# 25 ASSESSMENT OF THE SHELL MIDDEN AT THE ELEANOR BETTY SALT WORK, BELIZE

*Valerie Feathers and Heather McKillop*

*The underwater site of Eleanor Betty is part of a network of Classic period (A.D. 300-900) salt production sites located along the coast of southern Belize (Feathers et al. 2017; McKillop 2002, 2005a; McKillop and Sills 2017). Most of these sites lay under 0.5 to 1.5 m of water due to sea-level rise. An inundated shell deposit was discovered during the 2011 field season. The deposit was excavated by the authors during the 2013 field season to assess the nature of the deposit (cultural or natural) and to determine the use of the shell (ritual or dietary). The midden was located between16-30 cm below the sea-floor and extended both inside and outside of the underwater wooden structure. The shells were exported to Louisiana State University for macroscopic and microscopic analyses. Approximately 3,979 fragments were identified as* Crassostrea rhizophora. *A total of 198 minimum number of individuals (MNI) of* Crassostrea rhizophora *were present. Evidence for predation was determined using the Height-Length Ratio (HLR) for complete shells. Butcher marks were analyzed and assigned to classes based on their break patterns.*

## Introduction

Analyses of a large underwater marine shell deposit were carried out to evaluate the role of shell at the Eleanor Betty Site, one of the Paynes Creek Salt Works, in southern Belize (Feathers et al. 2017; McKillop 2005a, 2017a, 2017b; McKillop and Sills 2016, 2017). Shell remains frequently are recovered from coastal and inland Maya sites. However, only a few shell middens have been excavated, including Cancun (Andrews et al. 1975), Moho Cay (McKillop 1984, 2004), Frenchman's Cay (McKillop and Winemiller 2004), Butterfly Wing (McKillop 1996, 2005b: 141), the Eleanor Betty site (Feathers et al. 2017), and five Paynes Creek Salt Works in deep water (McKillop 2017a). Analyses of the Eleanor Betty shell deposit focused on evaluating if the deposit was natural or cultural, whether there was evidence of modification as artifacts, and whether there were butchering marks indicating the shells were collected for food.

## Importance of Marine Shell in the Maya Area

Lange (1971) hypothesized that the Classic period inland population of the northern Yucatán and Belize was larger than what could be supported by agriculture. He argued that the exploitation of marine resources and the preservation of marine fish for inland trade increased the nutritional quality of the inland diet. Although lacking evidence of nutritional quality of the inland diet, Lange's hypothesis of inland transport of seafood continues to be evaluated.


**Figure 1**. Map of Maya area with sites mentioned in the text.

The coastal Maya traded marine shells to inland communities for ritual and food (Figure 1). Excavations at Isla Cancun revealed that thousands of shells had been butchered for subsistence purposes, including *Strombas gigas*

*Research Reports in Belizean Archaeology*, Vol. 15, 2018, pp. 275-285.

(queen conch) and *Melongena corona* (crown conch; Andrews 1969: 57, 58). Abundant *Strombas gigas* shells from Tancah, a coastal site along the western coast of the Yucatán just north of Belize, suggest marine exploitation for export as well as local consumption (Miller 1977). Remains of *Dinocardium r. vanhyningi* (cockle shells) excavated at Dzibilchaltun were used for food (Andrews 1969: 59).

*"Working" Shell for Trade and Utilitarian Use*

Marine shells were modified to make jewelry, scrapers, and other items for coastal and inland use. Microwear analysis of stone tools and the presence of an incised shell in Structure 4A, indicates shell manufacturing at Pook's Hill, Belize (Stemp et al. 2010) and at Aguateca, Guatemala (Emery and Aoyama 2007; Inomata et al. 2002). At Aguateca, marine shell ornaments were made using chert flakes, bifacial thinning flakes, oval bifaces, bifacial points, and obsidian prismatic blades.

Leaders of the Chan community were involved in the production of *Strombus* shell beads and other shell ornaments (Robin et al. 2014). Marine shell ornaments may have been produced by members of the royal family or attached specialists at Copan (Aoyama 1995). Evidence for the elite control of marine shell production and trade was found at Piedras Negras and Aguateca (Sharpe and Emery 2015). Several thousand marine mollusks were recovered from the primary center of Aguateca, whereas only four shells were recovered from Punta de Chimino, a secondary center located downstream from Aguateca. Elite caches contained more marine mollusks than other caches at Aguateca and Piedras Negras, suggesting the elite controlled the distribution of marine items to the secondary centers.

Evidence for non-dietary use of marine shells also can be found at coastal sites. Shells were carved into tinklers and discs for non-utilitarian purposes at the trading ports of Wild Cane Cay and Moho Cay (McKillop 2004:269, 2005b: Figure 6.32). Gastropods from Moho Cay were used as scrapers, sinkers, whorls, gorgets, beads, hammers, and as cutting tools (McKillop 1984:30-32). Queen conch remains, along with a large amount of worked and unworked shells from Ek Luum on Ambergris Caye, Belize, indicated that Ek Luum was a processing station where shells were prepared for inland trade (Shaw 1995). Few shells at Ek Luum exhibit breaks indicative of meat removal. The absence of breaks could indicate inland trade for consumption or trade of a non-manufactured shell for ritual purposes. Worked shells were recovered from other locations on Ambergris Cay, including shells cups from Ek Luum, San Juan, and Chac Balam as well as tinklers, pendants, and beads (Garber 1995:126-133, 135).

