18 FOCUSING ON INDIVIDUAL WOODEN BUILDINGS REVEALS CHANGES IN THE LATE TO TERMINAL CLASSIC ECONOMY AT THE PAYNES CREEK SALT WORKS

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Preservation of wooden building posts in red mangrove (Rhizophora mangle) peat below the sea floor at the Paynes Creek Salt Works in southern Belize provides a rare opportunity to study pole and thatch buildings that were likely the dominant construction in the Maya area in prehistory. In 2020 and 2021, when field research at the salt works was not possible due to the covid pandemic, individual wooden buildings at two of the largest sites, Ek Way Nal and Ta'ab Nuk Na, were radiocarbon dated. The dates indicate that the buildings were constructed at different times. Associated artifacts reveal both residences and salt kitchens at both sites and that production began earlier at Ta'ab Nuk Na and ended later at Ek Way Nal. Identification of tree species used in building construction at Ek Way Nal indicates the salt workers selected useful trees and did not overuse the environment.

How did the Classic Maya Obtain Dietary Salt?

Although we know from where the Classic Maya obtained salt, the organization of production and distribution from various sources has been subject to debate. Salt was available from solar evaporation along the arid Yucatan coast of Mexico and the Pacific coasts of Guatemala, Mexico, and El Salvador. Boiling brine in pots over fires in salt kitchens was practiced at inland salt springs and along the coasts of Belize and the Pacific where rainfall precluded solar evaporation. Solar evaporation remains visible on the modern landscape along the Yucatan, with historic records of use underscoring long-term use for producing salt (Andrews 1983). By way of contrast, salt production sites along the coast of Belize are less visible in the modern landscape due to sea-level rise submerging coastal sites and growth of red mangroves in the shallow coastal shorelines. Brine boiling to make salt is clear at sites since it leaves briquetage—broken ceramic vessels and associated supports used to hold the pots over the fire to evaporate the brine. Typically, a dozen or more vessels are supported over a fire, with constant re-filling with brine until only salt remains in the pot (Reina and Monaghan 1981).

The view that brine-boiling is inferior as a production technique to solar evaporation is outdated, since the methods are suitable to rainy and arid environments, respectively. In rainy settings such as southern Belize, the use of salt kitchens for brine-boiling extends the seasonal use of this method beyond the dry season and provides a place to store fuel, brine, pots of loose salt, salt cakes, and pots broken to remove the salt cakes. Salt kitchens also protect the brine-boiling fires from wind and other weather. Tree species selection for building construction at Ek Way Nal from the Late to Terminal Classic periods is examined to investigate whether wood resources were being depleted over time, as suggested for Tikal (Lentz and Hocaday 2009).

Figure 1. Map of the Maya area Showing Sites mentioned in the text. (Map by Mary Lee Eggart, LSU).

Research Reports in Belizean Archaeology, Vol. 18, 2023, pp. 205-217.

In the Maya area, salt kitchens are known historically from inland salt springs at Sacapulas and other communities focused on salt production in the Maya highlands of Guatemala and Mexico (Reina and Monaghan 1981) and prehistorically from the Paynes Creek Salt Works (Figure 1; McKillop 2002, 2005, 2019, 2022; McKillop and Sills 2016, 2021, 2022a; Sills and McKillop 2018; Watson and McKillop 2019). Pole and thatch buildings also were likely used at salt production sites elsewhere along the coast of Belize but the wood has not preserved, making the Paynes Creek Salt Works a valuable model for interpreting brine-boiling at other sites (Figure 1; McKillop 2019, 2020). The Belize salt sites include Cerros, Northern River Lagoon and other lagoon sites north of Belize City, Marco Gonzalez and other sites on Ambergris Cay, Moho Cay, Watson's Island, and the Placencia Lagoon Salt Works.

Regional Trade of Salt

A model of regional production and distribution of salt would have fulfilled the needs of the Classic Maya (McKillop 2019). Daily consumption rates for salt vary depending on a person's level of physical activity, the heat and humidity, and the amount of salt in food (McKillop 2002). The addictive quality of salt may have served to ensure the ancient Maya consumed enough of this biological necessity. Using an estimate of 6 grams/ person/ day of dietary salt, a total of 15,000 tons of salt was needed for five million Maya during the Classic period (McKillop 2019). Salt yields from historic records from solar evaporation on the Yucatan coast indicate 20,000 tons were produced per year (Andrews 1983). Reina and Monaghan's ethnographic study of a salt-making family at Sacapulas documented that they produced an estimated six tons per year of salt. Using the Sacapulas data as a model, estimates were made that the Paynes Creek salt kitchens produced from 60 to 600 tons of salt per year, based on 10 to 100 salt kitchens under use. Extending the salt yields the brine-boiling from Sacapulas to other salt works along the coast of Belize indicates 480 to 4800 tons of salt was produced at just seven of the salt works. Together with the inland salt springs at Salinas de los Nueve Cerros, Sacapulas, and elsewhere in the highlands, production and trade of salt within regions in the Maya area was possible (McKillop 2019).

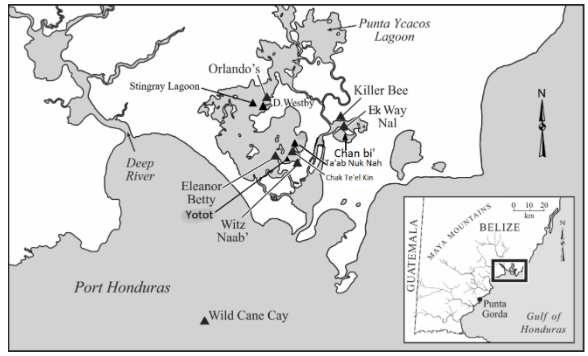

Figure 2. Map of Punta Ycacos Lagoon showing sites mentioned in the text, with insert showing location in southern Belize (Map by Mary Lee Eggart, LSU).

How was Salt Production Organized?

A new field project was initiated in 2019 by the authors to excavate large underwater sites at the Paynes Creek Salt Works to look for variability in activities, in order to evaluate how salt production was organized to meet inland salt needs. Two large underwater sites, Ek Way Nal and Ta'ab Nuk Na, were selected for excavations of each of the 10 pole and thatch buildings (Figure 2). Research was focused on determining if production was controlled by local salt workers or by inland elite who controlled seasonal workers, perhaps with inland overseers to manage the production and/or distribution of salt. The two contrasting explanations would produce different archaeological correlates: Residences would be expected for local workers living at the salt works who produced salt as part of surplus household production, similar to families at the Sacapulas salt works. In contrast, overseers' residences and storage facilities might be expected for inland control of production or distribution of the coastal salt.

