages.

Healy (1980:296) used a seriation analysis of 80,000 sherds, which were classified into 40 different types and varieties. He related his chronology for the Rivas region to the sequence suggested by Baudez and Coe (1962), but subdividing each period into two phases. For example, the Zoned Bichrome period was divided into Aviles and San Jorge phases; the Early Polychrome period was divided into the San Roque and Palos Negros phases; the Middle Polychrome period was divided into the Apompua and La Virgen phases; and the Late Polychrome period was divided into the Las Lajas and Alta Gracia phases. Healy correlated these phases with 39 radiocarbon dates from the Greater Nicoya region, only nine of which came from sites in Pacific Nicaragua (1980:305).

Silvia Salgado conducted a settlement pattern survey of the Granada region for her PhD research (1996a), with excavations at the site of Ayala (1996b). Based on her research—especially from excavated contexts—she subdivided the Bagaces period into three phases: the Siu phase (A.D. 300–500), the San Antonio phase (A.D. 500–650), and the Ayala phase (A.D. 650–800/900). Otherwise, the Granada chronology followed the “new” sequence proposed by Vázquez et al. (1994).

These specific phases are useful for interpreting local developments, but may complicate cross-regional comparisons, particularly because they continued to rely on southern (i.e., Costa Rican) dates and diagnostics. A significant challenge to that sequence was presented by McCafferty and Steinbrenner (2005a) when, based on the Santa Isabel excavations, it was found that many of the alleged Ometepe

period decorated types were introduced several centuries earlier, during the Sapoá period. In a recent chapter, Steinbrenner and McCafferty (2021) even argue that virtually all the radiocarbon dates associated with Ometepe period contexts are either too early for the traditional time range or are of dubious affiliation. Consequently, they suggest some potential diagnostic ceramics types but cannot identify any archaeological sites from the late period with adequate investigation. This is particularly perplexing since this would be the period associated with the majority of the ethnohistorical evidence suggesting Mesoamerican influences.

Since 1990, the amount of archaeological research in Pacific Nicaragua has increased dramatically. Frederick Lange (1995, 1996, 2021) directed several salvage projects in the Managua metropolitan zone. Settlement pattern studies have been conducted in Rivas, Masaya/Tisma, and Granada (Niemeel 2003; Niemeel Garrard 2021; Román Lacayo 2013; Salgado González 1996a). Large projects have been conducted by researchers from the University of Calgary (McCafferty 2021), Leiden University (Donner et al. 2018), Saitama University (Hasegawa 2018; Hasegawa et al. 2019), SUNY Plattsburgh, and California State University at Long Beach, often in collaboration with archaeologists from the National University of Nicaragua in Managua (Lechado and Balladares Navarro 2016, 2019), the Nicaraguan Institute of Culture (Moroney Ubeda 2011; Zambrana Fernández 2012), and the municipality of Managua (Espinoza Perez et al. 2023).

Dated archaeological contexts

Archaeological excavations since 1960, and especially over the past 20 years, have generated 79 radiocarbon dates that warrant a new effort to develop a region-specific chronology for Pacific Nicaragua. We list the available radiocarbon dates in Table 1 and describe their contexts briefly in the following paragraphs. Where possible this includes figures with Harris matrices and specific radiocarbon dates; for other sites with limited information the dates are included as Supplementary content. It must be emphasized that the quality of the reported data varies, especially for some of the older studies for which limited information was available as to contexts and associated material culture. Following this section, we suggest a new chronology specific to the region.

Ayala (Granada, Gr 2)

The Ayala site is located near the base of the Mombacho volcano in the Department of Granada. It was initially sampled by Albert Norweb in 1961 but was more extensively investigated by Silvia Salgado González (1996a) during her regional survey. Salgado subsequently excavated the site, revealing Bagaces and Sapoá period occupations (Salgado González 1996b:437; Salgado González and Zambrana Fernández 1994).

Eleven total radiocarbon dates are available from Ayala. Unfortunately, those reported by Haberland (1978:405) do not have decipherable error ranges. Two other dates pertain to what was interpreted as an Ometepe period midden in Op. 8, with radiocarbon ages of 840 ± 60 and 810 ± 60 BP, dates more consistent with the Sapoá period (Op. 7). Of the remaining seven dates, four came from a Bagaces midden and three

came from a Bagaces structure (Op. 13). Sequences can be generated for all three operations, although one of the upper two dates from Op. 13 is out of stratigraphic order (Figure 2). Two additional dates were rejected because of suspected contamination.

Brito

Brito was discovered during the preliminary survey in advance of the proposed Trans-Oceanic canal. It is located on the Pacific coast north of San Juan del Sur. A brief excavation was conducted by the National Autonomous University of Nicaragua (UNAN) that identified possible salt-making activities in the low-lying mangrove swamp (Lechado and Balladares Navarro 2016). Four dates were reported, with radiocarbon ages spanning 630 to 1630 BP years (supplementary material: Figure S1) but no detailed analysis of the materials has been presented.

Chilamatillo (Managua, N-MA-8-100)

The site of Chilamatillo is located on the shore of Lake Xolotlan, in the municipality of Tipitapa. A test pit was excavated in 2017. The great majority of ceramic fragments dated to the Sapoá/Ometepe periods (Hasegawa 2018). Two radiocarbon dates are reported in sequence of each other, with very closely similar radiocarbon ages of 770 and 780 years BP (supplementary material: Figure S2).

Cruz (Ometepe Island, Ri-7)

A deeply stratified site on the east side of Ometepe Island, south of Puerto de Gracia. According to Norweb's notes in Healy (1980:65–73), the Cruz site had Postclassic (Sapoá) materials above Zoned Bichrome (Bagaces) deposits in Levels 11 and 12. One date was reported: 1170 ± 125 BP (supplementary material: Figure S3).

El Rayo (Gr-39)

El Rayo is located on the Asese peninsula into Lake Cocibolca at the base of the Mombacho volcano, in the Department of Granada. It was first identified by Salgado in her settlement survey of Granada (Salgado González 1996a) but was further exposed by road construction that cut through a small cemetery at the base of a rock outcrop. Five field seasons between 2009 and 2021 encountered Bagaces and Sapoá period deposits (McCafferty 2021; McCafferty and Dennett 2013). Nine loci have been identified, including cemeteries, civic-ceremonial structures, and an extensive midden deposit. Current interpretation is that El Rayo served as a necropolis for the region (McCafferty et al. 2021).

Radiocarbon dates have been recovered from Locus 1, a stratified cemetery with Sapoá period urn burials over Bagaces period primary direct burials, and at Locus 2 where dates have been obtained from deeply stratified midden deposits (Figures 3 and 4). Four usable radiocarbon ages range from 960 to 1230 BP. Material culture associated with these dates, especially ceramics, indicate that the transition between the Bagaces and Sapoá period occurred about A.D.

Table 1. Radiocarbon dates from Pacific Nicaragua

Lab ID	Published age	Radiocarbon Age	s.d.	Site	Context	Nica Phase
PSU 9952		2545	20	Los Angeles	Charcoal, 252 cm, N54 E80 Level 10	La Arenera
PSU 6135		2265	20	La Arenera	organic soil under volcanic sand	La Arenera
LA19 (A14759)		2130	40	La Arenera	charcoal at base of Asososca Tephra (Avellan et al. 2012)	La Arenera
TKA-17309	2104±19 BP	2104	19	La Paz	Top of Mound 1	La Arenera
PSU 11313		1985	20	San Cristobal	Charcoal associated with oven feature	Las Delicias
PSU 11312		1980	20	San Cristobal	Charcoal associated with oven feature	Las Delicias
PSU 14753		1780	35	San Cristobal	Long bone from burial in San Cristobal cemetery	Las Delicias
Beta-257989	1790±50 BP	1790	50	Las Delicias	Las Delicias 1 - Usulután	Las Delicias
Beta-257990	1790±50 BP	1790	50	Las Delicias	Las Delicias 2 - Usulután	Las Delicias
Beta-438139	1630±30 BP	1630	30	Brito		Las Delicias
Beta-441229	1440±30 BP	1440	30	Los Martinez	Feature 32	Ayala
Beta-265454	1430±40 BP	1430	40	El Rayo	10 El Rayo, rejected	Ayala
TKA-19680	1412±25 BP	1412	25	La Paz	West side of Mound 1, lowest artifact bearing level	Ayala
Beta-265462	1360±40 BP	1360	40	El Rayo	35 El Rayo	Ayala
Gif 11816	1330 +/- 45 BP	1330	45	Sonzapote, Zapatera Island	radiocarbon 35:215 - 230	Ayala
Beta-73222	1300±50 BP	1300	50	Ayala	OP 13 Level 5, Bagaces structure	Ayala
Beta-73223	1000±80 BP	1000	80	Ayala	Op 13 Level 4, rejected	Outlier
Beta-73221	1270±60 BP	1270	60	Ayala	Op 13 Level 3, Bagaces structure	Ayala
Beta-438141	1290±30 BP	1290	30	Brito		Ayala
Beta-265463	1220±40 BP	1220	40	El Rayo	43 El Rayo	Ayala
Y-1125	1170±125 BP	1170	125	Cruz, Ometepe	Level 11 with Palos Negros and Bagaces types	Ayala
Beta-66955	1160±120 BP	1160	120	Ayala	Op 7 Level 10, rejected	Ayala
Beta-66954	1190±60 BP	1190	60	Ayala	Op 7 Level 8, Bagaces midden	Ayala
Beta-66953	1270±80 BP	1270	80	Ayala	Op 7 Level 7, Bagaces midden	Ayala

(Continued)

Table 1. (Continued.)

Lab ID	Published age	Radiocarbon Age	s.d.	Site	Context	Nica Phase
Beta-66952	1210±80 BP	1210	80	Ayala	Op 7 Level 6, Bagaces midden	Ayala
Beta-265450	1230±40 BP	1230	40	El Rayo	04 El Rayo	El Rayo
Beta-265451	1220±60 BP	1220	60	El Rayo	05 El Rayo	El Rayo
Beta 217130	1180±70 BP	1180	70	Santa Isabel, Rivas		El Rayo
Beta 217128	1090±60 BP	1090	60	Santa Isabel, Rivas		El Rayo
PSU 10280		1060	15	Los Angeles, Ometepe	Bone from skeleton eroding from street	El Rayo
TKA-19446	1039±43 BP	1039	43	La Paz	Urn 6 from the cemetery, with Vallejo Polychrome	El Rayo
Beta-265453	1030±50 BP	1030	50	El Rayo	09 El Rayo	El Rayo
Beta-140586	1030±90 BP	1030	90	Santa Isabel, Rivas		El Rayo
Beta-196665	1020±70 BP	1020	70	Santa Isabel, Rivas	Locus 4, S82W121 Feature 3	El Rayo
Beta-217127	1010±40 BP	1010	40	Santa Isabel, Rivas		El Rayo
Beta-265459	960±40 BP	960	40	El Rayo	07 El Rayo	El Rayo
Beta-196660	1010±70 BP	1010	70	Santa Isabel, Rivas	Locus 2, S62E52 Feature 43	Santa Isabel
Beta-196661	930±60 BP	930	60	Santa Isabel, Rivas	Locus 2, S70E65 Level 9	Santa Isabel
Beta-196659	970±60 BP	970	60	Santa Isabel, Rivas	Locus 2, S63E51.5 Level 7	Santa Isabel
Beta-196664	860±60 BP	860	60	Santa Isabel, Rivas	Locus 2, S73E68 Level 7	Santa Isabel
Beta-196663	990±60 BP	990	60	Santa Isabel, Rivas	Locus 2, S73E61 Level 6	Santa Isabel
Beta-196662	940±80 BP	940	80	Santa Isabel, Rivas	Locus 2, S72E60 Level 4	Santa Isabel
Beta-196656	980±50 BP	980	50	Santa Isabel, Rivas	N30E10 Level 10	Santa Isabel
Beta-257988	930±40	930	40	Tepetate, Granada	Urn burials	Santa Isabel
Beta-438140	930±30 BP	930	30	Brito		Santa Isabel
Beta-196654	920±50 BP	920	50	Santa Isabel, Rivas	N20E30 Level 9	Santa Isabel
Beta 217131	910±50 BP	910	50	Santa Isabel, Rivas		Santa Isabel
Beta-196657	900±60 BP	900	60	Santa Isabel, Rivas	Locus 2, S10E50 Level 4	Santa Isabel

(Continued)

Table 1. (Continued.)

Lab ID	Published age	Radiocarbon Age	s.d.	Site	Context	Nica Phase
TKA-18613	893±18 BP	893	18	La Paz	West side of Mound 1, lower floor, with post holes	Santa Isabel
TKA-19679	869±25 BP	869	25	La Paz	Urn 3 from the cemetery	Santa Isabel
TKA-19445	857±41 BP	857	41	La Paz	Urn 2 from the cemetery	Santa Isabel
Beta-196655	870±60 BP	870	60	Santa Isabel, Rivas	N21E8 Level 3	Santa Isabel
Beta 217129	860±70 BP	860	70	Santa Isabel, Rivas		Santa Isabel
Beta-196658	820±50 BP	820	50	Santa Isabel, Rivas	Locus 2, S60E41 Level 4	Santa Isabel
Beta-257985	820±40 BP	820	40	Tepetate, Granada	Urn burials	Santa Isabel
IAAA-160633	840 +/- 20 BP	840	20	Las Delicias		Santa Isabel
Beta-66957	810±60 BP	810	60	Ayala	Op 8 Level 4, Ometepe midden	Santa Isabel
Beta-66956	840±60 BP	840	60	Ayala	Op 8 Level 3, Ometepe midden	Santa Isabel
IAAA-160626	840 +/- 20 BP	840	20	Nejapa	UE5, last occupation floor Mound 5	Santa Isabel
IAAA-160627	810 +/- 20 BP	810	20	Nejapa	UE5, last occupation floor Mound 5	Santa Isabel
IAAA-160624	780±20 BP	780	20	Chilamatillo	Sondeo 1 Capa 9, 74–84 cm	Santa Isabel
IAAA-160623	770±20 BP	770	20	Chilamatillo	Sondeo 1 Capa 6, 40 - 52 cm	Santa Isabel
Beta-44128	820±30 BP	820	30	Sonzapote, Zapatera Island	Op1, B2, Rasgo 1 (67 cm)	Santa Isabel
Beta-44127	950±30 BP	950	30	Sonzapote, Zapatera Island	Op1, B2, Level 4	Santa Isabel
TKA-17308	761±18 BP	761	18	La Paz	West side of Mound 1, floor associated with quadrangular platform and Sapoá/Ometepe sherds	La Paz
WSU-?	747±135 BP	747	135	San Francisco (Tipitapa)	Sapoá/Ometepe	La Paz

(Continued)

Table 1. (Continued.)