*Coastal-Inland Maritime Trade: Ritual and Status*

The most common instances of coastal-inland trade of marine shells occur in the archaeological record with the recovery of *Spondylus* shells. Elite households excavated at Tikal (Moholy-Nagy 1963), Caracol (Teeter 2004), and Aguateca (Emery and Aoyama 2007; Inomata et al. 2002) revealed *Spondylus* shells. Over 30 marine shell species were recovered from Chichén Itzá (Cobos 1989). The abundance of shell remains suggests a reliance on local shell.

Excavations at Lubaantun uncovered the remains of a worked queen conch used to produce shell-disc blanks along with other marine shells (Wing 1975). Excavations at Altun Ha, Belize, revealed caches with a *Spondylus* disc and tubular shell beads, a *Spondylus* notched pendant, and *Oliva* beads, as well as many other shell adornments (Pendergast 1979). Remains of pendants made from *Spondylus americanus* and tinklers made from *Oliva sayana* were recovered from Dzibilchaltun (Andrews 1969 54:55). *Spondylus* shells were included as grave offerings in Structure10L-26 tomb at Copan (Beaubien 2004).

Kidder et al. (1946:145) reported that "shell formed part of the mortuary furniture in every tomb…" at Kaminaljuyu. Shell remains included *Spondylus*, *Oliva*, *Olivella*, and *Marginella* shells in the form of trumpets, tinklers, and pendants. *Spondylus* shells, a carved *Strombus* shell, and unidentified shell "teeth" from a jadeite mask were recovered from the burial of Yukom Yich'ak K'ak at Calakmul (Vargas et al. 1999). Other sites where marine shell has been recovered from inland burials included Pacbitun (Healy 1990), Caledonia (Healy et al. 1998), Bats'ub Cave (Prufer and Dunham 2009), Dos Pilas (Emery 2008), Buenavista del Cayo (Yaeger et al. 2015), Chan (Robin et al. 2014), and Lamanai (Pendergast 1981). Shells were used as jewelry, music, tools, or musical instruments (Chase 1981; McKillop 1984, 1996:59, 2004: 269; 2005b: Figure 6.32).

**Ancient Maya Shell Middens**

Marine shells were important to the coastal and inland ancient Maya for food, tools, and ornaments. Marine shells have been recovered from shell middens and construction fill at coastal sites, in burials and caches at coastal and inland sites, and in household refuse deposits (Andrews 1969; McKillop 1984, 2005b; McKillop and Winemiller 2004; Pendergast 1992). Few ancient Maya shell middens have been excavated (Andrews et al. 1975; Feathers et al. 2017; McKillop 1984, 1996, 2005b:36, 37, 39, 141; McKillop and Winemiller 2004).

Mollusks were an integral part of the coastal Maya diet. Isla Cancun, a Preclassic Maya settlement in Quintana Roo, Yucatán, had a large midden containing a variety of marine remains, including 6,547 shells, from 99 species (Andrews 1969; Andrews et al. 1975). About 28.6% of the midden was comprised of queen conch (Andrews et al. 1975:186-187).

Shells recovered from Frenchman's Cay were analyzed to provide an in-depth look at the diet and landscape of the Maya who occupied the site (McKillop and Winemiller 2004). Three mounds are present on Frenchman's Cay – Great White Lucine, Crown Conch, and *Spondylus*. Excavations indicated Frenchman's Cay was a Late Classic to Early Postclassic site (A.D. 600-1000; McKillop 2005b). Fifty-eight genera of shell were recovered for a total of 2,785 shells with a weight of 13,528.46 g. Ninety-eight species, including *Isognomon alatus* and *Crassostrea rhizophorae* (mangrove oysters), and 1,315 minimum number of individuals (MNIs) were identified. Butchering for meat removal was indicated by the presence of a circular hole in the spire of queen conch shells. Almost all species recovered were edible and likely contributed to the coastal diet (McKillop and Winemiller 2004).

A large midden was discovered on the northern end of Moho Cay near Belize City (McKillop 1984). The midden contained predominately marine shells and manatee bones, but also pottery sherds, broken chert, obsidian, as well as the remains of deer, shark, and green turtle (McKillop 1984, 2004). Small holes for meat removal were found near the muscle attachment point of the Queen Conch shells recovered from the site.

Marine shell at the trading port of Wild Cane Cay included abundant shells from midden deposits, as well as modified shell from burials (McKillop 2005b). An infant burial from Fighting Conch mound included a carved *Spondylus* shell disk (McKillop 2005b: Figure 6.32a). A carved *Melongena* shell disk was found in a Late Classic burial in household middens (McKillop 2005b: Figure 4.8).