A variety of different activities associated directly or indirectly with salt making, were expected in the pole and thatch buildings and the open areas at the salt works (McKillop and Sills 2021: Table 4). Salt kitchens were excavated previously at Site 74 (Potok Site), providing a template for archaeological correlates of activities (McKillop and Sills 2016). High abundance of briquetage was expected inside and along the exterior walls of the salt kitchen, as at Sacapulas, where broken pots were stored along the inside walls and later discarded outside the buildings. Briquetage comprised 98% of the artifacts at Site 74, with a few distinctive Warrie Red water jar sherds and Belize Red serving bowl sherds. Manos and metates may be expected at salt kitchens or salt workers' nearby residences, since corn meal was used in the salt production process. At Sacapulas, the interior of pottery vessels is coated with corn meal before the brine is added and boiling begins, in order to prevent the salt from adhering to the pot. Earlier in the production process at Sacapulas, when salty water is poured over raised containers of salty soil to catch the enriched, saltier water in a jar below, the brine is judged to be salty enough when a small ball of corn meal floats in the enriched brine.

Enriching the salt content of brine before it is boiled is common worldwide where the brine-boiling method is used, in order to reduce the evaporation time and amount of wood fuel used. Evidence for brine enrichment is found at the Eleanor Betty and Witz Naab' sites at the Paynes Creek Salt Works. A wooden canoe was found between two lines of palmetto palm posts, raised by wooden stakes, at the Eleanor Betty site (McKillop et al. 2014). A large clay funnel was found below the canoe, evidently used to channel enriched brine into a container below the canoe (Figure 3). Excavations at one of the earthen mounds at Witz Naab' revealed it consisted mainly of soil that was interpreted as a slag heap for brine enrichment (Watson et al. 2018; Watson and McKillop 2019). Earthen mounds are a common feature on the salt production landscape at the Placencia Lagoon Salt Works farther north (Sills 2016).

Referring again to Sacapulas, once the brine was evaporated and the pots were full of loose salt, it was either stored in large jars along the wall or further hardened over the fire to make salt cakes for trade at regional markets. The pots were broken to remove the salt cakes at Sacupulas, with the broken pots stored along the inside walls of the salt kitchen and then periodically discarded outside the salt kitchen along the exterior of the building. Abundant broken pots at Ek Way Nal and other Paynes Creek Salt Works would be an archaeological correlate of breaking pots to remove the salt cakes. This practice was also typical of other salt works by salt springs in the

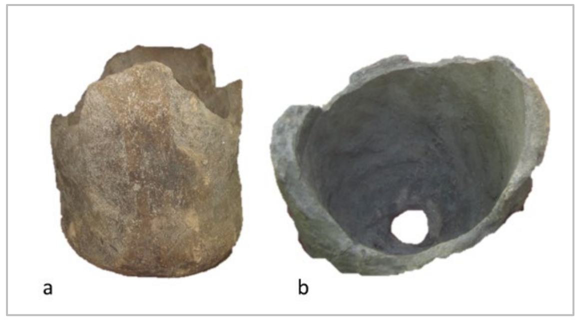

Figure 3. Side and interior views of clay funnel from under the canoe used to hold salty soil for brine enrichment at the Eleanor Betty Site. (Photo by H. McKillop).

Maya highlands of Guatemala and Mexico and forms a model for the Paynes Creek Salt Works (McKillop 2021). In contrast, Andrea Yankowski's (2010) ethnoarchaeological field research at traditional salt works in the Philippines revealed that the salt cakes remained in their pots for transport and trade inland.

The expectations at the Paynes Creek Salt Works for trade of salt cakes in their pots would be a shortage of vessels in comparison to the vessel supports and other briquetage at the salt kitchens and the presence of discarded salt-making pots at consumer sites. Cynthia Robin and colleagues (2019) interpret thousands of tiny sherds near the main plaza at Aventura in northern Belize as the remains of pots broken on site after the transport of salt cakes in the pots from coastal production sites.

Trade of salted fish is common world-wide associated with salt production and was likely undertaken at the Paynes Creek Salt Works as well. Marilyn Masson (2004) suggested that catfish were salted and transported inland from the salt works at Northern River Lagoon. She found an excess of catfish head bones in contrast to fewer post-cranial elements in middens at the site. On the central coast of Belize, Elizabeth Graham (1994) interpreted cut tuna vertebrae as evidence of cutting and spaying fish to dry for inland trade. The absence of bone at the Paynes Creek Salt Works may be attributed to the acidic red mangrove peat that destroys material composed of calcium carbonate, including bone and temper in the pottery.

Archaeological correlates of residences would include a diversity of pottery shapes suitable for cooking, eating, and serving, storing water, and other uses, as well as a variety of other