Lab ID	Published age	Radiocarbon Age	s.d.	Site	Context	Nica Phase
TKA-18614	734±18 BP	734	18	La Paz	West side of Mound I, lower floor, with post holes	La Paz
TKA-17307	667±18 BP	667	18	La Paz	Mound I fill covering platform, associated with Sapoá/Ometepe sherds	La Paz
Hv-2690	AD 1275±50	675	50	La Paloma, Ometepe	La Paloma Phase, Middle Polychrome	La Paz
Hv-2691	AD 1290±50	660	50	La Paloma, Ometepe	La Paloma Phase, Middle Polychrome	La Paz
Beta-438143	630±30 BP	630	30	Brito		La Paz
IAAA-160631	610 +/- 20 BP	610	20	Las Delicias		La Paz
IAAA-160625	600 +/- 20 BP	600	20	Oro Verde	human bone from inside funerary urn	La Paz
IAAA-160632	590 +/- 20 BP	590	20	Las Delicias		La Paz
Hv-2692	AD 1445±30	505	30	San Lazaro, Ometepe	Madera Polychrome, Ometepe Period	La Paz
Y-1124		1330	?	Ayala	Indecipherable error range	unused
Y-1122		1340	?	Ayala	Indecipherable error range	unused
Beta-265452	250±40 BP			El Rayo	Contaminated, rejected	unused
Beta-265455				El Rayo	Contaminated, rejected	unused
Beta-265456	240±50 BP	240	50	El Rayo	Contaminated, rejected	unused
Beta-265457	160±40 BP	160	40	El Rayo	Contaminated, rejected	unused
Beta-265458				El Rayo	Cancelled	unused
Beta-265460	250±40 BP	250	40	El Rayo	Contaminated, rejected	unused

840 (Figure 5). The ceramics changed dramatically across this transition, suggesting significant and rapid culture change (McCafferty and Dennett 2013).

La Arenera (Managua)

La Arenera is a site on the outskirts of Managua that was covered by a thick deposit of volcanic sand (McCafferty 2009). An extensive surface collection and several small test pits recovered artifacts associated with the living surfaces at the time of the eruption, including ceramic vessels broken in situ.

Dennett et al. (2011) published on the compositional analysis of the Negative Resist pottery.

Volcanological investigation by Pardo and colleagues (Pardo et al. 2009) identified the Asososca maar as the source of the volcanic sand that covered La Arenera and obtained a radiocarbon age of 1245±125 BP from a paleosol below the sand layer. Rausch and Schmincke (2010) accepted a recent date for tephra emplacement (~1000 BP), noting the presence of Usulután pottery below the sand, but they link it to the Nejapa maar rather than Asososca. Avellán et al. (2012) provided additional support for the interpretation that Asososca

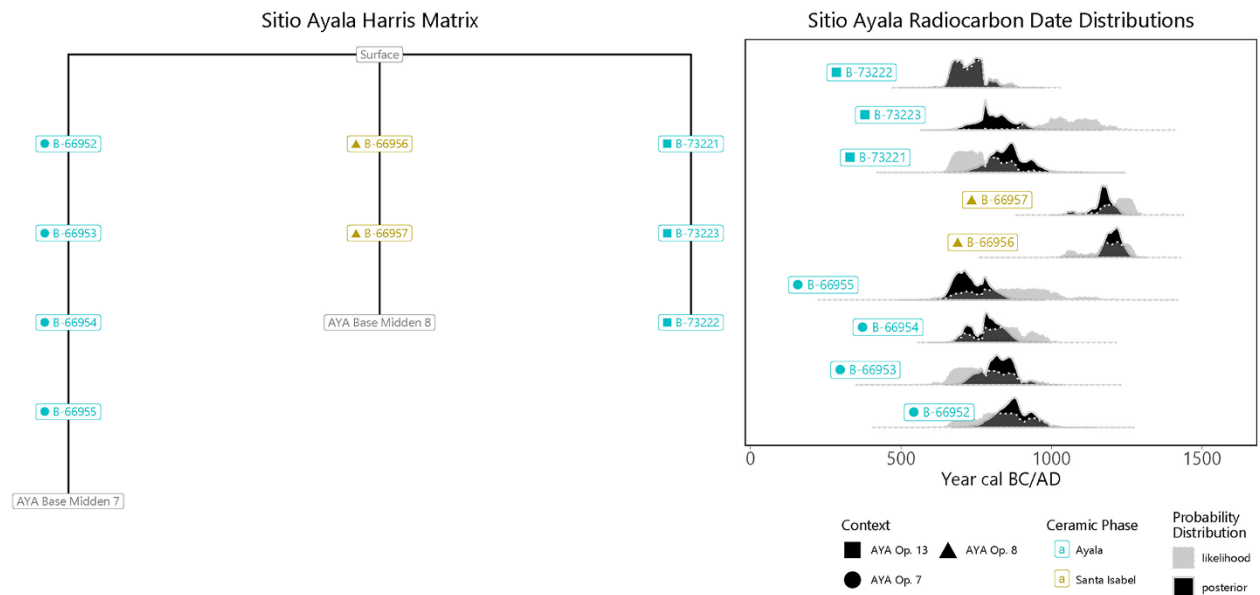


Figure 2. Dated contexts at Ayala: (left) stratigraphic relations; (right) calibrated and modeled probability distributions.

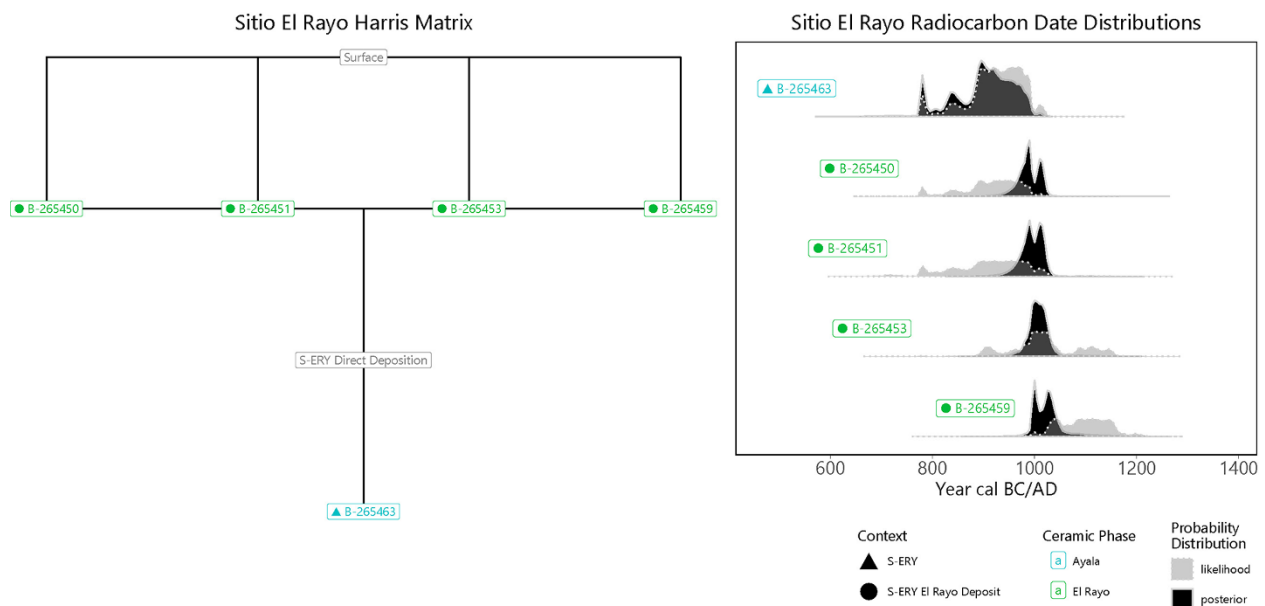


Figure 3. Dated contexts at El Rayo: (left) stratigraphic relations; (right) calibrated and modeled probability distributions.

was the source vent and reported a more reliable radiocarbon age of 2130 ± 40 BP obtained from charcoal from the base of the deposit (supplementary material: Figure S4). During his own recent work (Neff et al. 2019), Neff generated two radiocarbon dates on an organic-rich layer lying directly below the volcanic sand, the uppermost of which accords well with the 2130 ± 40 BP date of Avellán et al. (2012). In our model, we place this recent date from the top of the paleosol below the sand (PSU-6135) as earliest in a sequence with Avellán's charcoal date, which represents a tree growing at the time of the eruption. The recent radiocarbon dates agree perfectly with the Usulután-dominated ceramic assemblage found by McCafferty (2009), Espinoza Perez et al. (1998) and Neff et al. (2019) on the surface underlying the tephra.

La Paloma (Ometepe Island. OM 2)

La Paloma (OM 2) is located on the west end of Ometepe Island, just south of the town of Moyogalpa. Haberland (1992) worked at the site in 1962–1963 and reported remains pertaining to the Zoned Bichrome through Middle Polychrome periods. Two radiocarbon dates (supplementary material: Figure S5) pertain to the Middle Polychrome period, called the La Paloma Phase (A.D. 1100–1300) by Haberland (1992).

La Paz (Mateare)

The La Paz site is located on the shore of Lake Xolotlan, at the foot of the Chiltepe Peninsula, in the Mateare municipality.



Figure 4. El Rayo, Locus 2, Operation 1 deeply stratified excavation showing transition from Sapoá materials over Bagaces materials.

A mound was excavated, as well as a cemetery and additional test pits (Hasegawa et al. 2019). Nine dates are reported, including five in relative sequence from the interior of the mound and three from the cemetery. The dates range in age from 2104 to 667 BP; three of the dates form a tight cluster between 761 and 667 years BP (Figure 6).

Las Delicias (Managua)

Located within the city of Managua, near the shore of Lake Xolotlan, Las Delicias was excavated as a rescue project by archaeologists from the Patrimony office and Mi Museo (Moroney Ubeda 2011; Pavón Sanchez 2008, 2009). Although much of the site was destroyed during housing construction, numerous burials were rescued along with associated grave goods suggesting a Late Tempisque date. A second field season occurred in 2014 as the housing development continued. Again, Late Tempisque period burials were encountered, as well as another area that included a house mound with a ring of post holes, associated with later period ceramics. Two radiocarbon ages cluster at 1790 BP and relate to the earlier occupation, while two others clustering around 700 BP relate to the later occupation (supplementary material: Figure S6).

Los Ángeles (Ometepe Island, OM 9, N-RI-MO-003)

Haberland (1986, 1992) defined an Early Formative phase called Dinarte based on deeply buried ceramics he encountered during excavations at Los Ángeles in 1962–1963. He later compared the small collection of Dinarte Phase ceramics to the Early Formative Tronadora Phase ceramics of the Arenal región of Costa Rica (Hoopes 1994). In 2021, Neff and Brown (2022) led an effort to resample the early deposits that met with only equivocal success in that no

radiocarbon samples were found in association with the few possible Dinarte Phase sherds. However, one sample was obtained from a deep context associated with Los Ángeles Phase (early Tempisque Period) diagnostics (supplementary material: Figure S7). In addition, one date on human bone was obtained from a skeleton that was found eroding from a street in the modern town of Los Ángeles in 2010. Ceramics from the latter context pertained to the Sapoá Period.

Los Martinez (Managua)

A large site on the outskirts of the Managua urban center was excavated to salvage information prior to residential development. This was a multicomponent site with occupations during the Tempisque, Bagaces, and Sapoá periods (Zambrana Fernández 2012). A single date was recovered from Feature 32, a stone walkway, which yielded a radiocarbon age of 1440±BP.

Nejapa (Managua)

Nejapa is a site overlooking Managua, excavated by the National University of Nicaragua (Managua). The site featured architectural remains as well as burials (Lechado and Balladares Navarro 2019). Two dates from the last occupation floor of Mound 5 are reported, one 840±20 BP and one 810±20 BP. In a more recent project, Neff et al. (2024) reported four additional dates from an excavation placed adjacent to a machine-dug trench through the site. These new dates came from Level 3 (855±15 BP), Level 4 (845±15 BP), Level (970±15 BP), and Level 7 (895±20 BP) (Figure 7).

Oro Verde (Ciudad Sandino)

A single date was recovered from human bone found within a burial urn. It yielded a radiocarbon age of 600±20 BP.

San Cristobal (Managua)

Located near the Managua airport, San Cristobal was initially excavated by Susan Wyss in the 1980s, when she found a Sapoá/Ometepe period occupation (Wyss 1983). In 2021, a housing project encountered deeply buried cemetery remains from the Late Tempisque period (Espinoza Pérez et al. 2023). An AMS date of 1780±35 BP (supplementary material: Figure S8) was recently obtained from a fragment of a long bone from one of the burials. The mechanized excavation also exposed an oven feature some distance from the burials, from which two almost identical dates of 1980±20 and 1985±20 BP were obtained and combined into a single observation in our model. The oven feature appeared to be in a slightly lower stratigraphic context from the cemetery, but we do not model the three dates as a sequence here because of uncertainties related to mechanized disturbance of the whole area. Like the burials, the feature had Late Tempisque period pottery in association.

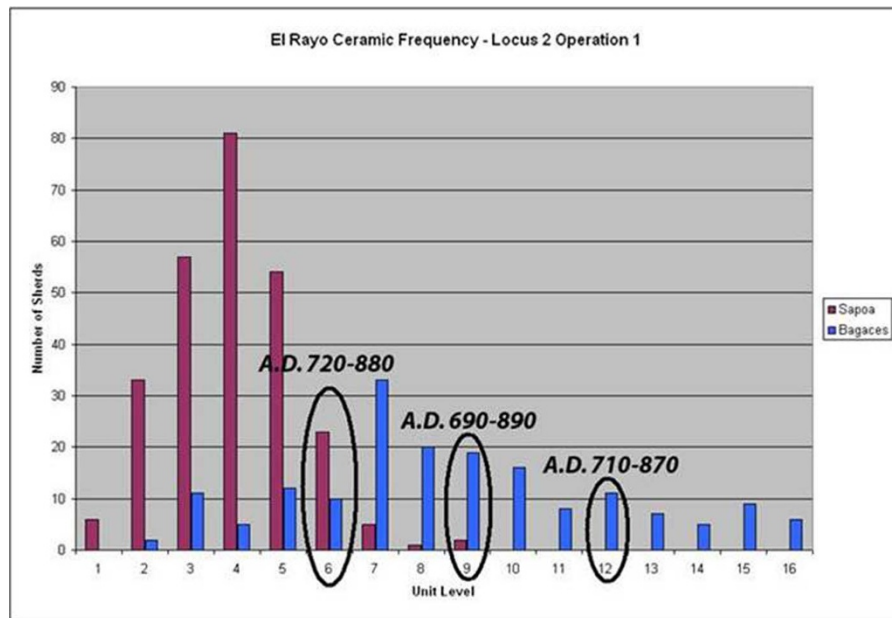


Figure 5. Ceramic frequencies with radiocarbon dates from El Rayo, Locus 2, Operation 1.