Butterfly Wing is a Protoclassic (75 B.C – A.D. 400) shell midden located by the mouth of the Deep River in southern Belize (McKillop 1996, 2002:11; McKillop et al. 2004:349). *Strombus pugilis, Crassostrea rhizphophora,* and *Isognomon alatus shells* dominated the shell midden, all edible species. The recovery of a *Strombus gigas* celt indicates the ancient Maya at Butterfly Wing also were using the sea as a resource for utilitarian items (McKillop 1996:59).

In an attempt to categorize marine resource use and trade, Andrews (1969:41) divided shell remains into two categories. The first concerns shells from coastal middens, which would have been used for local consumption and perhaps for meat extraction for inland trade, whereas the second focuses on shells at inland sites, which were not used for subsistence purposes, but rather for ritual events. He suggests that sites close to the coast, such as Dzibilchaltun, imported shell for ritual and as a food delicacy.

**The Eleanor Betty Shell Deposit**

An underwater shell deposit was unexpectedly discovered at the Eleanor Betty site during excavations in 2011(Aucoin 2012; Feathers et al. 2017). Excavations were carried out in 2013 to map the extent of the shell deposit, to evaluate if the deposit was natural or cultural, and to analyze the shells for evidence of butchering for food or modification as artifacts. The sediment was expected to be alkaline and preserve bone, since shells have calcium carbonate ($CaCo_3$).

Four transects were added north and south of the 2011 Transect to define the extent of the shell deposit (Feathers et al. 2017). A total of 19 new units were excavated in 10 cm levels to a depth of 30 cm below the sea floor. The shell deposit was mapped and excavated separately from the rest of the unit. Transect 6, Unit 3-4 m, was excavated in two-centimeter levels from 16 cm to 30 cm depth due to the concentration of shells. Two-centimeter levels were possible because most of the shells were broken and small. The deposit was compact with little sediment. A wall of Transect 4 was cleaned to see the depth of the deposit (Figure 2). The presence of charcoal, ceramics, and briquetage above, within, and below the shell deposit indicates it was associated with the Eleanor Betty salt works. Shell was exported under permit to the Archaeology Lab at Louisiana State University (LSU) for further study.

*Laboratory Methods*

The minimum number of individuals (MNI) and the number of individual species present (NISP or fragments), weight, presence/absence of butcher marks, and height-length ratio (HLR) for human predation were determined for the recovered shell, following methods used by other researchers (Andrews et al. 1975; Claassen 1998; Kent 1988; McKillop and Winemiller 2004). The MNI assessment used a trait unique to the shell, in this case the umbone (the raised protuberance located posteriorly to the hinge on a bivalve shell; Figure 3) and counting the number of umbones on one side of the shell.

All shells were included in the counts for NISP. Weights for the shell were obtained using a Delta Range® Mettler PE 3600 electronic balance in the Archaeology Lab at LSU. A plastic container was used to hold the shell on the scale during the weighing process. Shell weight can vary according to the environmental setting. For example, a shell of one taxa found in less acidic soil has more calcium carbonate

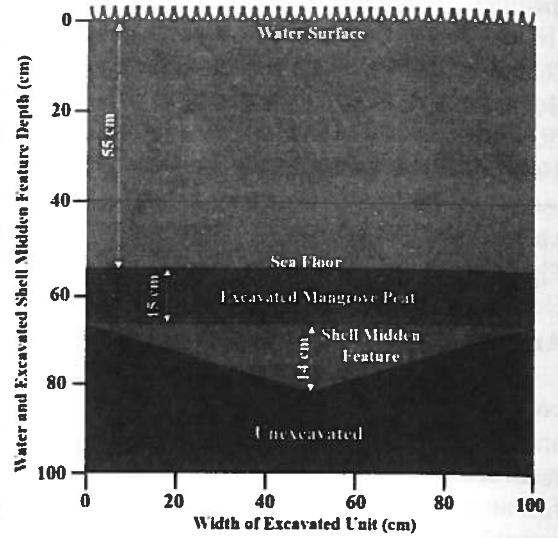


**Figure 2.** Schematic profile drawing of shell midden excavation. Drawing by V. Feathers.

**Figure 3.** Photograph of Crassostrea rhizophora from the Eleanor Betty site. The circle indicates the umbone. Photo by V. Feathers.

than that of the same taxa of shell from more acidic soil. Thus, the weight of the shells will be different. Shells were counted and sorted by species in the lab at LSU, in the field, and at the field base camp in Belize. Complete right and left umbones were used to obtain an MNI count. The umbones were sorted by side.