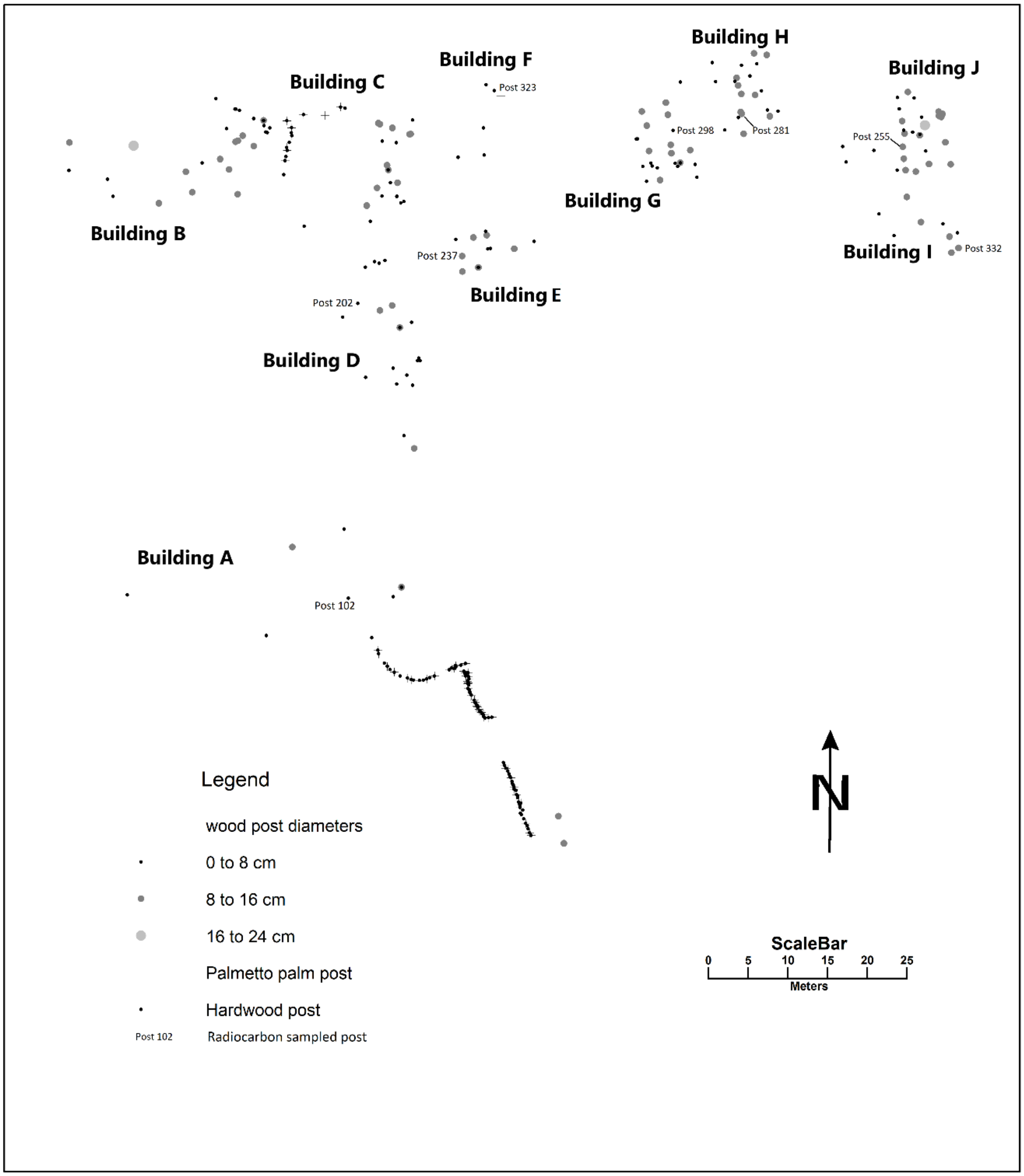

Figure 4. Map of wooden building posts at Ek Way Nal. (map by H. McKillop).

goods and food for a household. Briquetage would not be expected at residences, except in limited quantities if the pots were made at home for use in the salt kitchens. At Sacapulas, the brine boiling pots were made outside the salt workers' homes and carried to the salt kitchens. The pots were dried in the sun and not in a kiln.

Woodworking was a common activity at the Paynes Creek Salt Works. Pottery making paddles such as the one found at Chac Te'el Kin (McKillop 2019: Figure 6.5), the rosewood handle for the jadeite gouge at Ek Way Nal (McKillop 2019: Figure 6.11), canoe paddles from Ka'ak' Naab (McKillop 2005) and other sites (McKillop 2019: Figures 6.14-6.15); McKillop and Sills 2016), and the canoe from the Eleanor Betty site (McKillop et al. 2014), indicate wood working was a common activity.

Chert stone tools, including one from Ek Way Nal, were identified as cutting and whittling wood (McKillop and Aoyama 2018). Stone tools were also needed for cutting building posts, beams, and other wood and for sharpening the ends of posts that were driven into the ground during building construction. Black and white mangrove wood was selected from the immediate environs of Ek Way Nal, but other trees were selected from farther away, including the deciduous forest on the south side of the Deep River (McKillop and Sills 2022b). Some of the stone tools were made from high-quality northern Belize chert with styles similar to those made at the chert tool-manufacturing site of Colha. The Colha stone tools were distributed to sites in northern Belize, but water transport along the Caribbean likely facilitated their transport to southern Belize to Wild Cane Cay and to the Paynes Creek Salt Works.

The Pole and Thatch Buildings at Ek Way Nal: Their Ages and Uses

Wooden posts were discovered at Ek Way Nal during flotation survey by a team systematically traversing back and forth on Research Flotation Devices (RFDs) and marking the location of posts on the sea floor. The post locations were marked by survey flags in shallow water and in deeper water by fishing floats tied to fishing line held in the sea floor with wire. The posts were individually mapped using a total station from a datum of poured concrete with a 2” PVC pipe embedded in the cement (Figure 4).

Associated artifacts also were individually flagged and mapped in order to identify activities associated with buildings and outdoor spaces (McKillop and Sills 2021). A date on the rosewood handle from the jadeite gouge (McKillop et al. 2019) found beside post 252 which also was dated, indicate a Late Classic age.

Although the footprint of some of the buildings was obscured by mangrove accretion since the time the site was abandoned, several buildings reveal a rectangular shape, notably Buildings G, H, I, and J (Figure 2; McKillop and Sills 2021: Figure 6). Posts included palmetto palm (*Acoelorraphae wrightii*) and various species of hardwoods. Some palmetto palm posts were found as isolated posts in buildings with the majority forming a long line of posts at the south end of the site near Building A.

Figure 5. Wooden post with sharpened base and worm-eaten top where the post protruded above the sea floor, Building C (N 3 M, E 0 M) at Ek Way Nal. (Photo by H. McKillop).

The wooden posts protruding from the sea floor form the walls of buildings that appear to be contemporaneous, but that observation derives from the even deposition of mangrove peat as sea-level rose after the salt works were abandoned. The wooden building posts were spectacularly preserved below the sea floor in the mangrove peat, but not in the water above. The jagged top of worm-eaten posts barely protruded, if at all, above the sea floor. Few complete posts were excavated during survey or excavation, so their depth below the sea floor is unknown. However, in some cases, the posts were buried over a meter below the sea floor.

This depth resembles the depth posts for modern pole and thatch buildings in traditional Maya villages are driven into the ground (Wauchope 1938). In some cases, the complete posts less than 50 cm in length were excavated, showing the sharpened base (Figure 5).