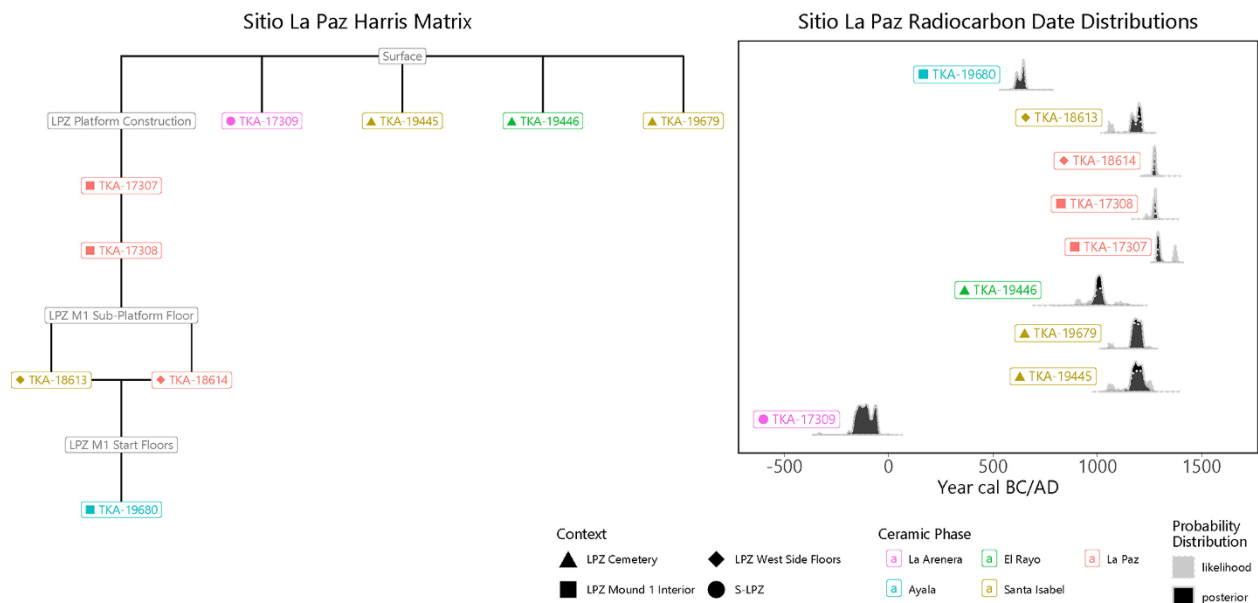


Figure 6. Dated contexts at La Paz: (left) stratigraphic relations; (right) calibrated and modeled probability distributions.

San Francisco (Tipitapa)

A single date was reported from the San Francisco site, near the shore of Lake Cocibolca (Wyckoff 1976): 747±135 BP.

San Lazaro (Ometepe Island)

San Lazaro (OM 16) is located on the southern coast of the Concepción half of Ometepe Island. Haberland (1992) excavated a test pit at the site in 1962–1963, which indicated the site pertains exclusively to the late Middle Polychrome period (Haberland's San Lazaro Phase), dated A.D. 1300–1400. The date obtained from the site, 505±50 BP, falls slightly outside of this time range.

Santa Isabel (Ri-44)

Santa Isabel is a site on the western shore of Lake Cocibolca, in the Department of Rivas. It was first sampled by Willey and Norweb in the late 1950s/early 1960s (Healy 1980), and in the 1990s it was surveyed by Niemel, who also conducted small scale excavations (Niemel 2003; Niemel Garrard 2021). The most extensive excavations were carried out by the University of Calgary between 2000 and 2005 (McCafferty 2008, 2021; McCafferty and Steinbrenner 2005b; Steinbrenner 2010). These included sampling of six low mounds, primarily residential, and recovering numerous burial urns. Notably, Santa Isabel contributes 18 radiocarbon dates, of which all but three have sufficient associated information

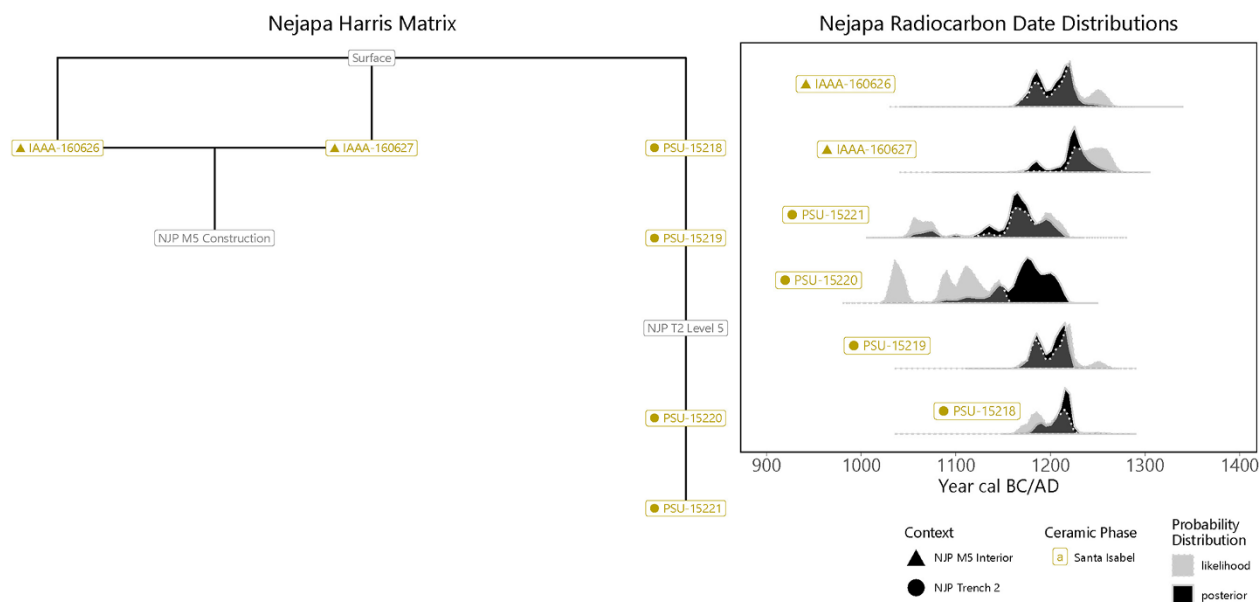


Figure 7. Dated contexts at Nejapa: (left) stratigraphic relations; (right) calibrated and modeled probability distributions.

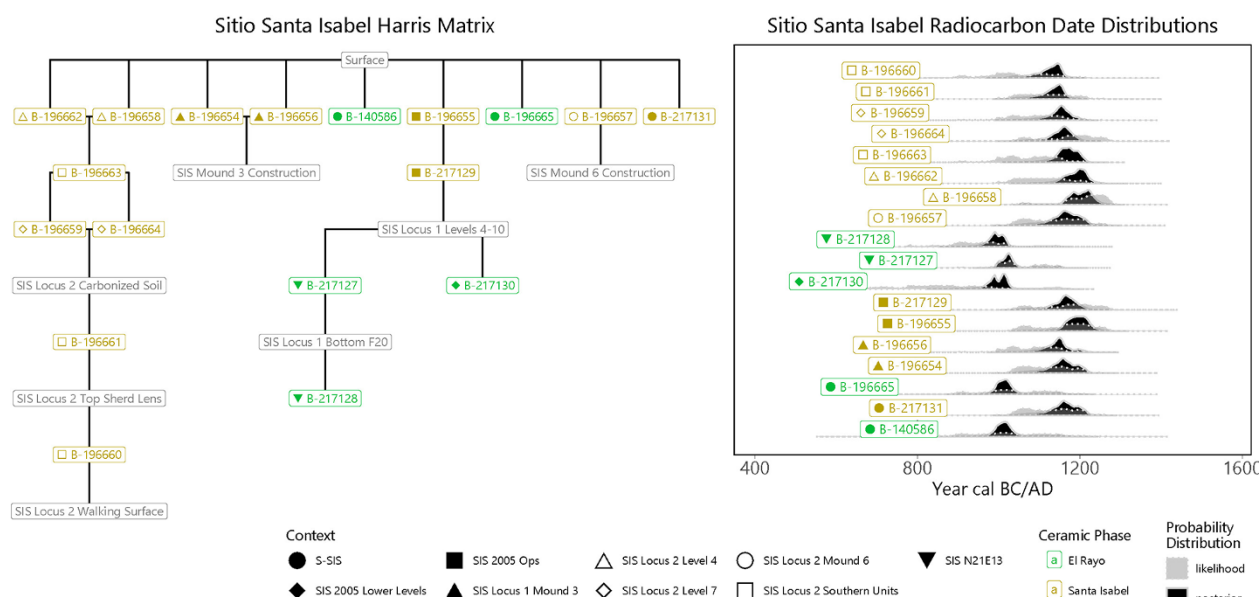


Figure 8. Dated contexts at Santa Isabel: (left) stratigraphic relations; (right) calibrated and modeled probability distributions.

from Loci 1 and 2 to reconstruct stratigraphic relationships (Steinbrenner 2010:196–225). The dates range from 1180 to 820 BP, but with the greatest concentration between 930 and 820 BP (Figure 8). There was also a faint trace of Tempisque and Bagaces material culture in deep levels. A stratigraphic pit into Mound 3 reached sterile soil at about 2 meters below surface (Figure 9). Seriating the diagnostic pottery by 10 cm-excavation levels it was found that the deepest levels had only Papagayo Polychromes, with other types such as Bramadero Polychrome, Granada Polychrome, Madeira Polychrome, Pataky Polychrome, and Vallejo Polychrome found in upper levels.

Sonzapote (Zapatera Island)

Sonzapote is known from Bovallius (1886) for monumental sculpture found in association with a cluster of architectural platforms. Excavations were conducted to date the site (McCafferty et al. 2013). Two components were identified: an earlier occupation related to mound construction and associated with Late Tempisque/Early Bagaces ceramics, and a second component of Sapoá/Ometepe period burial urns associated with Castillo Engraved pottery but minimal polychrome. The short field season concentrated on Mound 14, a large rectangular structure with relatively good architectural integrity. The excavations on the southwest corner

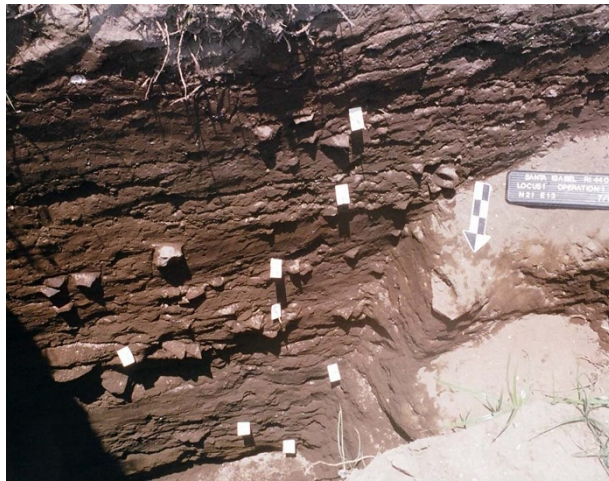


Figure 9. Santa Isabel, Locus 3 deeply stratified excavation showing superimposed floor level deposits.

identified successive walking surfaces associated with the mound construction, with an intrusive burial urn of Espinoza Red Banded, a Late Tempisque/Early Bagaces ceramic diagnostic.

The Gif 11816 date from an earlier project was mistakenly reported as A.D. 1330 instead of the correct 1330+45 BP (Navarro Genie 1993). The consequent interpretation that associated statuary to the Ometepe period therefore needs to be revised to about 700 years earlier.

Two radiocarbon dates pertain to the feature around the intrusive Espinoza Red Banded urn. The ^{14}C dates are later than expected, however, 820+30 and 950+30 BP (supplementary material:Figure S9). We tried running our model with these dates included in the Ayala phase, but they were so far beyond the range of other Ayala dates that Oxcal was unable to resolve the order within our Pacific Nicaragua sequence. Because there is a well-defined Sapoá/Ometepe presence at Sonzapote, we decided not to consider these samples to be outliers but rather to include them in our Santa Isabel period, on the assumption that they represent later charcoal that intruded into the fill around the Espinoza Red Banded vessel. Note that the excavated area was relatively close to the surface with much root disturbance.

Ceramics from Sonzapote were somewhat dissimilar to those from the western lakeshore. The predominant type found in the deeper context had an orange surface with appliqué decoration, including zoomorphic heads. These are unknown from other sites and rare in museum collections; they are tentatively designated as Sonzapote Orange (McCafferty et al. 2013). Similarly, Jobo Incised is rare from local mainland contexts but may be more common in northern Nicaragua (Jorge Zambrana Fernández, personal communication 2013). In reference to the later component, Castillo Engraved was by far the most abundant decorated type, while polychrome pottery was rare—this is very different from the tendency in sites from the western shore. Of the polychromes, the best diagnostic found was a sherd of Luna Polychrome, typical of the Ometepe period.

Tepetate (Granada, Gr-10)

Tepetate is located on the north side of modern Granada, where it has been severely impacted by modern development and looting. The archaeological site has been known for over 100 years, and nineteenth- and early twentieth-century scholars described it as having large mounds with facades of flat stones (Carmack and Salgado 2006). It was investigated by Salgado (1996a) as part of her survey. Excavations by the University of Calgary project occurred in 2008 (McCafferty 2021), with exploration of one of the last remaining mounds, a stone foundation, and two clusters of urn burials.

Probably because of the highly acidic soil at Tepetate, surface paint on polychrome pottery was poorly preserved, making it difficult to identify types and varieties beyond simply “Papagayo, variety unknown.” Many of the decorated sherds included fine-line incising, characteristic of varieties known as Mombacho. There were also numerous molds, especially for producing vessel supports and figurines of the Papagayo type. Two dates were obtained, 930+40 and 820+40 BP (supplementary material:Figure S10).