Measurements of the shell height (maximum dorsal-ventral) and shell length (anterior-posterior) were converted into height-length rations (HLR) to assess predation and

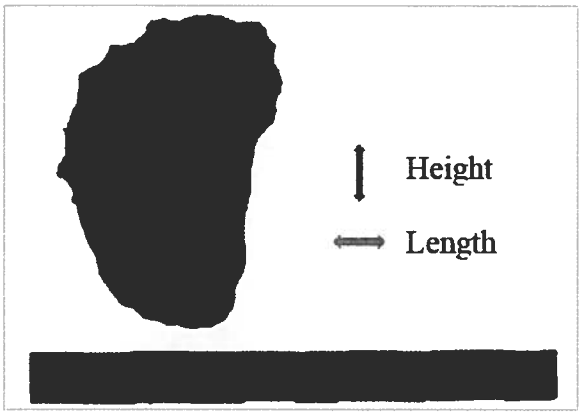


**Figure 4.** Measurements for Height-Length Ratio. Orange line represents height. Blue line represents length. Photo by V. Feathers.

identify if the shell deposit at Eleanor Betty was a multiple or one-time deposit (Gunter 1938; Kent 1988:28; Figure 4). Archaeologists use shell size to determine the impact of human predation and meat yield. Shell size is also determined by age and can be substituted for age. The height-length ratios for both complete right and left valves were obtained by dividing the height by the length. Only shells with a complete umbo, ventral, anterior, and posterior margins were used. Measurements were obtained with sliding calipers.

Butcher marks were identified and classified into six categories: 1) L-shaped, 2) V-shaped, 3) horizontal break, 4) vertical break, 5) slanted break, and 6) notched break based on Kent's (1988) methods for opening oysters (Figure 5). There are several opening methods which result in the different break patterns. The first method involves heating, steaming, or boiling the oyster to easily open the valves and cook the meat. This method does not leave a butcher mark on the shell. The second method is stabbing. A blade-like object is forced between the valves along the posterior margin in order to cut the abductor muscle. A U-shaped notch usually forms parallel to the muscle scar on the margin of the shell as a result. Marks of this nature are classified as "notched" (Category 6). The third method, hammering, involves striking the oyster. A hammer stone is used to lightly strike the shell valve above the abductor muscle. This impact stuns the oyster, allowing the harvester to open the valves and retrieve the meat. A small abrasion mark is usually located on the valve as a result of hammer stone use. The cracking method involves breaking the ventral edge of the shell in order to remove the meat with a blade. A hammer stone is usually employed with this method. This method results in a straight break along the ventral margin. Categories 1-5 could be a result of the cracking method.

*Results*

Approximately 4,733 shell fragments weighing 2,304.24 g were recovered from the excavated units. Eighty-three percent (n=3,933) of the recovered shell were associated with the shell midden. The most abundant species was *Crassostrea rhizophora* (n=3,979), red mangrove oysters, which form beds along the roots of red mangroves in intertidal, brackish waters beside the underwater site. Transect 6, Unit 3-4 m contained the most oysters (n=3,204).

Assessment of the right and left umbones of *C. rhizophora* resulted in an MNI of 198 shells (198 left, 64 right). A total of 57 left valves and 43 right valves was measurable (complete; Table 1). Seventy of the 100 complete valves had complete dorsal-ventral and anterior-posterior margins and were used for HLR measurements. The average for the left and right valves was 1.89 cm and 1.87 cm, respectively. The maximum HLR was 2.84 cm for the left and 2.92 cm for the right. The minimum was 1.22 cm for the left and 1.35 cm for the right. The range was 1.62 cm for the left and 1.57 cm for the right. The standard deviation was 0.34 cm for the left and 0.33 cm for the right. Twenty-four of the 100 shells could be measured for length and not height. Six could be measured for height but not length.

Butcher marks were present for 57 of the 198 shells assessed for MNI. The most abundant break was a notch (n=17; Figure 5, Table 2). No hammer stone abrasions were observed. However, the outside layer of the shell was fragile and flaking, which may have obscured the hammer stone scar. The notch marks could have resulted from the use of a tool, such as a piece of chert, inserted parallel to the abductor muscle in order to open the shells and collect the meat. The cracking method appears to be the most employed method for opening