Radiocarbon Dating Building Construction

Radiocarbon dating a wooden post from each of the 10 buildings at Ek Way Nal indicated that they were not contemporaneous. The posts were driven into the ground during building construction. Studies of modern Maya pole and thatch buildings indicate posts were driven into the ground to various depths (Wauchope 1938). However, only the lower portions of the posts were preserved in the mangrove peat that formed the sea floor and extended to over 4 M below (McKillop et al. 2010). The peat was deposited as sea-level rose, creating a level sea floor and obscuring the different construction dates for the buildings. Wood above the sea floor at Ek Way Nal decayed, leaving worm-eaten tops of posts barely protruding from the sea floor.

The Ek Way Nal buildings were constructed over four phases (Figures 6-7; McKillop and Sills 2021). Buildings B and G were constructed first, in Phase 1, dated from A.D. 650 to 700, during the early part of the Late Classic or Tepeu 1. Building J has a radiocarbon date ranging from A.D. 680 to 980, with the A.D. 680 to 770 referred to as Phase 2, in the Late Classic Tepeu 2. Buildings A, C, D-F, and H date to the end of the Late Classic and through the Terminal Classic Phase 3, from A.D. 770 to 900. Building I dates to the early part of the Early Postclassic period, from A.D. 900 to 1000.

Building Use Over Time

The spatial patterning of artifacts mapped on the sea floor indicates that some buildings were salt kitchens, but others were residences, or were used for fish and/or meat processing (Figure 8; McKillop and Sills 2021). Buildings B, E, and G were identified as salt kitchens by the abundance of briquetage. Fish and/or meat was processed at Buildings A and C as identified by use-wear on the edges of chert tools (McKillop and Aoyama 2018). The diversity of pottery and other artifacts associated with Buildings F and J suggested they were residences. Buildings D and H were not assigned functions since few artifacts were recovered from the sea-floor survey in those areas.

Combining building use and dates indicates the earliest buildings at Ek Way Nal were used for salt production in Phase 1 during the Late Classic. Processing fish and/or meat was added to salt production sometime from the end of the Late Classic through the Terminal Classic. The salt workers had residences at the salt works at that time. The earliest construction at Ek Way Nal included salt kitchens at Buildings B and G in Phase 1 at the beginning of the Late Classic. Most of the buildings were constructed in Phase 3, sometime from the end of the Late Classic

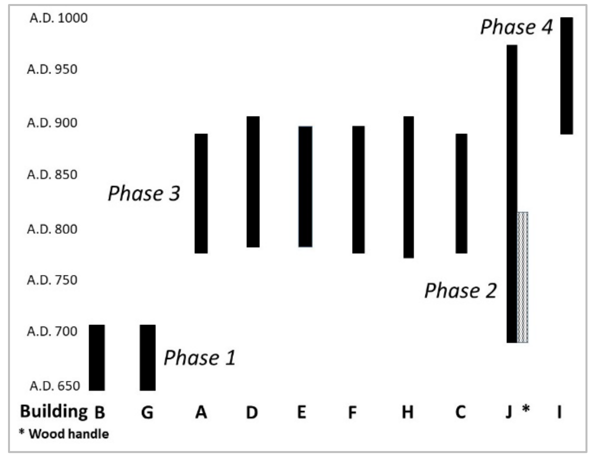

Figure 6. Graph showing four phases of building construction at Ek Way Nal from radiocarbon dated building posts and the rosewood handle from the jadeite gouge. (Figure by H. McKillop).

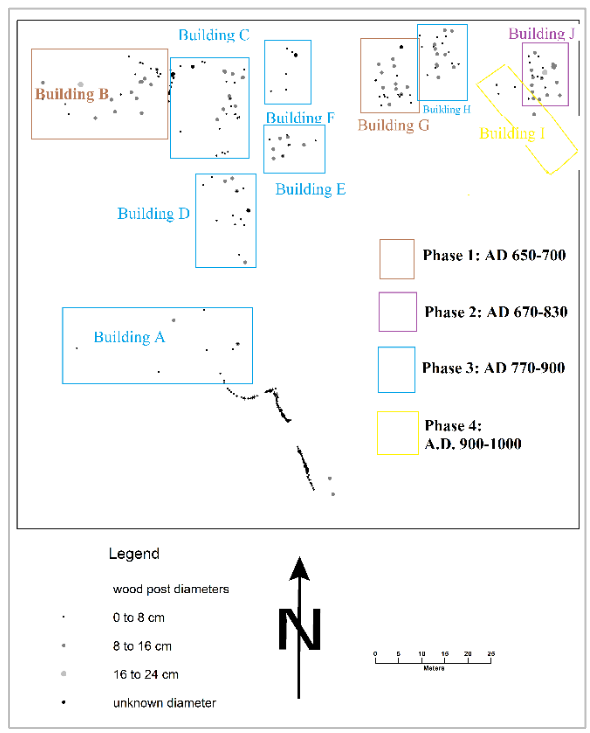

Figure 7. Map of posts at Ek Way Nal showing buildings by construction phase. (Map by H. McKillop).

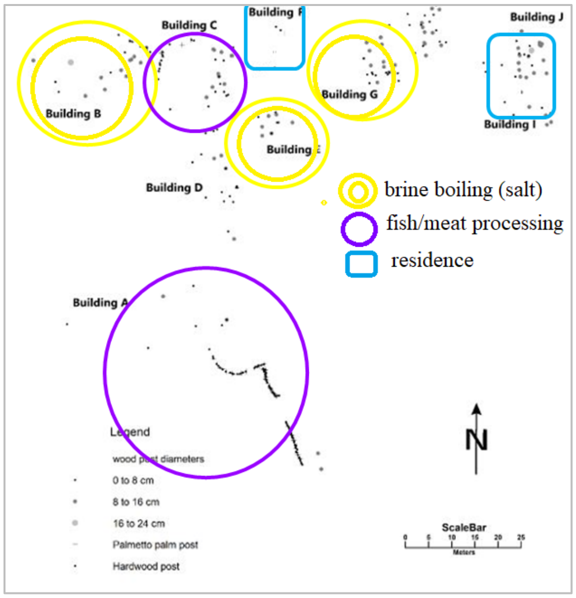

Figure 8. Map of wooden posts at Ek Way Nal showing building uses suggested by artifacts mapped on the sea floor. (Figure by H. McKillop).

through the Terminal Classic periods. Phase 2 included Building J as a residence. The jadeite gouge with a rosewood handle was found by post 252 in the southwest corner of the building. Use-wear analysis was inconclusive to the function of the gouge, although the tightly-woven grains (which gave the translucent green appearance) indicate it was a durable material (McKillop et al. 2019). Phase 3 included processing fish and/or meat in Buildings A and C, as well as salt production in Building E. Phase 4 includes Building I of unknown function from the sea-floor material.