Constructing a chronology for Pacific Nicaragua

The radiocarbon dates listed in Table 1 provide a basis for proposing a new, region-specific chronology for Pacific Nicaragua. Based on the large amount of recent archaeological research, the cultural development of Pacific Nicaragua is coming into focus. This is particularly true for the time period between A.D. 600 and 1300. Earlier and later periods have not been sufficiently sampled. One point of confusion, however, is that by sharing the existing chronological sequence with other parts of Nicaragua and Costa Rica, particular qualities became blurred. For example, the diagnostic ceramics of Pacific Nicaragua are not the same as those from the eastern side of Lake Cocibolca (Donner and Geurds 2018), or across the political border in Costa Rica (Vázquez et al. 1994). For this reason, we believe that it is important to define a new, more localized chronology for the region lying south and west of Lake Xolotlan and Lake Cocibolca.

To make our assumptions explicit, and incorporate any possible information available, we utilize the Bayesian approach implemented in Oxcal 4.4 (Bronk Ramsey 1995, 2009) to help constrain the calibrated ranges of the radiocarbon dates listed earlier. In the ideal case, such a Bayesian analysis would summarize chronometric evidence from a series of contexts with clear stratigraphic relationships to each other. Buckley and colleagues (2023), for instance, recently analyzed AMS dates from human bone collagen representing burial contexts in the La Ventilla neighborhood of Teotihuacán to refine the site’s ceramic chronology and to address the possibility of abandonment and reoccupation. In another study, Clayton (2020) modeled radiocarbon dates from three carefully excavated Epiclassic structures at Chicoloapan, a site in the Basin of Mexico that expanded as Teotihuacan declined. Developing a regional chronology based on multiple dated contexts from multiple sites introduces additional complexity, but careful consideration of ceramic associations and attention to stratigraphic relationships within sites nonetheless promise some gain over simple presentation of unmodeled calibrated dates. In effect, Bayesian modeling allows

us to test the validity of our understanding of the ceramic sequence at the regional level by examining its consistency with stratigraphic and contextual information (Hamilton and Krus 2018). Use of Bayesian models in studies of broader, regional chronological relations is exemplified by recent studies in the Valley of Guatemala (Arroyo et al. 2020; Inomata et al. 2014), the Maya lowlands (Inomata 2017), and southern Central America (Mejía Ramón 2023).

Our approach to building a new chronology for Pacific Nicaragua necessarily relies on radiocarbon measurements from multiple sites, none of which has contexts representing the entire sequence. Additionally, stratigraphic relations among contexts from single sites are not always clear due to the exploratory nature of many of the excavations and uneven reporting. Nevertheless, given the destruction of several sites and financial/logistical difficulty in returning to others, ignoring such dates is also not a useful option. Because of these limitations in our data, we rely jointly on our understanding of the ceramic sequence and secondarily on stratigraphic relations within sites when such information is available. These data are presented as Harris matrices where possible in the accompanying figures.

First, we generated an individual model for each site with more than one date. For each site with insufficient published information to resolve stratigraphic sequences, dates were placed into singular phases representing the extent of datable occupation of the site. This assumes that at the very minimum dates from the same site are more likely than not to correlate with each other than be randomly distributed across time. Sigma Boundaries were used to constrain the site-specific models unless an abrupt appearance/abandonment can be ascertained. This allows for a lag in (dis)appearance, assuming a normal distribution of dates across time versus a uniform.

Next, we used OxCal's cross-reference feature to place radiocarbon dates within trapezoid models for each ceramic phase (alongside dates from sites with only one date). As Lee and Bronk Ramsey (2012:107–108) point out, the trapezoidal model implements at the assemblage level the “popularity principle” that underlies frequency seriation (Ford 1962; Orton and Hughes 2013:228). That is, the types defining a ceramic complex or assemblage are assumed not to appear abruptly but rather to originate at some point then gradually increase in frequency, then enjoy some period of maximum popularity, then to gradually decline in popularity until they disappear. Thus, the starting boundary of each period has a starting point, a duration for the period to mature, and a point of full maturity, while the end boundary has a point when popularity begins to decline, a duration of the decline, and a point of final disappearance (compare this to the “bat-leship graphs” suggested by Deetz and Dethlefsen [1967] for gravestone studies). The “boundaries” for periods defined by a trapezoidal model are the midpoint between the start and end of the rise to popularity and the midpoint between the start and end of the decline in popularity. For the two phases with few enough dates such that OxCal struggles to converge on a plausible posterior for the transition length, we used a uniform prior distribution between 0 and 300 years. Moreover, for the phase most lacking in dates (La Arenera, $n = 5$), we placed an additional boundary after the end of

the phase at calendar date A.D. 750—centuries after its near-certain existence—to ensure that the converged distribution converged to zero rather than asymptotically approach it.

We followed Bronk Ramsey (2009) in dealing with the possibility of temporal outliers by allowing the model to predict the probability that a date is inconsistent with the model and adjust the output proportionally. We constructed an outlier model where errors should be distributed across a Student's t -distribution of a fifth order, with a uniform prior magnitude between 1 and 104, and prior outlier probabilities of 0.05 for non-suspect dates in sites with potential outliers. Potential outliers include dates with Agreement indices below $A = 60.0$, and any other date in the sequence that constrains such potential outliers such that the posterior distribution is unlikely. Removing specific dates or combinations thereof would represent a potential scenario out of n potential scenarios wherein the resulting sequence is correct. Thus, prior outlier probabilities for potential outliers were assigned such that dates within a removal scenario sum to $1/n$.

Given our desire to obtain conditional probabilities for relationships between different phases, we employed OxCal's MCMC_Sample feature to generate 30,000 sets of plausible dates for correlated sequences of events (namely the Start and End periods of the trapezoid rise and fall boundaries). These were used to obtain the Gantt chart, the stacked area diagram, the probabilities of overlap between phases and assemblages, and the lengths of possible overlaps and gaps by calculating the individual value within each set, then obtaining the distribution of such values across all sets. The model can be reproduced with the OxCal code in the supplemental materials, with the posterior distribution of all dates in all figures of the manuscript reflecting the resulting output.

Results

For cultural-historical analysis, we recommend the chronology as depicted in the timeline of Figure 10, based on the start and end periods of a complex's florescence as predicted by our OxCal model. This summarizes the period for which a particular ceramic complex is most likely to have been in widespread use, comparing the ranges with other schema for Pacific Nicaragua. When using ceramics as a proxy for time absent direct dating, we recommend the chronology as depicted in the Gantt chart of Figure 11. This figure summarizes the range of possible dates a complex may have existed as the color bars (and red error bars), with the uncertainty in the range of the culture-historical periods as the overlain black boxes. Finally, when trying to associate a known or radiometric date with a ceramic/cultural phase absent a known association we recommend the stacked area plot of Figure 12. For any given year, the chart depicts as empty space the probability that the year falls beyond the boundaries of known phases (a “gap”). The remaining area composed by the stacked periods depicts the relative probability that a given year falls within each phase. Since phases can overlap, phase probabilities are independent of each other and do not depict the absolute probability.

The naming convention employed for our new phases identifies chronological units best represented from the dated archaeological contexts. For example, the Ayala phase,

Years AD/BC	Haberland (1992)	Healy (1980), Rivas	Vasquez et al. (1994), Greater Nicoya	Salgado et al. (1994), Granada	This study, Pacific Nicaragua
AD 1550	Ometepe				
AD 1500					
AD 1450	Santa Ana Phase	Late Polychrome Period (Alta Gracia Phase)	Ometepe Period	Ometepe Period	Definite gap
AD 1400	San Lázaro Phase				
AD 1350	San Lázaro Phase	Late Polychrome Period (Las Lajas Phase)			La Paz Phase
AD 1300	La Paloma Phase				Probable gap
AD 1250	La Paloma Phase				
AD 1200					
AD 1150	Gato/La Paloma Phases	Middle Polychrome Period (La Virgen Phase)	Sapoá Period	Sapoá Period	Santa Isabel Phase
AD 1100					
AD 1050	Gato Phase	Middle Polychrome Period (Apompua Phase)			El Rayo Phase
AD 1000					
AD 950					Possible gap
AD 900					
AD 850					
AD 800					
AD 750	San Roque Phase	Early Polychrome Period (Palos Negros Phase)		Bagaces Period (Ayala Phase)	Ayala Phase
AD 700					
AD 650					
AD 600			Bagaces Period	Bagaces Period (San Antonio Phase)	Probable gap
AD 550		Early Polychrome Period (San Roque Phase)		Bagaces Period (Siu Phase)	
AD 500					
AD 450					
AD 400					
AD 350					
AD 300					
AD 250	Manantial Phase	Zoned Bichrome Period (San Jorge Phase)			Las Delicias
AD 200					
AD 150					
AD 100					
AD 50			Tempisque Period	Tempisque Period	
BC/AD					
100 BC	Sinacapa Phase				
200 BC		Zoned Bichrome Period (Aviles Phase)			La Arenera Phase
300 BC					
400 BC	Angeles Phase				
500 BC					
600 BC					
700 BC	Dinarte/Angeles Phases		Orosí Period	Orosí Period	
800 BC					
900 BC					
1000 BC	Dinarte Phase				
1500 BC					
2000 BC					

Figure 10. Proposed culture-historical chronology for the Nicaragua lakes basin compared to other chronologies proposed for Greater Nicoya and parts thereof.

for which seven dates were recovered from the Ayala type site, or the Santa Isabel phase, for which 12 dates were recovered from the Santa Isabel type site. Undoubtedly, future research programs will encounter other sites from which

additional dates will be added to the corpus to fill in the gaps in the sequence, and perhaps better characterize the suggested phases. Additional refinements to the regional periodization may also be expected based on new data and/or

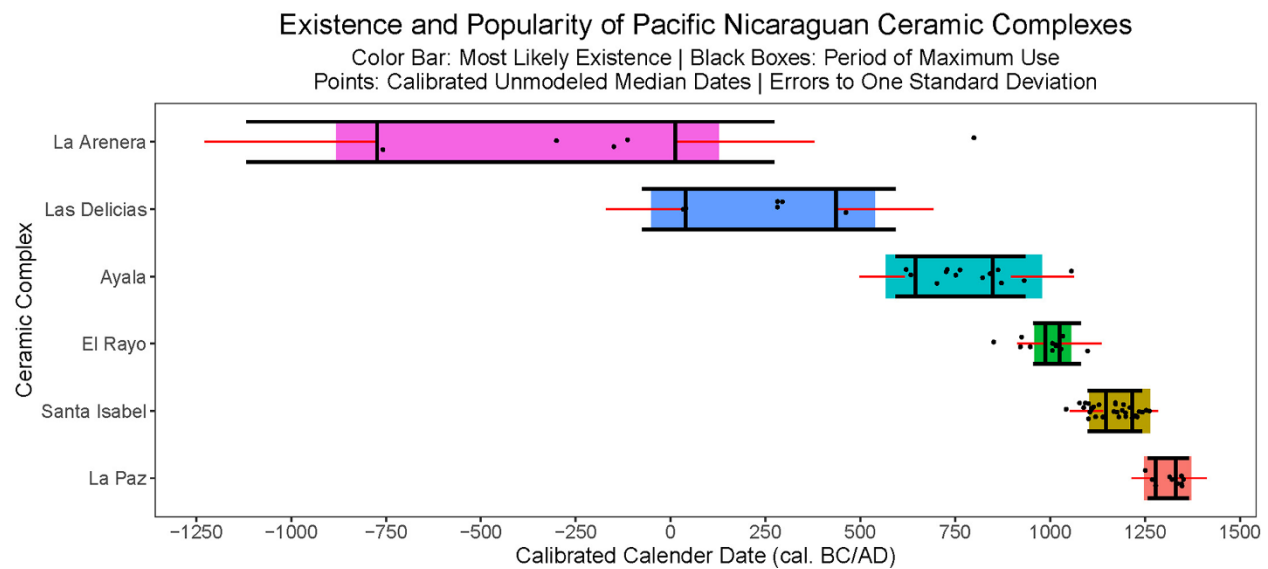


Figure 11. Gantt chart showing predicted periods of a ceramic complex's existence and popularity given the current data.

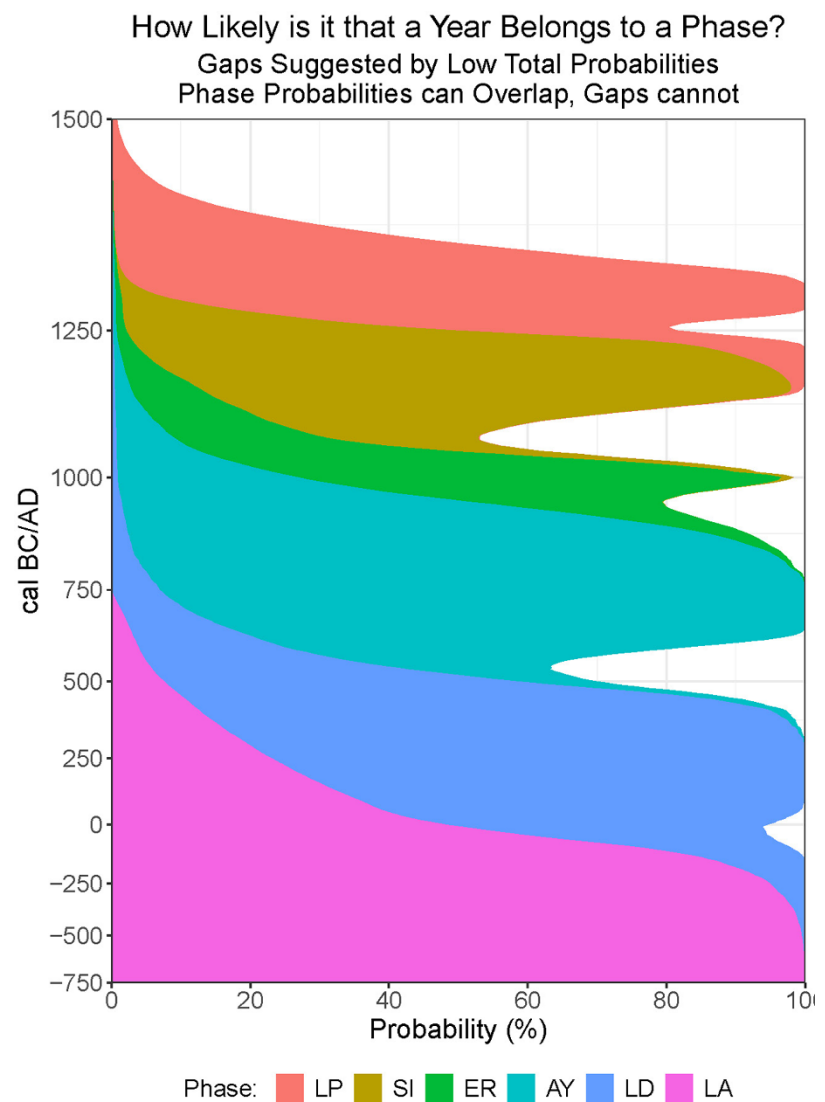


Figure 12. Stacked area diagram showing the likelihood a given year falls within a particular phase.

based on implementation of different modeling assumptions. As demanded by good scientific practice, these time periods should be subject to critical evaluation as new information becomes available. Nevertheless, these represent the best contexts under the current state of the archaeological record.