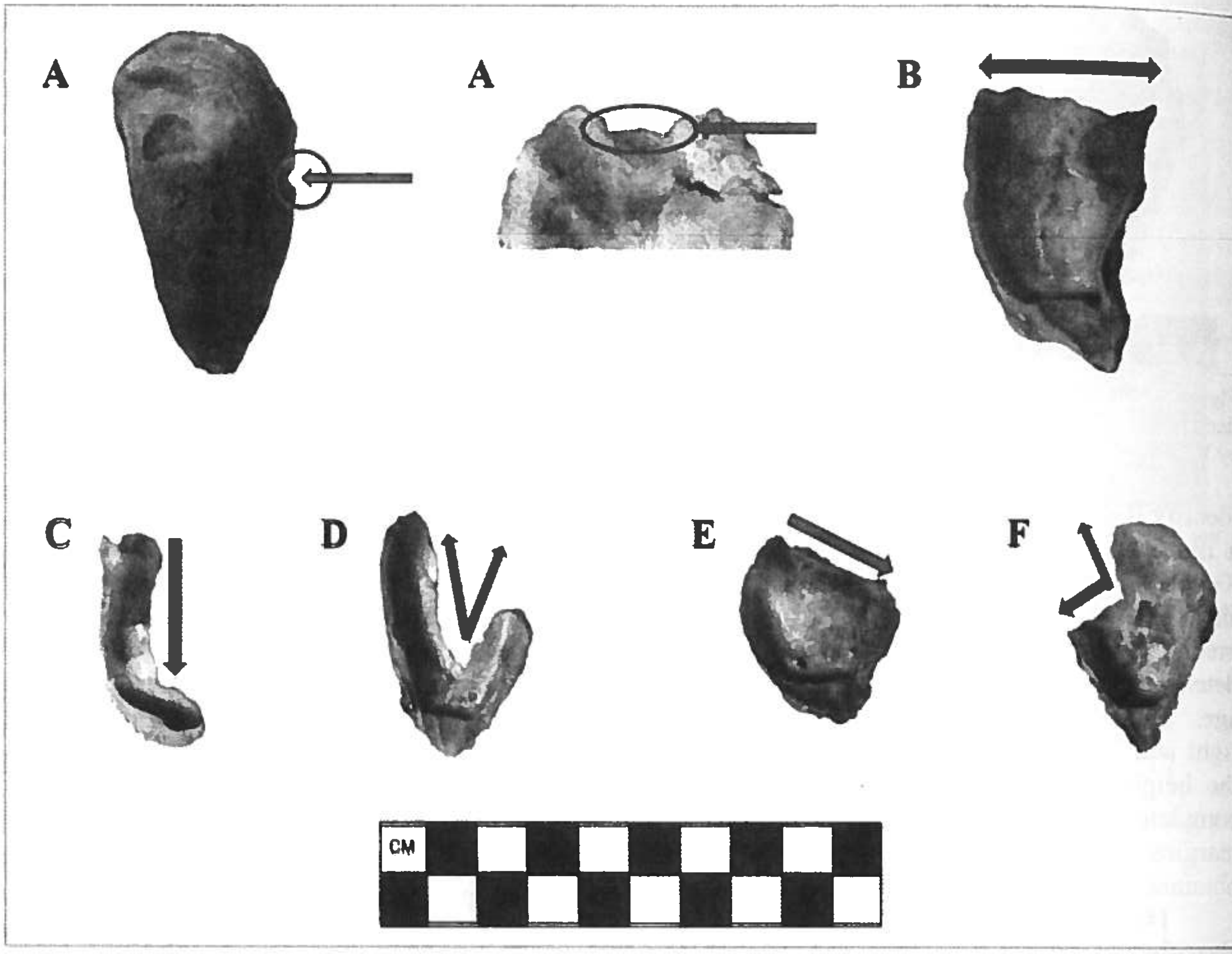


**Figure 5**. Photos of break patterns on Eleanor Betty *Crassostrea rhizophora* shells based on Kent (1988). A) Notch; B) Horizontal; C) Vertical; D) V-Shape; E) Slanted; and F) L-shape.

**Table 1**. Height-Length Ratio (HLR) Measurements for Shell from all Excavations.

| | Height cm | Length cm | Left | Right | HLR left cm | HLR right cm |
|---|---|---|---|---|---|---|
| Total # | | | 57 | 43 | | |
| Minimum | 2.66 | 1.19 | | | 1.22 | 1.35 |
| Maximum | 7.7 | 3.78 | | | 2.84 | 2.92 |
| Average | 4.69 | 2.47 | | | 1.89 | 1.87 |

**Table 2**. Classification of *C. rhizophora* break patterns from the Eleanor Betty Shell Midden.

| Break Pattern | Number Present | Processing Method |
|---|---|---|
| L-shaped | 14 | Cracking |
| V-shaped | 6 | Cracking |
| Horizontal Line | 8 | Cracking |
| Vertical Line | 10 | Cracking |
| Notch | 17 | Stabbing |
| Slanted | 2 | Cracking |

shells based on the vertical, horizontal, V-shaped, and L-shaped breaks. If these breaks are considered as one class, then this combination would result in the most abundant break pattern (n=38).

**Discussion**

The shell midden was determined to be a cultural midden for several reasons. An abundance of briquetage (3,721 g) and charcoal (6,248.48 g) was found intermixed with the deposit. No human remains and only two unidentified animal bones were recovered during excavations. However, the absence of skeletal material is not surprising since Eleanor Betty was a salt production workshop. There is no evidence the shells were used as jewelry, music, tools, or musical instruments as seen at other Maya sites (Chase 1981; McKillop 1984, 1996:59, 2004a 269; 2005b: Figure 6.32). Approximately 55% of the recovered shell was located within the shell midden feature (Transect 6, Unit 3-4 m).

Based on the height-length ratio averages for the left and right valves, the oysters for Eleanor Betty are bed oysters (Kent 1988). The average salinity for *C. rhizophora* habitats is 7.2 to 28 practical salinity units (PSU). Growth can occur in areas with 0 PSU to 40 PSU (Galstoff 1964; Nascimento 1991). The underwater environment is ideal for growth and harvesting of mangrove oysters. The Eleanor Betty site is in an intertidal, brackish area surrounded by red mangroves that have *C. rhizophora* oysters growing on the prop roots in the water.