Dating Individual Buildings at Ta'ab Nuk Na

After radiocarbon dating individual pole and thatch buildings at Ek Way Nal, the same process was carried out for Ta'ab' Nuk Na, idincating it too was a multicomponent site. The site has 10 pole and thatch buildings indicated by 500 mapped wooden posts. Pottery, stone tools, and wooden artifacts were individually mapped using a total station, following sea-floor survey and flagging of posts and artifacts embedded in the sea floor (McKillop and Sills 2022a). Radiocarbon dating indicated the first construction was Buildings H and F in Phase 1, from the end of the Early Classic to the beginning

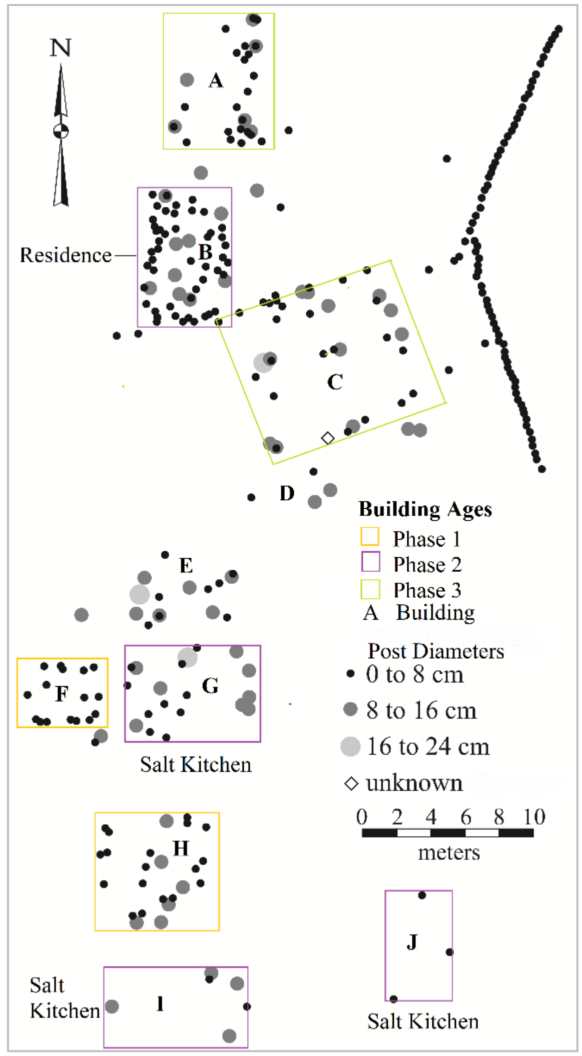

Figure 9. Map of wooden posts at Ta'ab Nuk Na showing age and use of buildings. (Map by H. McKillop).

of the Late Classic. Building H was interpreted as a salt kitchen on the basis of briquetage.

Most of the buildings were constructed in Phase 2, during the Late Classic, between A.D. 650 and 780. Three salt kitchens were identified by briquetage, including Buildings G, I, and J. Building B was identified as a residence on the basis of a diversity of pottery, stone tools, and wood objects. Buildings A and C were constructed in Phase 3, between A.D. 760 and 900, which includes the later part of the Late Classic.

Tree Selection for Late to Terminal Classic Maya Buildings

Tree species from the radiocarbon-dated buildings at Ek Way Nal were evaluated to discover whether tree species and habitat selection of trees for building construction changed from the Late to the Terminal Classic, when inland cities were abandoned. Species identification has not yet been carried out for the Ta'ab Nuk Na posts. Overuse of the forest is suggested at Tikal, where wooden lintels from temple buildings indicated a change to less desirable wood overtime (Lentz and Hockaday 2009). Clearing rainforest to expand slash and burn farming in order to provide sufficient food for the increasing populations in the Late Classic (A.D. 600-800) may have increased soil erosion and depleted soil nutrients, resulting in a reduction of productive land, as explained by a pollen core at Copan (Abrams and Rue 1988). However, other cores indicate a continuity of forest cover from the Late to Terminal Classic at Copan, including Copan (McNeil 2012; McNeil et al. 2012).

Wood post samples from Ek Way Nal were kept in water, first to desalinate them, and subsequently to maintain the wood structure which would deteriorate if the wood was allowed to air dry. Identification of wood species was aided by modern comparative wood collections, wood slides, and by digital images and descriptions of diagnostic traits of wood structure. A variety of tree species were selected for building construction, including palmetto palms and hard woods.

Ancient Landscape and Habitat Selection of Trees for Buildings

The landscape of the salt works was a mangrove ecosystem comprised of red mangroves (*R. mangle*), black mangroves (*Avicennia germinans*), white mangrove (*Laguncularia racemose*), and buttonwood (*Conocarpus erectus*) in the Late and Terminal Classic periods (McKillop et al. 2010). Ek Way Nal and the other salt works were on dry land along the low-lying margins of the salt water lagoon system. The sites were submerged by sea-level rise and are currently underwater from depths ranging from a few cm to over 2 m in various arms of the lagoon system (McKillop 2019: Figure 4.7). Red mangroves grow along the shoreline of the lagoon and in the water, since they are adapted to high salinity. Black mangroves are on mudflats inland from the shoreline, also in areas of high salinity. White mangroves and buttonwood are farther inland. Palmetto palms grow in dense stands on dry land farther back from the lagoon as well as in scattered clumps on the savanna. All three mangrove species are prolific and grow in large stands in the lagoon system, although high salinity at Ek Way Nal in particular has dwarfed the height of the red mangroves (McKillop 2019: Figure 5.1). Buttonwood is an isolated tree scattered along the shoreline. Tropical broadleaf rainforest trees are available nearby, south of the Deep River, as well as in isolated locations on dry land near the salt works (McKillop and Sills 2022b; Robinson and McKillop 2013: Figure 4).