For purposes of discussion, but recognizing that choosing specific begin and end dates for our chronological units inadequately represents the results of our Bayesian modeling, we propose the following sequence of culture-historical phases for the last 2,000 years of Pacific Nicaragua prehistory based on the median values of the start and end dates of the period of maximum use rounded to the nearest decade. We assume a “transitory” phase or coexistence between two adjacent complexes for dates outside of the periods unless otherwise indicated by gaps. Probable gaps are those periods of time where the model predicts there to be no existing complex with a greater than 50 percent probability, with possible gaps having greater than a 35 percent probability:

La Arenera	500 cal B.C. to cal A.D. 1
Las Delicias	cal A.D. 30 to 430
Probable Gap (57.7%)	cal A.D. 430 to 650
Ayala	cal A.D. 650 to 840
Possible Gap (38.7%)	cal A.D. 840 to 1000
El Rayo	cal A.D. 1000 to 1050
Santa Isabel	cal A.D. 1050 to 1210
Probable Gap (68.1%)	cal A.D. 1210 to 1280
La Paz	cal A.D. 1280 to 1330
Definite gap (99.3%)	cal A.D. 1330 to Spanish conquest

Generally, the data are consistent with a sequential model as proposed by cultural-historical similarity seriation. With only two exceptions, the periods of maximum use of neighboring phases are independent of each other in less than 6 percent of simulations (Figure 13). The earliest potential set of overlapping phases—a 47 percent likelihood for La Arenera-Las Delicias—may in large part be due to the limited amount of dating. However, other lowland Mesoamerican regions commonly show a coexistence between early phases in the archaeological record (Blake et al. 1995; Mejía Ramón 2023). The latter set of overlapping phases is a near one-in-four chance that El Rayo and Santa Isabel overlap. Despite the sizable number of dates for both phases, El Rayo’s short existence—combined with a minor plateau in the calibration curve—makes it difficult to resolve the former’s end and Santa Isabel’s beginning.

While the periods of maximum use for the most part are independent, the same cannot be said of the period of existence (Figure 14). Only Ayala is more likely than not to be independent of its neighbors, and this only by a margin

of 8 and 5 percent, respectively. Overlaps between adjacent phases are often substantial enough such that considering them “transitional” grossly understates their duration. On average, other ceramic types were in use for between one-fifth (La Paz) to nearly all (El Rayo) of the complex’s existence. Thus, while ceramic remains from short-lived complexes may be suggestive of coevality between sites (akin to Rowe’s [1962] phases), ceramics in Pacific Nicaragua are poor indicators of sequentiality (more akin to Rowe’s stages).

Discussion

Based on a large amount of recent archaeological research, the cultural development of Pacific Nicaragua is coming into focus. One point of confusion, however, is that by sharing the existing chronological sequence with other parts of Nicaragua and Costa Rica, particular qualities become blurred. For example, the diagnostic ceramics of Pacific Nicaragua are not the same as those from the eastern side of Lake Cocibolca (Donner and Geurds 2018), or across the political border in Costa Rica (Vázquez et al. 1994). For this reason, we believe that it is important to define a new, more localized chronology for the region lying south and west of Lake Xolotlan and Lake Cocibolca.

The early occupations of the Nicaragua lakes basin remain poorly defined. A Lowe point allegedly found on Ometepe Island (Prufer et al. 2021) hints at late Paleoindians around Lake Cocibolca with the capability of crossing from the mainland to Ometepe Island. Footprints at Acahualinca, within metropolitan Managua, have recently been verified to pertain to an Archaic Period group impacted by a volcanic eruption between about 7000 and 7500 cal BP (Neff 2023; see Schmincke et al. 2009 and Bryan 1973 for earlier dating efforts). Haberland’s (1986, 1992) discovery of “Dinarte Phase” pottery showing similarities to the Tronadora Complex of Costa Rica (Hoopes 1994) in deep excavations at Los Ángeles, Ometepe Island hints at early farming populations in the lakes basin. Although recent efforts to resample the Dinarte Phase (Neff and Brown 2022) returned only equivocal results, a radiocarbon date associated with Los Ángeles Phase pottery types (Haberland 1992; Healy 1980) from Los Ángeles (PSU 9952) appears to show people on the island prior to 500 cal B.C. Unfortunately, despite a small standard deviation on this date, the “Hallstatt Plateau” on the radiocarbon curve spreads the two-sigma calibrated range across two-and-a-half centuries, from 800 cal B.C. to 565 cal B.C. (supplementary material: Table S1). Pottery associated with the date includes types we place in the La Arenera phase (discussed later), which is where we place it in our model. Analysis of sediment cores designed to detect early human impacts around Lakes Cocibolca and Xolotlan are currently underway and will be presented in future publications.

The La Arenera complex (in existence from before 500 cal B.C.–cal A.D. 120) is best known from the Managua area, including two ¹⁴C dates from the type site. Diagnostic ceramics include Rosales Black-on-Red Incised serving vessels and figurines, Bocana Incised Toya variety, and Negative Resist vessels (Figure 15) similar to Usulután Negative Resist

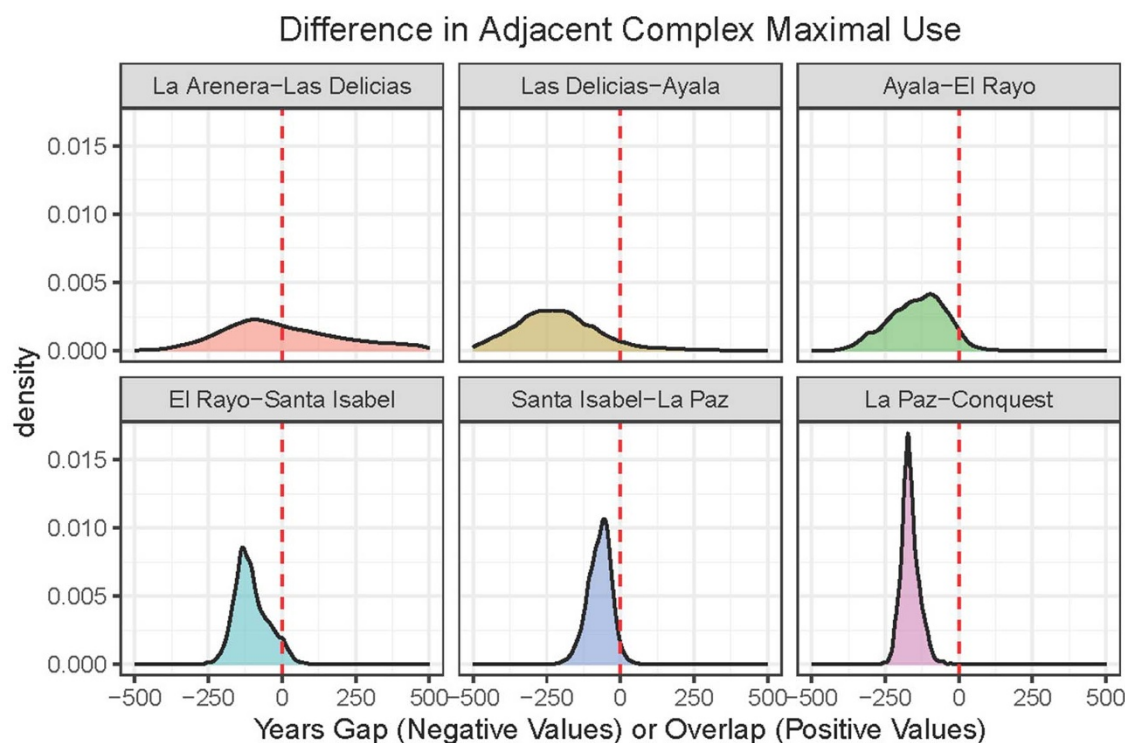


Figure 13. Difference between the end of a particular period and the start of the next, indicating gaps and overlaps in periods of popularity.

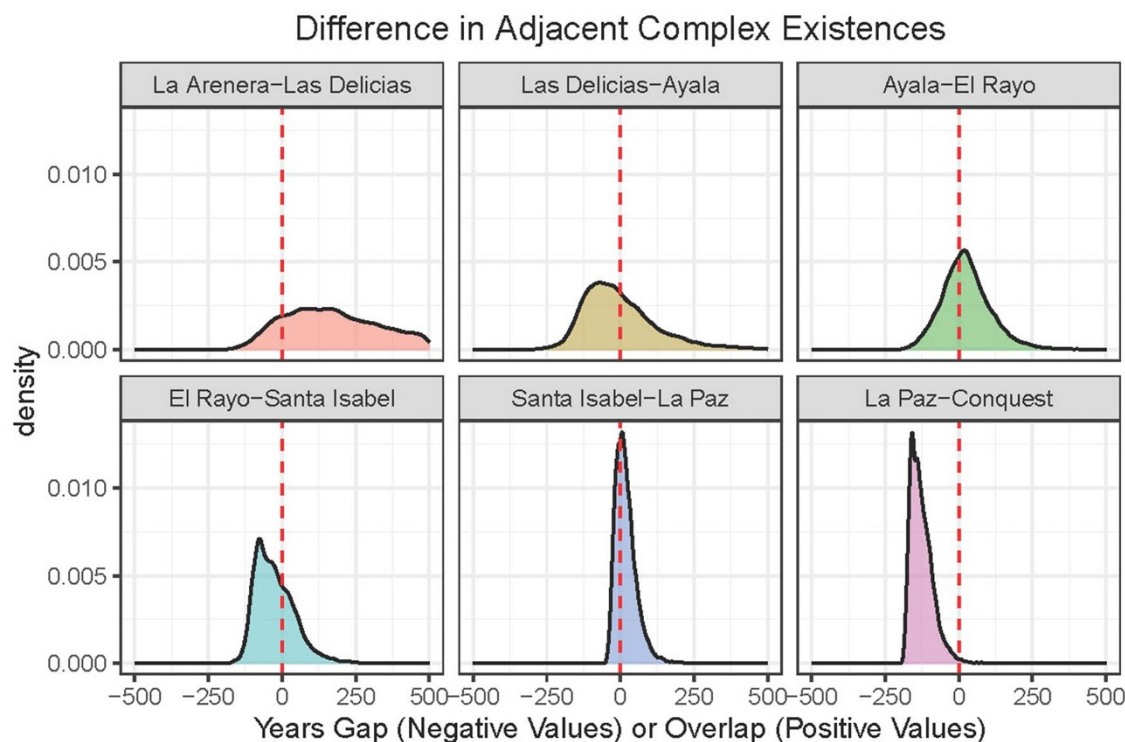


Figure 14. Difference between the disappearance of a particular ceramic complex and the appearance of the next, indicating gaps and overlaps in material existence.

from El Salvador. Similar ceramic assemblages were found by Lange and his colleagues during salvage excavations in Managua (Brown et al. 1996; Espinoza Perez 1995). As modeled here, the period of maximum use (hereafter, simply “phase”) extends from 500 cal B.C. or earlier through around 100 cal B.C.

The end of occupation at the type site of La Arenera certainly came suddenly, with the explosive eruption of Asososca



Figure 15. Diagnostic ceramics from the La Arenera phase. (a) Rosales Black-on-Red Incised, (b) Bocana Incised, Toya variety, (c) Usulután-like Negative Resist.



Figure 16. Diagnostic ceramics from the Las Delicias phase. (a) Bocana Incised, (b) Negative Resist spouted vessel, (c) Espinoza Red Banded, (d) Jobo Punctate, and (e) Sonzapote Orange.

Maar and the resulting burial of the occupation surface with more than eight meters of sand (Pardo et al. 2009), an event now dated to between 345 and 45 cal B.C. (Avellán et al. 2012; this is sample A14759).

The transition between the La Arenera and Las Delicias phases is still very poorly defined. Given the present information, there is nearly a 50/50 chance of there being an overlap or a gap ranging up to hundreds of years between the periods of maximum use. This largely arises from the small number of dates from both phases. Such a gap, if confirmed by future work, may have arisen from intense volcanism, possibly starting with the Asososca Maar eruption that covered La Arenera itself. Although one volcanological study (Perez and Freundt 2006; Schmincke et al. 2009) suggests that a highly explosive eruption of Masaya volcano deposited the Masaya Triple Layer tuff on the Managua zone shortly after the Asososca eruption, recent re-dating of the Acahualinca footprints (Neff 2023) places this event closer to 7,000 years ago, as proposed by Avellán et al. (2012).

The Las Delicias complex (in existence ca. 50 cal B.C.–cal A.D. 530) is defined based on two ^{14}C dates from the

Las Delicias cemetery in Managua on the shore of Lake Xolotlán together with three dates from San Cristóbal, also close to the shore of Lake Xolotlán (Espinoza Perez et al. 2023). The model indicates a most likely phase duration of roughly 400 years, but with the 90 percent high-est probability density range extending up to 700 years. Much of this uncertainty is due to the limited number of dates.

Diagnostic ceramics include Negative Resist vessels, including spouted vessels, and Bocana Incised vessels (Figures 16a–b). Both the Las Delicias and San Cristóbal cemeteries included these vessels as grave goods, in addition to occasional ground stone artifacts.

Ticuantepe, a unique burial complex was discovered during deep construction work. Two adult individuals had been placed on aligned grinding stones and were accompanied by two large vessels filled with additional human skeletal remains, as well as several small redware ollas. The chronological assignment of this context was provided by Jorge Zambrana Fernández (personal communication 2016) based on comparative materials.



Figure 17. Diagnostic ceramics from the Ayala phase. (a) Chavez White on Red. (b) Leon Punctate. (c) Tola Trichrome, (d) Momta Polychrome.

The early context at Sonzapote may also date to the Las Delicias phase, based again on Zambrana's identification of Jobo Incised and Espinoza Red Banded pottery (Figures 16 c–d; McCafferty et al. 2013). The predominant ceramic type, however, has an orange surface with modelled and incised decoration that we call Sonzapote Orange (Figure 16e).