Shell height and length were measured to determine if there was evidence of overharvesting. If the measurements showed a large difference in the average height-length ratio, then this difference would suggest the salt makers were regularly harvesting, and possibly over-harvested, the oysters. The shells would not have matured into adulthood, resulting in a difference of shell height and length throughout the midden. Alternatively, if the average HLR measurements do not differ, then human predation by the salt makers likely did not occur. The HLR measurements showed no major differences as the averages were 1.87 cm and 1.89 cm for the right and left, respectively, indicating a lack of predation by humans.


**Figure 6**. Porosity of Crassostrea rhizophora shell due to predation by sponges, mud conchs, oyster bores, and/or barnacles from the Eleanor Betty 2013 excavations.

However, several shells were porous in appearance, suggesting predation by animals such as sponges, mud conchs, oyster borers, or barnacles (Galstoff 1964; Kent 1988; Figure 6).

Although the shell midden was small compared to other shell middens, several of the shells had butcher marks. The butcher marks indicate the shells were used for food. A hammer stone likely was used to open the shells. The pressure of the hammer stone would have broken the ventral edge of the shell and "stunned" the oyster (Kent 1988). The salt makers would have removed the meat for consumption at this point. Although butcher marks are clear evidence of modification for subsistence, heat also may have been used to open the oysters.

The shell midden may have been part of a ritual prior to the start of salt production season. The shell feature and associated ceramics lay 16 to 30 cm depth below the seafloor. About 40 g of Warrie Red and Mangrove Unslipped jars were associated with the shell midden feature. The water jars likely would have stored brine. A few Belize Red sherds from serving vessels (14 g) were recovered. The associated briquetage is composed of sand temper and not shell, so shell clearly was not used as temper. No ceramics, shell, charcoal, or botanicals were encountered below 30 cm depth, indicating this deposit was the initial layer of the site. Ocarinas and serving vessels recovered at other Paynes Creek Salt Works indicate the occurrence of ritual activities (McKillop 2002). Rituals are performed prior to salt production season at Sacapulas (Reina and Monaghan 1981). Temple platforms, shrines, and large wooden crosses attest to the sacred nature of Emal, Yucatán, (Kepecs 2003:128). A central ball court in addition to burnt offerings of cacao was discovered near the epicenter of Salinas de los Nueve Cerros (Woodfill et al. 2015).

Once the ritual was complete, the salt makers at Eleanor Betty could have built their hearth on top of the initial offering. Due to the shallow nature of the site (55 cm below the water table at its deepest depth on the western edge of the excavated units), the hearth (located in Units 2-3 m and 3-4 m of all transects) did not survive due to the slow inundation process. The changing tides would have spread the shell north-to-south and east-to-west, creating a shallow, elongated shell midden rather than a smaller, heaped deposit. Sea-level rise has inundated the site and most of the other Paynes Creek Salt Works (McKillop et al. 2010).

## Conclusions

Eleanor Betty was one of the Paynes Creek Salt Works located along the coast of southern Belize during the Classic period. The midden consisted of a single species of shell, *C. rhizophora* (MNI=198). The recurrence of a single species underscores the interpretation that the shell midden was a single-use event. In contrast, at the nearby trading port of Wild Cane Cay, there were more than 45 species of shell (McKillop 2005b). At Frenchman's Cay, there were 98 species of shell (McKillop and Winemiller 2004). Butterfly Wing was dominated by several species, including *C. rhizophora*, *Isognomon alatus*, and *Spondylus pugilis* (McKillop 2002). The Cancun shell midden also had a variety of shells (Andrews 1969). The Classic period midden on Moho Cay was dominated by *Strombus gigas*, but also contained manatee and other animal bones (McKillop 1984, 2004).

Single-species reliance on nearby available shell at Eleanor Betty suggests the shell midden was a single meal or feast perhaps eaten as part of an opening ceremony prior to the salt production season. The presence of a few Belize Red sherds – the remains of painted serving bowls tempered with volcanic ash – also suggests that a small feasting event took place, as proposed for the nearby Stingray Lagoon site (McKillop 2002:95). Sea-level rise and fall, in conjunction with the changing motion of the tides, likely spread the shell midden across the site over time, obscuring the midden's original greater depth and more concentrated location.

Available data for the Cancun, Butterfly Wing, Frenchman's Cay, Moho Cay, and Wild Cane Cay middens indicate a heavy reliance on marine resources, supporting, in part, Lange's (1971) hypothesis that marine fauna were an essential part of the Maya diet. The presence of butcher marks on 57 of the recovered shells from the Eleanor Betty shell midden indicate they were used as part of a meal, once again supporting, in part, Lange's (1971) hypothesis that the coastal Maya had a heavy reliance on marine fauna. Unlike shells recovered from sites such as Aguateca, Piedras Negras, Wild Cane Cay, and Moho Cay, the shells at Eleanor Betty do not provide additional evidence for shell modification for musical instruments or utilitarian items. Although true for the coastal Maya, more evidence exists for the support of marine fauna as status indicators when incorporated into the inland Maya diet than as a stable dietary resource. Most marine shell was imported for ritual purposes and not for subsistence.