The ancient Maya at Ek Way Nal selected trees from the mangrove ecosystem surrounding Ek Way Nal, from the dry land on the coast, and from the broadleaf forest west of the nearby Deep River (Figure 2). These habitats were easily accessible from Ek Way Nal by boat. The extensive savannah, dominated by grass, with scattered clumps of pine, oak, and sandpaper trees, was not used for extraction of wood for building construction, despite its proximity to the salt works. Trees were cut and transported to Ek Way Nal for building posts, with the ends each sharpened to a point to dig into the ground. Recovery of a wooden canoe from the Eleanor Betty Site (McKillop et al. 2014), a complete canoe paddle from Ka'ak Naab' site (McKillop 2005), and paddle blade pieces from the Potok and Elon sites (McKillop 2019), document canoe transport was available, not only for transporting salt cakes, but also for moving building posts, palm thatch, and other goods and resources.

Wood carving tools

Tools were needed both to fell trees and to chip the ends of each post before they were driven into the ground during construction of the pole and thatch buildings. Tools also were needed for making small objects including the rosewood handle of the jadeite tool from Building J (McKillop et al. 2019). Use-wear analysis by Kazuo Aoyama indicated some chert stone tools from the Paynes Creek Salt Works were used for

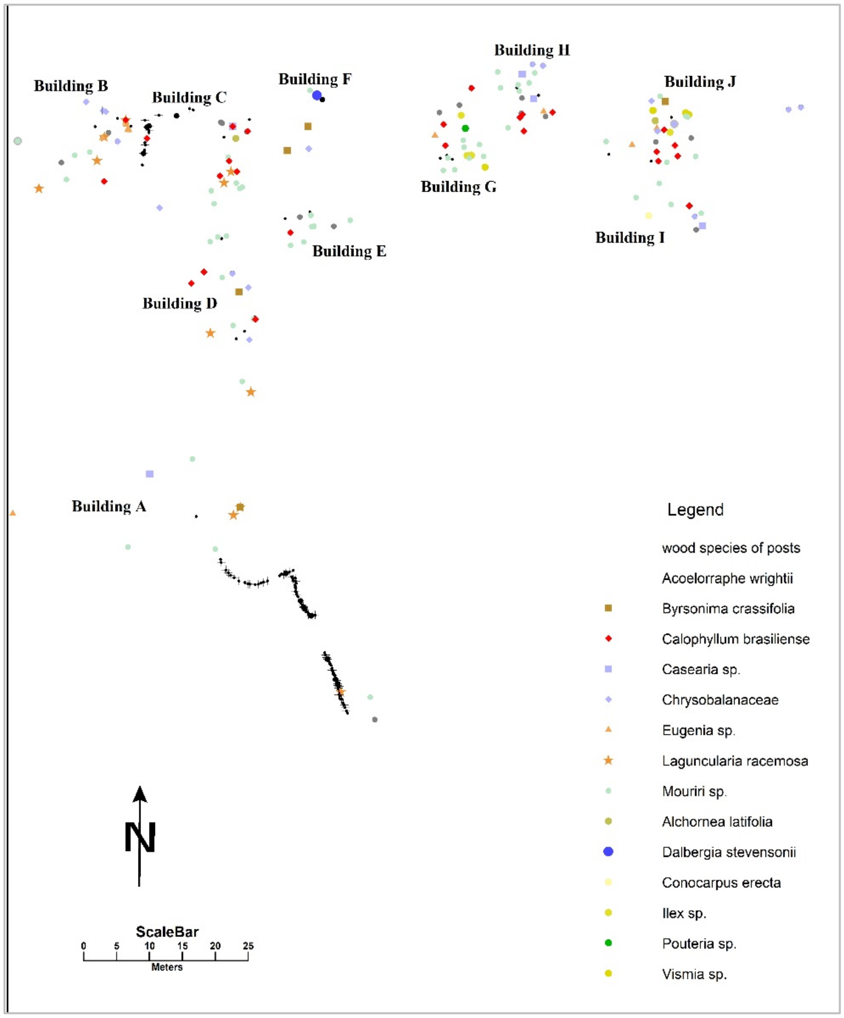

Figure 10. Number of trees by habitat for each phase at Ek Way Nal. (Figure by H. McKillop).

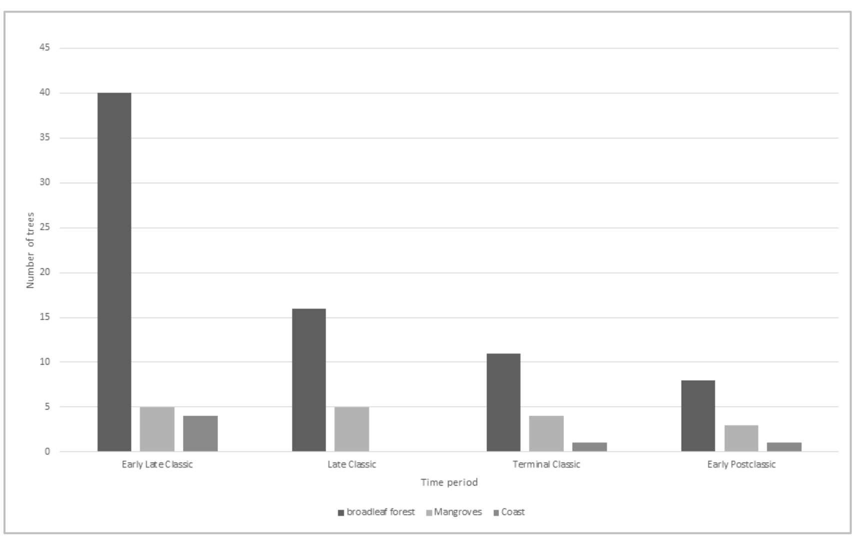

Figure 11. Tree species of wooden posts identified from Ek Way Nal. (Map by H. McKillop).

Table 1. Number of posts of different species for pole and thatch building construction by Phase at Ek Way Nal. Late Classic Phase 1 (A.D. 650-720); Late Classic Phase 2 (A.D. 680-880); Terminal Classic Phase 3 (A.D. 780-920); Early Postclassic Phase 4 (900-1000). (Chronology from McKillop and Sills 2021: Table 1 and Figure 7).