A probable gap (present in 57.7 percent of simulations) of up to 460 years separates Las Delicias from the subsequent Ayala phase.

The Mombacho volcano south of Granada experienced a catastrophic flank collapse with a minimum age of A.D. 345 (Shea et al. 2008; Stansell 2013), when millions of tons of basalt boulders slid into Lake Cocibolca to form the Asese peninsula and several hundred surrounding islands. The resultant tsunami waves may have washed away coastal villages, while sulfur dioxide and other toxic compounds could have polluted the water, impacting the natural environment. The southern side of the volcano then also collapsed between A.D. 270 and A.D. 650. Both catastrophic events may help explain the relative lack of dated sites between about A.D. 300–600, at least around Granada.

The Ayala complex (cal A.D. 570–970) is well defined from the type site of Ayala, as well as nearby El Rayo. Three dates from Operation 7 at Ayala and four dates from Operation 13 are in stratigraphic sequences and are modeled as such. However, Beta-77223 from the Operation 7 sequence, had an extremely low agreement index and including it in the model reduced the model agreement index to below the 60 percent acceptability cutoff, motivating us to flag it as an outlier. The model suggests a duration of about 200 years for the phase, beginning around cal A.D. 650 and ending within a few years of cal A.D. 840.

Compositional analysis of redware pottery from this time period indicates that Ayala was a major manufacturing center, distributing its ceramics throughout the region (Dennett 2016; Dennett et al. 2019). Diagnostic ceramics include Tola Trichrome, Leon Punctate, Chavez White-on-Red, and Charco Black-on-Red (Figures 17a–c). Two new types introduced during this period are Momta Polychrome (Figure 17d) and Belo Polychrome, manufactured locally but with stylistic elements related to a wider “constellation of practice” (Dennett 2016, 2021; Dennett et al. 2019).

The El Rayo complex (cal A.D. 960–1050) follows another possible gap of up to 300 years—present in 38.7 percent of simulations after the end of the Ayala phase. While four of the 11 dates have median calibrated unmodeled dates before the modeled start of the complex's existence, a plateau on the calibration curve between A.D. 910–980 means that any *ante quem* constraints on these dates will tend to push their modeled ages rapidly toward recency—especially given that there is at present about a one-in-three chance that Ayala did not exist during the plateau. However, in light of the dramatic break from the previous ceramic complex, we are inclined to interpret this possible gap between Ayala and El Rayo as valid and indicating discontinuity between the two phases. As indicated by the stratigraphic sequence from El Rayo's Locus 2 and the associated ^{14}C dates the transition seems to have been rapid (see Figure 5), although the continued use of Ayala phase redwares implies a degree of cultural integration.

Redware ceramics are replaced with polychromes, especially varieties of Papagayo Polychrome (Figures 18a–d). This change includes new vessel forms and decorative elements. These may be developments from the Momta/Belo Polychromes of the Ayala phase, but also relate to Las Vegas Polychrome from Honduras. Although compositional



Figure 18. Diagnostic ceramics for the El Rayo phase. (a–d) Papagayo Polychrome, (e) Sacasa Striated, (f) Vallejo Polychrome, (g) Castillo Engraved, (h) Lago Modelled.

analysis by Dennett (2016, 2021) indicates that Granada continued as a major ceramic manufacturing area, she also finds that compositional diversity increased, indicating proliferation of workshops. Another innovation during the El Rayo phase was large, oval vessels known as Sacasa Striated, which were used both for cooking (probably preparation of a beverage similar to *pinolillo*) but subsequently for urn burials (Figure 18e; McCafferty and McCafferty 2012). Other decorated pottery types introduced during this phase include Vallejo Polychrome, Castillo Engraved, and Lago Modelled (Figures 18f–h). Other evidence for discontinuity in the early ninth century includes introduction of a new fishing toolkit (Wilke 2021) and changes in mortuary practices (McCafferty et al. 2021). While hesitant to attribute material culture change to immigration, we would be remiss not to acknowledge that the early ninth century also stands out as the time period when the Chorotega, immigrants from Central Mexico, are thought to have arrived in Pacific Nicaragua (Steinbrenner 2021a).

The Santa Isabel complex (in existence cal A.D. 1110–1260) is best defined at the type site of Santa Isabel, but is also found at El Rayo, La Paz, Nejapa, Sonzapote, and Tepetate. Ceramic types that originated during the preceding period, especially polychromes, continue into Santa Isabel times,

leading us to favor continuity in occupation, despite the probable century-long gap between the El Rayo and Santa Isabel phases according to the model. In addition to Papagayo and Vallejo Polychromes, Bramadero, Madeira, and Pataky Polychromes were added to the assemblage of serving wares (Figures 19a–c). Based on the number of sites with Santa Isabel phase dates this may have represented a period of population growth and diversification. Santa Isabel itself was by far the largest site west of Lake Colcibolca at this time (Niemel Garrard 2021). It may have been a “port of trade” for the region (Chapman 1957) and was the site of manufacture of exotic goods such as greenstone, shell, textiles, and carved bone jewelry (McCafferty 2008, 2021; McCafferty and McCafferty 2008). We cannot, however, discard the possibility that bias in archaeological attention has produced a sample in which Santa Isabel contexts are overrepresented.

The La Paz phase (cal A.D. 1280–1330) closely follows Santa Isabel, with only 3 percent of simulations suggesting any gap whatsoever between the periods of maximum use. Indeed, 66.1 percent of simulations suggest an overlap of up to 20 percent between the two complexes’ existence. La Paz is best represented by sites along the shore of Lake Xolotlan.

The major Santa Isabel phase sites of El Rayo and Santa Isabel seem to have been abandoned around the beginning



Figure 19. Diagnostic ceramics from the Santa Isabel phase. (a) Bramadero Polychrome. (b) Madeira Polychrome. (c) Pataky Polychrome.

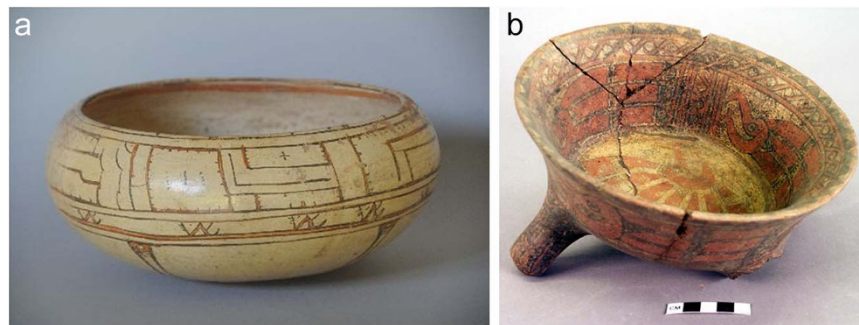


Figure 20. Diagnostic ceramics from the La Paz phase. (a) Luna Polychrome. (b) Managua Polychrome.

of the La Paz period, which conceivably could be evidence of the ethnic changes and implied warfare mentioned in ethnohistorical texts (Ibarra Rojas 2010). Diagnostic ceramics of this phase include continuations of types from Santa Isabel, with the addition of Luna and Managua Polychromes (Figures 20a–b), but we have not carried out detailed ceramic analysis to evaluate the case for continuity.

La Paz is the end of the Prehispanic sequence in our model. The 90 percent probability range for its termination extends from cal A.D. 1321 through 1427, and even the end of the decline period specified by our trapezoidal model only extends to cal A.D. 1506. Thus, the available database includes no evidence of occupation at the time of the Spanish invasion nor likely for a period of up to 200 years prior to it, despite ethnohistoric accounts to the contrary (Ibarra Rojas 2001; McCafferty 2015; Steinbrenner and McCafferty 2021). This contradiction may result from modern population growth over locations of final Prehispanic occupation, which as a result have not been investigated. Salvage archaeology projects in urban areas, such as Managua, Granada, and Rivas might rectify this bias in the future, although no such evidence has been recovered thus far, nor have late period artifacts been identified in visual inspections of construction trenches.

Conclusions

This proposed chronology differs from the existing sequence both in terminology and divisions, and for its specific focus on sites, dates, and diagnostic ceramics from Pacific Nicaragua. When the Greater Nicoya chronology was proposed in the

early 1990s, relatively little was known about Nicaragua, and little work was being done there. Consequently, the Greater Nicoya sequence was heavily biased in favor of Costa Rican sites and ceramic types. Nicaragua was included based on Norweb's (1964) definition of Greater Nicoya that included Pacific Nicaragua and a handful of small projects, but the reality was that it contributed little to the interpretations.

In contrast, however, 30 years later we have information from several major projects and a substantial number of radiocarbon dates. This permits a critical evaluation of how well different regions within Greater Nicoya align chronologically. At least for the later periods there are significant differences between decorated ceramics and mortuary practices between Nicaragua and Costa Rica, raising the possibility that Greater Nicoya may have been less uniform in material culture than is often assumed and therefore invites questions as to the validity of the concept (Ibarra Rojas 2021). The goal of this revision to the Pacific Nicaragua chronology, then, is to create a sequence that is more internally consistent. It should still be comparable with that of northwestern Costa Rica, but the distinct, local manifestations of the shared tradition deserve recognition.

The new chronology employs terminology based on “type sites” where the phases are well-represented based on absolute dating, and ideally with well-developed ceramic analysis to document the diagnostic ceramic types. In contrast to the traditional Greater Nicoya sequence with five periods, the proposed chronology is divided into six phases of shorter duration, but with several gaps for which we currently lack dated sites. Some of the gaps in our Pacific Nicaragua chronology may indicate periods of demographic contraction

caused in part by regionally significant volcanic disasters. For Greater Nicoya as a whole, we believe our results from Pacific Nicaragua imply that much finer chronological distinctions are possible, as indicated by the last column of Figure 10.

As with all archaeological analysis, the caveat is that with more data further refinements and revisions will need to be made. After several decades of intense research, this is a good time to consider recent work and develop new hypotheses. This proposed chronology is just such a new suggestion, open for critical review and hopefully further refinement as new data are generated.

On a larger scale, “Greater Nicoya” has often been considered as a southern frontier of ancient Mesoamerica (McCafferty et al. 2012). This new chronology and cultural sequence for Pacific Nicaragua offers the potential to better distinguish the frontier, particularly via the dramatic changes in material culture across the Ayala/El Rayo transition. The innovative Papagayo Polychrome type with its cream-colored slip and multiple varieties bears similarities with Las Vegas Polychrome from Honduras, but also with polychromes from the Gulf Coast and the central highlands of Mexico (McCafferty and Dennett 2017). Vallejo Polychrome often features iconography closely related to the Mixteca-Puebla stylistic tradition, including variations on the feathered serpent and calendrical glyphs (Manion and McCafferty 2017; McCafferty 2019; McCafferty and Steinbrenner 2005a). The greater variety of polychrome types in the subsequent Santa Isabel period, however, diverges from central Mexican themes, suggesting local development. The mechanisms of contact and interaction remain problematic, but the fact that Mesoamerican languages were still spoken in Pacific Nicaragua in the Colonial period (and into the early twentieth century) suggests the possibility of continuous interaction (Constenla 1994). And yet other cultural characteristics, such as foodways, are not consistent with Mesoamerican culture (McCafferty 2015).

This reconsideration of Pacific Nicaragua’s chronology and cultural sequence will hopefully lead to further research and improved interpretations of the enigmatic region with apparent relevance to ancient Mesoamerica. Importantly, this new chronological “backbone” will enable more nuanced interpretations of the sociocultural phenomena involved in Pacific Nicaragua and regional interactions. For example, what was the significance of the Negative Resist ceramics of the La Arenera and Las Delicias phases in relation to El Salvadoran and Honduran populations (for example, were Usulután ceramics imported to Nicaragua from western El Salvador)? To what extent were the inhabitants of Pacific Nicaragua interacting with Chibchan groups from eastern Nicaragua and Costa Rica? In what ways were Mesoamerican migrants impacting autochthonous societies beginning in the late Ayala and El Rayo phases? Did that contact continue in the Santa Isabel phase? And an overarching question remains of what happened in the final centuries prior to European contact, for which we currently lack significant dated contexts? From a larger theoretical perspective, what can Pacific Nicaragua contribute to issues of frontier dynamics, as a periphery to the Mesoamerican core that may have played an important role in provisioning

exotic materials (such as cacao) via an extensive trade network (Steinbrenner 2006)? We hope that this new chronological structure will encourage more rigorous and imaginative interpretations that will ultimately integrate Pacific Nicaragua into discussions of greater Mesoamerican cultural dynamics.

Supplementary material. The supplementary material for this article can be found at <https://doi.org/10.1017/S0956536126100935>.

References cited

- Abel-Vidor, Suzanne
1980 The Historical Sources for the Greater Nicoya Archaeological Subarea. *Vinculos: Revista de Antropología del Museo Nacional de Costa Rica* 6:155–176.
- Arroyo, Barbara, Takeshi Inomata, Gloria Ajú, Javier Estrada, Hiroo Nasu and Kazuo Aoyama
2020 Refining Kaminaljuyu Chronology: New Radiocarbon Dates, Bayesian Analysis, and Ceramics Studies. *Latin American Antiquity* 31(3):477–497.
- Avellán, Denis R., José L. Macías, Natalia Pardo, Teresa Scolamacchia, and Dionisio Rodríguez
2012 Stratigraphy, Geomorphology, Geochemistry and Hazard Implications of the Nejapa Volcanic Field. Western Managua, Nicaragua. *Journal of Volcanology and Geothermal Research* 213–214:51–71.
- Baudez, Claude F., and Michael D. Coe
1962 Archaeological Sequences in Northwestern Costa Rica. *Akten des 34 Internationalen Amerikanistenkongresses* 1:366–373. Verlag Ferdinand Berger, Horn, Wien.
- Blake, Michael, John E. Clark, Barbara Voorhies, George Michaels, Michael W. Love, Mary E. Pye, Arthur A. Demarest, and Barbara Arroyo.
1995 Radiocarbon Chronology for the Late Archaic and Formative Periods on the Pacific Coast of Southeastern Mesoamerica. *Ancient Mesoamerica* 6:161–183. <https://doi.org/10.1017/S0956536100002169>.
- Bonilla, Leidy, Marlin Calvo, Juan Guerrero, Silvia Salgado, and Frederick Lange
1990 La cerámica de la Gran Nicoya. *Vinculos: Revista de Antropología del Museo Nacional de Costa Rica* 13(1–2):1–327.
- Bovallius, Carl
1886 *Nicaraguan Antiquities*. Serie Arqueologica No. 1, Swedish Society of Anthropology and Geography. Stockholm, Sweden.
- Bransford, John F.
1881 *Archaeological Researches in Nicaragua*. Smithsonian Institution, Washington, DC.
- Braswell, Geoffrey E.
1997 El Intercambio Comercial Entre los Pueblos Prehispanicos de Mesoamerica y la Gran Nicoya. *Revista de la Universidad del Valle de Guatemala* 7:17–28.
- Bronk Ramsey, Christopher
1995 Radiocarbon Calibration and Analysis of Stratigraphy: The OxCal Program. *Radiocarbon* 37(2):425–430. <https://doi.org/10.1017/S0033822200030903>.
- Bronk Ramsey, Christopher
2009 Bayesian Analysis of Radiocarbon Dates. *Radiocarbon* 51(1):337–360. <https://doi.org/10.1017/S0033822200033865>.
- Bronk Ramsey, Christopher
2009 Dealing with Outliers and Offsets in Radiocarbon Dating. *Radiocarbon* 51(3):1023–1045. doi:10.1017/S0033822200034093.
- Brown, Marshall, Margaret Krieg, and Christopher Wilmott
1996 La Segunda Temporada en el Sitio Villa Tiscapa (N-MA-36). In *Abundante Cooperación Vecinal: La Segunda Temporada del Proyecto “Arqueología de la Zona Metropolitana de Managua,”* edited by Frederick W. Lange, pp. 9–36. Alcaldía de Managua, Nicaragua.