*Acknowledgements* Support for this research was provided by the National Science Foundation under Grant No. 1026796 to H. McKillop, K. McKee, H. Roberts, and T. Winemiller under permits from the Belize government Institute of Archaeology. The Robert C. West Graduate Student Research Award from the Department of Geography and Anthropology, Louisiana State University, partially funded airfare for V. Feathers. We would like to thank our 2013 field crew, Dr. E. Cory Sills, Dr. Rachel Watson, and our boat captain, John Young, for their assistance with field excavations and analyses as well as their camaraderie. Additionally, we are grateful for the hospitality and support of our host family at Village Farm, Tanya Russ and John Spang.

## References

Andrews IV, E. Wyllys
1969 *The Archaeological Use and Distribution of Mollusca in the Maya Lowlands*. Middle American

Research Institute Publication 34. Tulane University, New Orleans.

Andrews IV, E. Wyllys, Michael P. Simmons, Elizabeth S. Wing, E. Wyllys Andrews V, and Joann M. Andrews
1975 Excavation of an Early Shell Midden on Isla Cancun, Quintana Roo, Mexico. In *Middle American Research Institute* Publication 31, edited by Margaret Harrison and Robert Wauchope, pp. 147–197. Tulane University, New Orleans.

Aoyama, Kazuo
1995 "Microwear Analysis in the Southeast Maya Lowlands: Two Case Studies at Copan, Honduras." *Latin American Antiquity* 6:129-144.

Aucoin, Taylor
2012 *Excavation of Transect 4 at the Eleanor Betty Site, A Submerged Classic Maya Salt Work, Belize*. Honors Thesis, Department of Geography and Anthropology, Louisiana State University, Baton Rouge, Louisiana.

Beaubien, Harriet F.
2004 "Excavation and Recovery of a Funerary Offering of Marine Materials from Copán." In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by Kitty F. Emery, pp. 45-54. Cotsen Institute of Archaeology, University of California, Los Angeles.

Chase, Diane Z.
1981 "The Maya Postclassic at Santa Rita Corozal." *Archaeology* 34:25-33.

Claassen, Cheryl
1998 *Shells*. University Press, Cambridge.

Cobos, Rafael
1989 "Shelling In: Marine Mollusca at Chichén Itzá." In *Coastal Maya Trade*, edited by Heather McKillop and Paul F. Healy, pp. 49-58. Occasional Papers in Anthropology 8. Trent University, Peterborough.

Emery, Kitty F.
2008 "Techniques of Ancient Maya Bone Working: Evidence from a Classic Maya Deposit." *Latin American Antiquity* 19:204-221.

Emery, Kitty F. and Aoyama Kazuo
2007 "Bone, Shell, and Lithic Evidence for Crafting in Elite Maya Households at Aguateca, Guatemala." *Ancient Mesoamerica* 18: 69-89.

Feathers, Valerie, Heather McKillop, E. Cory Sills, and Rachel Watson
2017 "Excavating the Underwater Shell Deposit at an Ancient Maya Salt Work in Belize: The Eleanor Betty Site." *Research Reports in Belizean Archaeology* 14: 289-298.

Galstoff, Paul S.
1964 *The American Oyster Crassostrea viginica Gmelin*. Electronic Document.
http://www.nefsc.noaa.gov/publications/classics/galtsoff1964/

Garber, James F.
1995 "The Artifacts." In *Maya Maritime Trade, Settlement, and Populations on Ambergris Caye, Belize*, edited by Thomas Guderjan and James Garber, pp. 113-137. Labyrinthos, Culver City, Ca.

Gunter, Gordon
1938 "Comments on the Shape, Growth, and Quality of the American Oyster." *Science* 88:546-547.

Healy, Paul F.
1990 "Excavations at Pacbitun, Belize: Preliminary Report on the 1986 and 1987 Investigations." *Journal of Field Archaeology* 17:247-262.

Healy, Paul F., Jaime J. Awe, and Hermann Helmuth
1998 "An Ancient Maya Multiple Burial at Caledonia, Cay District, Belize." *Journal of Field Archaeology* 25:261-274.

Inomata, Takeshi, Daniela Triadan, Erick Ponciano, Estela Pinto, Richard E. Terry, and Markus Eberl
2002 "Domestic and Political Lives of Classic Maya Elites: The Excavation of Rapidly Abandoned Structures at Aguateca, Guatemala." *Latin American Antiquity* 13:305-330.

Kent, Bretton W.
1988 *Making Dead Oysters Talk: Techniques for Analyzing Oysters from Archaeological Sites*. Maryland Historical Trust, Historic St. Marys City, Jefferson Patterson Park and Museum.

Kepecs, Susan
2003 "Salt Sources and Production." In *The Postclassic Mesoamerican World*, edited by Michael E. Smith and Frances F. Berdan, pp. 126-130. The University of Utah Press, Salt Lake City.

Kidder, Alfred V., Jesse D. Jennings, and Edwin M. Shook
1946 *Excavations at Kaminaljuyu, Guatemala*. Carnegie Institution of Washington Publication 561. Washington, D.C.

Lange, Frederick W.
1971 "Marine Resources: A Viable Subsistence Alternative for the Prehistoric Lowland Maya." *American Anthropologist* 73:619-639.