		Phase and Building										
		1	1	2	3	3	3	3	3	3	4	
		B	G	J	A	C	D	E	F	H	I	
Tree Species	**Habitat**											Total #
Concarpus erectus	Mangrove ecosystem										1	1
Laguncularia racemosa	Mangrove ecosystem	4			3	2	2					11
Avicennia germinans	Mangrove ecosystem		1							1		2
Calophyllum brasiliense	Tropical broadleaf forest	2	3	5		6	3	1		3	1	24
Dalbergia sp.	Tropical broadleaf forest								1			1
Pouteria sp.	Tropical broadleaf forest		1									1
Ilex sp.	Tropical broadleaf forest		3	1								4
Vismia sp.	Tropical broadleaf forest		1	3								4
Eugenia sp.	Tropical broadleaf forest	3	1	1	2					1	1	9
Aceoloraphea wrightii	Coastal woodland and tropical broadleaf forest	1			55	11			1			68
Byrsonima crassifolia	Coastal woodlands			1			1		2			4
Caesaria sp.	Coastal woodlands				1	1				2	1	5
CHRYSOBALANCEAE	Coastal woodlands	4								2	1	7
Total		14	10	11	61	20	5	1	4	9	5	140

woodworking, including one chert tool from Ek Way Nal (McKillop and Aoyama 2018). A lenticular biface from Late Classic Building B at Ek Way Nal was used for whittling and cutting wood (McKillop and Aoyama 2018: Figure 4 a).

Temporal Changes in Tree Species Selection

There were changes in the tree species selected over time, but there is no evidence of overexploitation of the rainforest or selection of lower quality species over time (Figures 10-11; Table 1). Red mangrove wood was not used for building construction at Ek Way Nal, perhaps due to high salinity limiting growth as occurs today. White mangrove wood was used for buildings in Phases 1 and 3, whereas black mangrove wood was used for buildings in phase 1 (Table 1; Figures 3-5). One buttonwood post was identified from Phase 4. Most of the palmetto palm posts are associated with the phase 3 Building A. Hardwood species from the broadleaf forest south of the Deep River were common, with Santa Maria (*Calophyllum brasiliense*) used throughout the sequence. One rosewood post (*Dalbergia sp.*) from Phase 3 and one sapote (*Pouteria sp.*) from Phase 1 were used for building. Mouriri sp. is popular throughout the building sequence, being the dominant tree species selected for building construction at Ek Way Nal. The coastal woodland of dry land along the sea includes crabbo (*Byrsonima crassifolia*), and plums (*Caesaria sp.* and CHRYSOBALANCEAE) over the course of construction.

Tree species for building posts from each of the 10 pole and thatch buildings reported here, shows that wood selection by the householders at Ek Way Nal was similar during the Late to Terminal Classic periods, indicating the Maya managed the forest resources well. Some nearby trees in the mangrove ecosystem, notably black and white mangroves and buttonwood, were cut for building posts. Red mangrove was not selected, despite its ubiquity in the immediate mangrove landscape, which may be due to the high salinity limiting growth. White mangrove was used in the Late and Terminal Classic whereas black mangrove was used in the Late Classic and buttonwood in the Early Postclassic. Hardwood species were cut and hauled from the rainforest west of the Deep River, including Santa Maria, rosewood, and others. Rosewood was used for carving small objects, including the handle for the jadeite gouge from Building J (McKillop et al. 2019), as well as objects from other sites at the Paynes Creek Salt Works. Evidence from wood selection at Ek Way Nal indicates little variation or no overuse of the resources over time in the availability of resources—negating the idea of a generalized view of over exploitation as a causal reason for the abandonment of southern lowland cities.

Chronology of Salt Production

Radiocarbon dating individual buildings at Ek Way Nal and Ta'ab Nuk Na indicates both sites are multi-component, with the peak of salt production earlier at Ta'ab Nuk Na. Most of the buildings at Ta'ab Nuk Na were constructed during Phase 2 in the Late Classic. In contrast, most of the buildings at Ek Way Nal were constructed during Phase 3 in the Terminal Classic. Salt production took place from the end of the Early Classic, throughout the Late and Terminal Classic and during the first part of the Early Postclassic (Figure 12).

This research underscores the importance of radiocarbon dating each pole and thatch building at the salt works in order to evaluate production capacity of this dietary necessity. The research also shows the value of individually mapping artifacts and posts on the sea floor at the underwater sites in order to interpret building use. Using Sacapulas salt works as a model from which to develop archaeological correlates fits with Ta'ab Nuk Na and suggests the Maya living permanently at the community were engaged in surplus household production of salt that was well integrated in the regional economy, allowing them to acquire a variety of nonlocal goods. Although the salt industry at the Paynes Creek Salt Works depended on wood fuel, species identification of wooden building posts from Ek Way Nal from the Late to Terminal Classic periods indicates the salt workers managed the forest and did not overuse these resources.

Acknowledgements Field work was possible by permits and encouragement from the Belize government Institute of Archaeology. Field work was funded by National Science Foundation grant 0513398 to McKillop, as well as support from Louisiana State University. Radiocarbon dating of wood posts was funded by NSF grant 1826653 to McKillop and Sills. The field team included Bretton Somers, Mark Robinson, Amanda Evans, John Young, and the authors. We appreciate the assistance of Michael Wiemann with setting up the lab for wood species identification and for his assistance. Wood species identifications for Ek Way Nal were by Mark Robinson. We appreciate the encouragement and friendship of Tanya Russ and John Spang—our host family at Village Farm, as well as Celia Mahung and Toledo Institute for Development and the Environment that co-manages Paynes Creek National Park with the Belize government, and friends and enthusiasts from Punta Gorda.

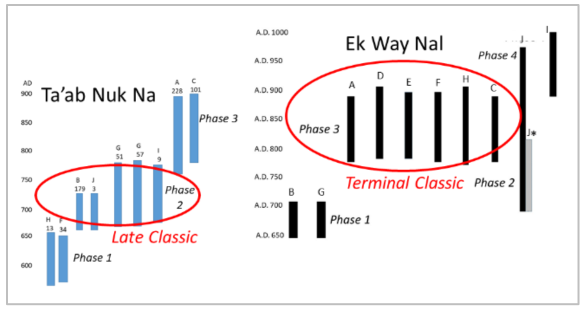

Figure 12. Comparison of the Radiocarbon Chronology of Building Construction at Ta'ab Nuk Na and Ek Way Nal. (Figure by H. McKillop).