- Bryan, Alan L.
1973 New Light on Ancient Nicaraguan Footprints. *Archaeology* 26:146–147.
- Buckley, Gina M., Sarah C. Clayton, Sergio Gómez Chávez, Rubén Cabrera Castro, Laurie Eccles, Brendan J. Culleton, and Douglas J. Kennett
2023 Refining Ceramic Chronology and Epiclassic Reoccupation at La Ventilla, Teotihuacan Using Trapezoidal Bayesian Modeling. *Radiocarbon* 65(3):617–641. <https://doi.org/10.1017/RDC.2023.21>.
- Carmack, Robert M., and Silvia Salgado
2006 A World-Systems Perspective on the Archaeology and Ethnohistory of the Mesoamerican/Lower Central American Border. *Ancient Mesoamerica* 17(2):219–229.
- Chapman, Anne C.
1957 Port of Trade Enclaves in Aztec and Maya Civilizations. In *Trade and Market in the Early Empires*, edited by Karl Polanyi, Conrad Arensberg, and Harry W. Pearson, pp. 114–153. The Free Press, New York.
- Chapman, Anne C.
1974 *Los Nicarao y los Chorotega segun los fuentes historicas*. Ciudad Universitaria, Costa Rica.
- Clayton, Sarah C.
2020 The Collapse of Teotihuacan and the Regeneration of Epiclassic Societies: A Bayesian Approach. *Journal of Anthropological Archaeology* 59:Article 101203. <https://doi.org/10.1016/j.jaa.2020.101203>.
- Coe, Michael D.
1962 Costa Rican Archaeology and Mesoamerica. *Southwestern Journal of Anthropology* 18:170–183.
- Constenla, Adolfo
1994 Las lenguas de la Gran Nicoya. *Vínculos: Revista de Antropología del Museo Nacional de Costa Rica* 18–19(1–2):191–207.
- Creamer, Winifred
1989 Mesoamerica as a Concept: An Archaeological View from Central America. *Latin American Research Review* 22:35–62.
- Day, Jane Stevenson
1994 Central Mexican Imagery in Greater Nicoya. In *Mixteca-Puebla: Discoveries and Research in Mesoamerican Art and Archaeology*, edited by Henry B. Nicholson and Eloise Quiñones Keber, pp. 235–248. Labyrinthos Press, Culver City.
- Deetz, James, and Edwin S. Dethlefsen
1967 Death's Head, Cherub, Urn and Willow. *Natural History* 76(3):29–37.
- Demarest, Arthur A., and Robert Sharer
1982 The Origins and Evolution of Usulután Ceramics. *American Antiquity* 47(4):810–822.
- Dennett, Carrie L.
2016 Ceramic Economy and Social Identity in Pre-Columbian Pacific Nicaragua. PhD dissertation, Department of Archaeology, University of Calgary, Calgary.
- Dennett, Carrie L.
2021 Ceramic Economy and Communities of Practice in Granada and Rivas, A.D. 1–1300. In *The Archaeology of Greater Nicoya: Two Decades of Research in Nicaragua and Costa Rica*, edited by Larry Steinbrenner, Alexander Geurds, Geoffrey G. McCafferty, and Silvia Salgado, pp. 261–311. University Press of Colorado, Boulder.
- Dennett, Carrie L., Lorelei Platz, and Geoffrey G. McCafferty
2011 Preliminary Ceramic Compositional Analysis from the La Arenera Site, Pacific Nicaragua. *La Universidad: Órgano científico-sociocultural de la Universidad de El Salvador* 14:373–397.
- Dennett, Carrie L., Silvia Salgado, and Ronald L. Bishop
2019 Re-Evaluating Ceramic Economy at Ayala (A.D. 1–1250), Granada, Pacific Nicaragua. *Cuadernos de Antropología* 29(1):1–34.
- Donner, Natalia R., Alejandro Arteaga, Alexander Geurds, and Kaz van Dijk
2018 Caracterización inicial de los sitios arqueológicos en la subcuenca del río Mayales, Departamento de Chontales, Nicaragua. *Cuadernos de Antropología* 28(1):126.
- Donner, Natalia R., and Alexander Geurds
2018 The Valley of Juigalpa, Mayales River Subbasin Microregion (Chontales, Nicaragua). *Date List I. Radiocarbon*, 2018:1–10.
- Espinoza Perez, Edgar
1995 La Cerámica Temprana de Nicaragua y sus Vinculos Regionales. In *Descubrimiendo las Huellas de Nuestros Antepasados: El Proyecto "Arqueología de la Zona Metropolitana de Managua,"* edited by Frederick Lange, pp. 17–24. Alcaldía de Managua, Nicaragua.
- Espinoza Perez, Edgar, Humberto Leon Obando, Ligia Obando Garcia, Marling Vega Caceres
2023 *San Cristobal de Managua, Dos Mil Anos de Poblaciones Cultas (500 a.C.–1550 d.C.)*. Dirección Específica de Cultura y Patrimonio Histórico Municipal, Biblioteca Digital No. 275, Alcaldía de Managua, Nicaragua.
- Ford, James Alfred
1962 A Quantitative Method for Deriving Cultural Chronology. *Museum Brief* 9. University of Missouri Museum of Anthropology, Columbia, MO.
- Fowler, William R. Jr.
1989 *The Evolution of Ancient Nahua Civilizations: The Pipil-Nicarao of Central America*. University of Oklahoma Press, Norman.
- Geurds, Alexander
2017 Cronología Prehispanica en Centroamerica: Un acercamiento preliminar. In *Arqueología de Nicaragua: Memorias de Mi Museo y Vos*, edited by Nora Zambrana Lacayo, pp. 78–89. Mi Museo, Museo del Arte y Arqueología Precolombina, Granada, Nicaragua.
- Haberland, Wolfgang
1978 Lower Central America. In *Chronologies in New World Archaeology*, edited by Royal Ervin Taylor and Clement Woodward Meighan, pp. 395–430. Studies in Archaeology. Academic Press, New York.
- Haberland, Wolfgang
1986 Settlement Patterns and Cultural History of Ometepe Island, Nicaragua: A Preliminary Sketch. *Journal of the Seward Anthropological Society* 14(1982–1983):369–386.
- Haberland, Wolfgang
1992 The Culture History of Ometepe Island: Preliminary Sketch (Survey and Excavations, 1962–1963). In *The Archaeology of Pacific Nicaragua*, edited by Frederick W. Lange, Payson D. Sheets, Anibal Martinez, and Suzanne Abel-Vidor, pp. 63–118. University of New Mexico Press, Albuquerque.
- Hamilton, W. Derek, and Anthony M. Krus
2018 The Myths and Realities of Bayesian Chronological Modeling Revealed. *American Antiquity* 83(2):187–203.
- Hasegawa, Etsuo
2018 Excavaciones en el sitio Chilamatillo (N-Ma-8-100), Municipio de Tipitapa, departamento de Managua, Nicaragua. *Mi Museo y Vos* 33:24–37.
- Hasegawa, Etsuo, Jorge Zambrana, Mario Solano, and Orvin Zambrana
2019 Excavaciones en el sitio La Paz y Reconciliación, municipio de Tipitapa, departamento de Managua, Nicaragua. *Mi Museo y Vos* 34:2–29.
- Healy, Paul F.
1980 *Archaeology of the Rivas Region, Nicaragua*. Wilfred Laurier Press, Waterloo.
- Hoopes, John W.
1994 The Tronadora Complex: Early Formative Ceramics in Northwestern Costa Rica. *Latin American Antiquity* 5(1):1–30.
- Ibarra Rojas, Eugenia
2001 *Fronteras étnicas en la conquista de Nicaragua y Nicoya: Entre la solidaridad y el conflicto 800 d.C.–1544*. Editorial de la Universidad de Costa Rica, San José, Costa Rica.
- Ibarra Rojas, Eugenia
2021 Indigenous Peoples of Pacific Nicaragua and Nicoya in the Sixteenth Century: A Historical Approach. In *The Archaeology of Greater Nicoya: Two Decades of Research in Nicaragua and Costa Rica*, edited by Larry Steinbrenner, Alexander Geurds, Geoffrey McCafferty, and Silvia Salgado, pp. 47–66. University Press of Colorado, Boulder.
- Inomata, Takeshi
2017 The Emergence of Standardized Spatial Plans in Southern Mesoamerica: Chronology and Interregional Interactions Viewed

- from Ceibal, Guatemala. *Ancient Mesoamerica* 28(1):329–355. <https://doi.org/10.1017/S0956536117000049>.
- Inomata, Takeshi, Raúl Ortiz, Bárbara Arroyo, and Eugenia Robinson
2014 Chronological Revision of Preclassic Kaminaljuyú, Guatemala: Implications for Social Processes in the Southern Maya Area. *Latin American Antiquity* 25(4):377–408. doi: [10.7183/1045-6635.25.4.377](https://doi.org/10.7183/1045-6635.25.4.377).
- Lange, Frederick
1984 The Greater Nicoya Archaeological Subarea. In *The Archaeology of Lower Central America*, edited by Frederick W. Lange and Doris Stone, pp. 165–194. University of New Mexico Press, Albuquerque.
- Lange, Frederick
2021 The Managua Metropolitan Project: A Retrospective. In *The Archaeology of Greater Nicoya: Two Decades of Research in Nicaragua and Costa Rica*, edited by Larry Steinbrenner, Alexander Geurds, Geoffrey McCafferty, and Silvia Salgado, pp. 105–124. University Press of Colorado, Boulder.
- Lange, Frederick W. (editor)
1995 Descubriendo las Huellas de Nuestros Antepasados: El Proyecto “Arqueología de la Zona Metropolitana de Managua.” Alcaldía de Managua, Nicaragua.
- Lange, Frederick W. (editor)
1996 Abundante Cooperación Vecinal: La Segunda Temporada del Proyecto “Arqueología de la Zona Metropolitana de Managua.” Alcaldía de Managua, Nicaragua.
- Lechado, Leonardo, and Sagrario Balladares Navarro
2016 Dataciones Radiocarbónicas de Brito. *Fuente Estudios arqueológicos de Pre construcción del GCIN. II Fase*. Centro Arqueológico de Documentación e Investigación CADI – UNAN – MANAGUA.
- Lechado, Leonardo, and Sagrario Balladares Navarro
2019 *Nejapa: arquitectura en un poblado Prehispánico al suroeste de Managua*. UNAN, Managua.
- Lee, Sharen, and Christopher Bronk Ramsey
2012 Development and Application of the Trapezoidal Model for Archaeological Chronologies. *Radiocarbon* 54(1):107–122. https://doi.org/10.2458/azu_js_rc.v54i1.12397.
- Lothrop, Samuel K.
1926 *The Pottery of Costa Rica and Nicaragua*. 2 vols. Heye Foundation, Museum of the American Indian Memoir No. 8, New York.
- Manion, Jessica, and Geoffrey G. McCafferty
2017 Serpientes Emplumadas del Pacífico de Nicaragua. In *Arqueología de Nicaragua: Memorias de Mi Museo y Vos*, edited by Nora Zambrana Lacayo, pp. 302–308. Mi Museo, Museo del Arte y Arqueología Precolombina, Granada, Nicaragua.
- McCafferty, Geoffrey G.
2008 Domestic Practice in Postclassic Santa Isabel, Nicaragua. *Latin American Antiquity* 19(1):64–82.
- McCafferty, Geoffrey G.
2009 La Arenera, Nicaragua. <https://antharky.ucalgary.ca/mccafferty/miscellaneous/la-arenera-nicaragua>.
- McCafferty, Geoffrey G.
2015 The Mexican Legacy in Nicaragua, or Problems when Data Behave Badly. In *Constructing Legacies of Mesoamerica: Archaeological Practice and the Politics of Heritage in and Beyond Mexico*, edited by David S. Anderson, Dylan C. Clark, and J. Heath Anderson, pp. 110–118. *Archaeological Papers of the American Anthropological Association* Vol. 25.
- McCafferty, Geoffrey G.
2019 Mixteca-Puebla Style Ceramics from Early Postclassic Pacific Nicaragua. *Mexicon* XLI (3):77–83.
- McCafferty, Geoffrey G.
2021 Twenty Years of Nicaraguan Archaeology: Results of the University of Calgary Projects. In *The Archaeology of Greater Nicoya: Two Decades of Research in Nicaragua and Costa Rica*, edited by Larry Steinbrenner, Alexander Geurds, Geoffrey McCafferty, and Silvia Salgado, pp. 125–161. University Press of Colorado, Boulder.
- McCafferty, Geoffrey G., Fabio Esteban Amador, Silvia Salgado González and Carrie L. Dennett
2012 Archaeology on Mesoamerica’s Southern Frontier. In *The Oxford Handbook of Mesoamerican Archaeology*, edited by Deborah Nichols and Christopher A. Pool, pp. 83–105. Oxford University Press, Oxford.
- McCafferty, Geoffrey G., and Carrie L. Dennett
2013 Ethnogenesis and Hybridity in Proto-Historic Period Nicaragua. *Archaeological Review from Cambridge* 28(1):189–212.
- McCafferty, Geoffrey G., and Carrie L. Dennett
2017 El horizonte cerámico de engobe blanco del Postclásico Temprano de México y Centro América. In *Arqueología de Nicaragua: Memorias de Mi Museo y Vos*, edited by Nora Zambrana Lacayo, pp. 316–329. Mi Museo, Museo del Arte y Arqueología Precolombina, Granada, Nicaragua.
- McCafferty, Geoffrey G., and Sharisse McCafferty
2012 Ollas en forma de zapato tipo Sacasa Estriado: función y significado. *Mi Museo y Vos* 20:5–17.
- McCafferty, Geoffrey G., Oscar Pavón Sanchez and Ligia Galeano Rueda
2013 Preliminary Investigations at Sonzapote, Zapatera Island/Investigaciones Preliminares en Sonzapote, Isla Zapatera. *Mi Museo y Vos* 26:5–13.
- McCafferty, Geoffrey G., and Larry Steinbrenner
2005a The Meaning of the Mixteca-Puebla Stylistic Tradition on the Southern Periphery of Mesoamerica: The View from Nicaragua (with Larry Steinbrenner). In *Art for Archaeology’s Sake: Material Culture and Style across the Disciplines Proceedings of the 33rd Annual Chacmool Conference*, edited by Andrea Waters-Rist, Christine Cluny, Calla McNamee, and Larry Steinbrenner, pp. 282–292. The Archaeological Association of the University of Calgary, Calgary.
- McCafferty, Geoffrey G., and Larry Steinbrenner
2005b Chronological Implications for Greater Nicoya from the Santa Isabel Project, Nicaragua. *Ancient Mesoamerica* 16(1): 131–146.
- McCafferty, Geoffrey G., Andrea L. Waters-Rist, Sharisse McCafferty, Celise Fricker, and Jessica Manion
2021 Raising the Dead: Mortuary Patterns in Pacific Nicaragua. In *The Archaeology of Greater Nicoya: Two Decades of Research in Nicaragua and Costa Rica*, edited by Larry Steinbrenner, Alexander Geurds, Geoffrey McCafferty, and Silvia Salgado, pp. 395–432. University Press of Colorado, Boulder.
- McCafferty, Sharisse D., and Geoffrey G. McCafferty
2008 Spinning and Weaving Tools from Santa Isabel, Nicaragua. *Ancient Mesoamerica* 19(1):143–156.
- Mejía Ramón, Andrés G.
2023 La Transición Neolítica en el Sur de Centroamérica. *SocArXiv*. <https://doi.org/10.31235/osf.io/jhxcrc>.
- Moroney Ubeda, Bosco
2011 *Las Delicias: Poblado Indígena Mas Antiguo de Managua*. Dirección de Cultura y Patrimonio Histórico Municipal, Alcaldía de Managua, Nicaragua.
- Navarro Genie, Rigoberto
1993 Labor del Departamento de Arqueología (1980–85). In *30 años de arqueología en Nicaragua*, edited by Jorge Eduardo Arellano, pp. 19–21. Managua, Nicaragua: Museo Nacional de Nicaragua, Instituto Nicaragüense de Cultura.
- Neff, Hector
2023 C-14 confirma antigüedad de las huellas de Acahualinca: 7000 a 7500 a.p. *Sendero Ancestral* No. 4. Colección Leonor Martínez de Rocha. Managua.
- Neff, Hector, and Clifford T. Brown
2022 Informe Final: Proyecto Arqueológico Isla de Ometepe 2021. Manuscript submitted to the Dirección Nacional de Arqueología, May 24, 2022, Managua.
- Neff, Hector, Frederick W. Lange, Marty Kooistra, Carlos Caro, and Chad Rankle
2019 Sub-Tephra Archaeology and Geochemistry at La Arenera, Managua, Nicaragua Form a Record of Human Activity Before the Asososca Maar Eruption of 2130 B.P. *Geoarchaeology*. doi:[10.1002/gea.21733](https://doi.org/10.1002/gea.21733).
- Neff, Hector, Chad C. Rankle, Angel Marin-Flores, Edgar Espinoza Perez, Humberto León Obando, Ligia Obando, Heather Thakar, and Clifford T. Brown