References Cited

Andrews, Anthony P.
1983 *Maya Salt Production and Trade*. University of Arizona Press, Tucson.

Graham, Elizabeth A.
1994 *The highlands of the lowlands: Environment and archaeology in the Stann Creek District, Belize, Central America*. Monographs in World Archaeology 19. Washington, D.C.: Prehistory Press.

Lentz, David and Brian Hocaday
2009 Tikal Timbers and Temples: Ancient Maya Agroforestry and the End of Time. *Journal of Archaeological Science* 36: 1342-1353.

Masson, Marilyn A.
2004 Fauna exploitation from the Preclassic to the Postclassic periods at four Maya settlements in northern Belize. In *Maya Zooarchaeology: New Directions in Method and Theory*. K. F. Emery ed., pp. 97-122. Monograph 51. Los Angeles: Cotsen Institute of Archaeology, University of California at Los Angeles.

McKillop, Heather
2002 *Salt: White Gold of the Ancient Maya*. Gainesville: University Press of Florida.

2005 Finds in Belize document Late Classic Maya Salt Making and Canoe Transport. *Proceedings of* *the National Academy of Sciences* 102: 5630-34. doi.org/10.1073/pnas.0408486102

2019 *Maya Salt Works*. Gainesville: University Press of Florida.

2020 The Belizean Coast in Ancient Maya Society. *Research Reports in Belizean Archaeology* 17: 179-187.

2021 Salt as a Commodity or Money in the Classic Maya Economy. *Journal of Anthropological Archaeology* 62. https://doi.org/10.1016/j.jaa.2021.101277

2022 Surplus Household Salt Production in the Classic Maya Economy. In *Seven Millennia of Saltmaking: 3rd International Congress on the Anthropology of Salt*. Edited by Alberto Plata Montero, pp. 530-548. Colección Valle Salado de Añana, Vol. 3.1. Funcadión Valle Salado de Añana, Spain.

McKillop, Heather and Kazuo Aoyama
2018 Salt and marine products in the Classic Maya economy from use-wear study of stone tools. *Proceedings of the National Academy of Sciences* 115:10948-52. https://doi.org/10.1073/pnas.1803639115

McKillop, Heather, George Harlow, April Sievert, Michael Wiemann, and C. Wayne Smith.
2019 Demystifying jadeite: underwater Maya discovery at Ek Way Nal, Belize. *Antiquity* 93: 502–18. https://doi.org/10.15184/aqy.2019.35

McKillop, Heather and E. Cory Sills
2016 Spatial patterning of salt production and wooden buildings evaluated by underwater excavations at Paynes Creek Salt Work 74. *Research Reports in Belizean Archaeology* 13: 229-237.

2021 Briquetage and Brine: Living and Working at the Ek Way Nal Salt Works, Belize. *Ancient Mesoamerica* https://doi:10.1017/S0956536121000341

2022a Late Classic Maya Salt Workers' Residence Identified Underwater at Ta'ab Nuk Na, Belize." *Antiquity*, https://doi.org/10.15184/aqy.2022.106.

2022b Tree Selection for Late to Terminal Classic Maya Buildings at the Ek Way Nal Saltworks, Belize. *CLAAS Notes* 2: 15-24.

McKillop, Heather, E. Cory Sills, and Vincent Cellucci
2014 The ancient Maya canoe paddle and the canoe from Paynes Creek National Park, Belize. *Research Reports in Belizean Archaeology* 11: 297–306.

McKillop, Heather, E. Cory Sills, and Jessica Harrison
2010 A Late Holocene Record of Caribbean Sea-Level Rise: The K'ak' Naab' Underwater SiteSediment Record, Belize." *ACUA Underwater Archaeology Proceedings* 2010: 200–207.

McNeil, Cameron L.
2012 Deforestation, Agroforestry, and Sustained Land Management Practices Among the Classic period Maya. *Quaternary International* 249: 19-30.

McNeil Cameron L, Burney D. A. and L. Pigott-Burney
2010 Evidence Disputing Deforestation as the Cause for the Collapse of the Ancient Maya Polity of Copan, Honduras. *Proceedings of the National Academy of Science* 107:1017–1022.

Reina, Ruben E. and John Monaghan
1981 The Ways of the Maya: Salt Production in Sacapulas, Guatemala. *Expedition* 23:13–33.

Robin, Cynthia, Kacey Grauer, Zachary Nissen Laura Kosakowsky, and Kat Fitzgerald
2019 "Aventura in northern Belize context: Challenging traditional narratives of ancient Maya civilization through the results of the 2017 Field Season." *Research Reports in Belizean Archaeology* 16: 27-236.

Robinson, Mark E. and Heather I. McKillop
2013 Ancient Maya Wood Selection and Forest Exploitation: A View from the Paynes Creek Salt Works, Belize. *Journal of Archaeological Science* 40: 3584-3595.

Sills, E. Cory
2016 "Re-evaluating the ancient Maya salt works at Placencia Lagoon, Belize." Mexicon 38 (3): 69-74.

Sills, E. Cory and Heather McKillop
2018 Specialized salt production during the ancient Maya Classic period at two Paynes Creek salt works, Belize: Chan b'i and Atz'aam Na. *Journal of Field Archaeology* 43: 457-471.

Watson, Rachel and Heather McKillop
2019 A filtered past: Interpreting salt production and trade models from two remnant brine enrichment mounds at the ancient Maya Paynes Creek Salt Works, Belize. *Journal of Field Archaeology* 44: 40–51.

Wauchope, R.
1938 *Modern Maya houses*. Carnegie Institution of Washington Publication 502. Washington: Carnegie Institution.

Yankowski, Andrea
2010 Traditional Technologies and Ancient Commodities: An Ethnoarchaeological Study of Salt Manufacturing and Pottery Production in Bohol, Central Philippines. In *Salt Archaeology in*

China, Volume 2: Global Comparative Perspectives. Eds. Shiseng Li and Lothar von Falkenhausen, pp. 161-81. Beijing: Science Press.