- 2024 Arqueología y Volcanismo en la Cuenca del Lago de Xolotlán: Informe Técnico de La Temporada Junio y Julio 2023. Informe presented to the Nicaraguan Instituto de Cultura de los Pueblos y Juventudes, May 30, 2024.
- Niemel, Karen Stephanie
- 2003 Social Change and Migration in the Rivas Region, Pacific Nicaragua (1000 B.C.–A.D. 1522). PhD dissertation, Department of Anthropology, State University of New York, Buffalo.
- Niemel Garrard, Karen
- 2021 The Development of Social Complexity in the Rivas Region, Pacific Nicaragua. In *The Archaeology of Greater Nicoya: Two Decades of Research in Nicaragua and Costa Rica*; edited by Larry Steinbrenner, Alexander Geurds, Geoffrey G. McCafferty, and Silvia Salgado, pp. 162–192. University Press of Colorado, Boulder.
- Niemel, Karen S., Manuel A. Román Lacayo, and Silvia Salgado González
- 1998 Las secuencias cerámicas de los periodos Sapoá (800–1350 d.C.) y Ometepe (1350–1522 d.C.) en el Pacífico Sur de Nicaragua. In *XI Simposio de Investigaciones Arqueológicas en Guatemala, 1997*, edited by Juan Pedro Laporte and Héctor L. Escobedo, pp. 790–798. Museo Nacional de Arqueología y Etnología, Instituto de Antología e Historia, Ministerio de Cultura y Deportes y Asociación Tikal. Guatemala City.
- Norweb, Albert Holden
- 1964 Ceramic Stratigraphy in Southwestern Nicaragua. *Proceedings of the 35th International Congress of Americanists* No. 1, pp. 551–561. Mexico City.
- Orton, Clive, and Michael Hughes
- 2013 *Pottery in Archaeology*. 2nd ed, edited by G. Barker. Cambridge Manuals in Archaeology. Cambridge University Press, New York.
- Pardo, Natalia, Jose Luis Macías, Guido Giordano, Paola Cianfarra, Scolamacchia, Denis Avellán, and Fabio Bellatreccia
- 2009 The ~1245 yr BP Asososca Maar Eruption: The Youngest Event Along the Nejapa-Miraflores Volcanic Fault, Western Managua, Nicaragua. *Journal of Volcanology and Geothermal Research* 184:292–312.
- Pavón Sanchez, Oscar
- 2008 Rescate arqueológico del sitio Las Delicias, Managua. *Mi Museo y Vos* 7:4–6.
- Pavón Sanchez, Oscar
- 2009 Datos preliminares del sitio arqueológico Las Delicias. *Mi Museo y Vos* 8:8–9.
- Perez, Wendy, and Armin Freundt
- 2006 The Youngest Highly Explosive Basaltic Eruptions from Masaya Caldera (Nicaragua): Stratigraphy and Hazard Assessment. Geological Society of America Special Paper No. 412, pp. 189–407.
- Prüfer, Keith M., Mark Robinson, and Douglas J. Kennett
- 2021 Terminal Pleistocene through Middle Holocene Occupations in Southeastern Mesoamerica: Linking Ecology and Culture in the Context of Neotropical Foragers and Early Farmers. *Ancient Mesoamerica* 32:439–460. doi:10.1017/S0956536121000195.
- Rausch, Juanita, and Hans-Ulrich Schmincke
- 2010 Nejapa Tephra: The Youngest (c. 1 ka BP) Highly Explosive Hydroclastic Eruption in Western Managua (Nicaragua). *Journal of Volcanology and Geothermal Research* 192:159–177.
- Reimer, Paula J., William E. N. Austin, Edouard Bard, Alex Bayliss, Paul G. Blackwell, Christopher Bronk Ramsey, Martin Butzin, Hai Cheng, R. Lawrence Edwards, Michael Friedrich, Pieter M. Grootes, Thomas P. Guilderson, Irka Hajdas, Timothy J. Heaton, Alan G. Hogg, Konrad A. Hughen, Bernd Kromer, Sturt W. Manning, Raimund Muscheler, Jonathan G. Palmer, Charlotte Pearson, Johannes van der Plicht, Ron W. Reimer, David A. Richards, E. Marian Scott, John R. Southon, Christian S. M. Turney, Lukas Wacker, Florian Adolphi, Ulf Büntgen, Manuela Capano, Simon M. Fahrni, Alexandra Fogtmann-Schulz, Ronny Friedrich, Peter Köhler, Sabrina Kudsk, Fusa Miyake, Jesper Olsen, Frederick Reinig, Minoru Sakamoto, Adam Sookdeo, and Sahra Talamo
- 2020 The IntCal20 Northern Hemisphere Radiocarbon Age Calibration Curve (0–55 cal kBP). *Radiocarbon* 62.
- Román Lacayo, Manuel Antonio
- 2013 Social and Environmental Risk and the Development of Social Complexity in Precolumbian Masaya, Nicaragua. PhD dissertation, Department of Anthropology, University of Pittsburgh, Pittsburgh.
- Rowe, John Howland
- 1962 Stages and Periods in Archaeological Interpretation. *Southwestern Journal of Anthropology* 18(1):40–54.
- Salgado González, Silvia
- 1996a Social Change in the Region of Granada, Pacific Nicaragua (1000 B.C.–1522 A.D.). PhD dissertation, State University of New York, Albany.
- Salgado González, Silvia
- 1996b The Ayala Site: A Bagaces Period Site Near Granada, Nicaragua. In *Paths to Central American Prehistory*, edited by Frederick W. Lange, pp. 191–220. University Press of Colorado, Niwot.
- Salgado Gonzalez, Silvia, and Jorge Zambrana Fernandez
- 1994 El Sector Norte de Gran Nicoya: Nuevos Datos en la Provincia de Granada, Pacifico de Nicaragua. *Vínculos: Revista de Antropología del Museo Nacional de Costa Rica* 18–19(1–2):121–138.
- Schmincke, Hans-Ulrich, Steffen Kutterolf, Wendy Perez, Juanita Rausch, Armin Freundt, and Wilfried Strauch
- 2009 Walking through Volcanic Mud: The 2100-Year-Old Acahualinca Footprints (Nicaragua) I: Stratigraphy, Lithology, Volcanology and Age of the Acahualinca Section. *Bulletin of Volcanology* 71: 479–493.
- Shea, Thomas, Benjamin van Wyk de Vries, and Martin Pilato
- 2008 Emplacement Mechanisms of Contrasting Debris Avalanches at Volcan Mombacho (Nicaragua), Provided by Structural and Facies Analysis. *Bulletin of Volcanology* 70:899–921.
- Squier, Ephraim G.
- 1990[1853] *Observations on the Archaeology and Ethnology of Nicaragua*. Labyrinthos, Culver City.
- Stansell, Nathan D.
- 2013 Radiocarbon Ages for the Timing of Debris Avalanches at Mombacho Volcano, Nicaragua. *Bulletin of Volcanology* 75:686.
- Steinbrenner, Larry
- 2006 Cacao in Greater Nicoya: Ethnohistory and a Unique Tradition. In *Chocolate in Mesoamerica: A Cultural History of Cacao*, edited by Cameron L. McNeil, pp. 253–270. University Press of Florida, Gainesville.
- Steinbrenner, Larry
- 2010 Potting Traditions and Cultural Continuity in Pacific Nicaragua, A.D. 800–1350. Unpublished PhD dissertation, Department of Archaeology, University of Calgary, Calgary, Alberta.
- Steinbrenner, Larry
- 2021a Contact-Era Pacific Nicaragua Indigenous Groups and their Origins. In *The Archaeology of Greater Nicoya: Two Decades of Research in Nicaragua and Costa Rica*, edited by Larry Steinbrenner, Alexander Geurds, Geoffrey McCafferty, and Silvia Salgado, pp. 23–46. University Press of Colorado, Boulder.
- Steinbrenner, Larry
- 2021b Introduction. In *The Archaeology of Greater Nicoya: Two Decades of Research in Nicaragua and Costa Rica*, edited by Larry Steinbrenner, Alexander Geurds, Geoffrey McCafferty, and Silvia Salgado. University Press of Colorado, Boulder.
- Steinbrenner, Larry L., and Geoffrey G. McCafferty
- 2021 A Critical Re-Evaluation of Pacific Nicaragua's Late Period Chronology. In *The Archaeology of Greater Nicoya: Two Decades of Research in Nicaragua and Costa Rica*, edited by Larry Steinbrenner, Alexander Geurds, Geoffrey McCafferty, and Silvia Salgado. University Press of Colorado, Boulder.
- Vázquez Leiva, Ricardo, Frederick W. Lange, John W. Hoopes, Oscar M. Fonseca Zamora, Rafael González, Ana C. Arias Quirós, Ronald L. Bishop, Nathalie Borgnino, Adolfo Constenla Umaña, Francisco Corrales Ulloa, Edgar Espinoza Pérez, Laraine A. Fletcher, Juan Vicente Guerrero Miranda, Valerie Lauthelin, Dominique Rigat, Silvia Salgado González, and Ronaldo Salgado Galeano.

- 1994 Hacia futuras investigaciones en Gran Nicoya. *Vínculos: Revista de Antropología del Museo Nacional de Costa Rica* 18–19(1–2 [1992–1993]):245–277.
- Whisnant, David E.
1995 *Rascally Signs in Sacred Places: The Politics of Culture in Nicaragua*. University of North Carolina Press, Chapel Hill.
- Wilke, Sacha
2021 Exploring Technological Modifications: Variation of Non-Vessel “Objects” from El Rayo, Nicaragua. In *The Archaeology of Greater Nicoya: Two Decades of Research in Nicaragua and Costa Rica*, edited by Larry Steinbrenner, Alexander Geurds, Geoffrey McCafferty, and Silvia Salgado, pp. 312–330. University Press of Colorado, Boulder.
- Wyckoff, Lydia L.
1976 The Role of Northwestern Nicaragua in the Relations between Mesoamerica and the Greater Nicoya Sub-Area. Unpublished MA thesis, Department of Anthropology, Wesleyan University, Middleton.
- Wyss, Sue Bursey
1983 San Cristobal Archaeological Site, Managua, Nicaragua: Site Report and Preliminary Ceramic Analysis. MA thesis, Texas A&M University, College Station.
- Zambrana Fernández, Jorge
2012 *Estudios Arqueológicos en el Sitio “Los Martínez,” Sector el Pantanal—Managua*. Alcaldía, Managua, Nicaragua.