McKillop, Heather
1984 "Prehistoric Maya Reliance on Marine Resources: Analysis of a Midden from Moho Cay, Belize." *Journal of Field Archaeology* 11:25–35.

1996 "Ancient Maya Trading Ports and the Integration of Long-Distance and Regional

Economies: Wild Cane Cay in south-coastal Belize." *Ancient Mesoamerica* 7:49-62.

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

2004 "The Classic Maya Trading Port of Moho Cay." In *The Ancient Maya of the Belize Valley*, edited by James F. Garber, pp. 257-272. University Press of Florida, Gainesville.

2005a "Finds in Belize Document Late Classic Maya Salt Making and Canoe Transport." *Proceedings of the National Academy of Sciences* 102:5630-5634.

2005b *In Search of Maya Sea Traders*. Texas A&M University Press, College Station.

2017a "Diving Deeper in Punta Ycacos Lagoon at the Paynes Creek Salt Works, Belize." *Research Reports in Belizean Archaeology* 14: 279-288.

2017b "Early Maya Navigation and Maritime Connections in Mesoamerica." In *The Sea in History: The Medieval World*, edited by Michel Balard, pp. 701-715. The Boydel Press, Woodbridge, England.

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.

2017 "The Paynes Creek Salt Works, Belize: A Model for Ancient Maya Salt Production." In *The Value of Things*, edited by Jennifer P. Matthews and Thomas H. Guderjan, pp. 67-86. University of Arizona Press, Tucson.

McKillop, Heather, E. Cory Sills, and Jessica Harrison
2010 "Sea-Level and Inundation of the Classic Maya Paynes Creek Salt Works: Evidence from Marine Sediment." *Research Reports in Belizean Archaeology* 7:245-252.

McKillop, Heather and Terance Winemiller
2004 "Ancient Maya Environment, Settlement, and Diet: Quantitative and GIS Spatial Analysis of Shell from Frenchman's Cay, Belize. In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by Kitty F. Emery, pp. 57-80. Cotsen Instituteof Archaeology. University of California, Los Angeles.

Miller, Arthur G.
1977 "The Maya and the Sea: Trade and Cult at Tancah and Tulum, Quintana Roo, Mexico." In *The Sea in the Pre-Columbian World*, edited by Elizabeth P. Benson, pp. 97-140. Trustees for Harvard University, Washington D.C.

Moholy-Nagy, Hattula
1963 "Shells and other marine material from Tikal." *Estudios de Cultura Maya* 3:65–83.

Nascimento, Iracema A.
1991 "*Crassostrea rhizophorae* (Guilding) and *C. brasiliana* (Lamarck) in South and Central America. In *Estuarine and Marine Bivalve Mollusk Culture*, edited by Winston Menzel, pp. 125-134. CRC Press, Boca Raton.

Pendergast, David M.
1979 *Excavations at Altun Ha, Belize, 1964-1970, Volume 1*. Royal Ontario Museum, Toronto.

1981 "Lamanai, Belize: Summary of Excavation Results, 1974-1980." *Journal of Field Archaeology* 8:29-53.

1992 "Noblesse Oblige: The Elites of Altun Ha and Lamanai, Belize." In *Mesoamerican Elites: An Archaeological Assessment*, edited by Diane Z. Chase and Arlen F. Chase, pp. 61-79. University of Oklahoma Press, Norman.

Prufer, Keith M. and Peter S. Dunham
2009 "A shaman's burial from an Early Classic cave in the Maya Mountains of Belize, Central America." *World Archaeology* 41:295-320.

Reina, Ruben E., and John Monaghan
1981 "The Ways of the Maya: Salt Production in Sacapulas, Guatemala." *Expedition* 23(3):13-33.

Robin, Cynthia, Laura Kosakowsky, Angela Keller, and James Meierhoff
2014 "Leaders, farmers, and Crafters: The Relationship between Leading Households and Households across the Chan Community." *Ancient Mesoamerica* 25:371-387.

Sharpe, Ashley E. and Kitty F. Emery
2015 "Differential animal use within three Late Classic Maya states; Implications for politics and trade. *Journal of Anthropological Archaeology* 40:280-301.

Shaw, Leslie C.
1995 "Analysis of Faunal Material from Ek Luum." In *Maya Maritime Trade, Settlement, and Populations on Ambergris Caye, Belize*, edited by Thomas Guderjan and James Garber, pp. 175-181. Labyrinthos City, California.

Stemp, W. James, Christophe G.B. Helmke, and Jaime J. Awe
2010 "Evidence for Maya Household Subsistence and Domestic Activities: Use-Wear Analysis of the Chipped Chert Assemblage from Pook's Hill, Belize." *Journal of Field Archaeology* 35:217-234.

Teeter, Wendy G.
2004 "Animal Use in a Growing City: Vertebrate Exploitation at Caracol, Belize." In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by Kitty F. Emery, pp. 177-191. Cotsen Institute of Archaeology. University of California, Los Angeles.

Vargas, Ramón, Sylviane Boucher, Paula Alvarez González, Vera Tiesler Blos, Valeria García Vierna, Renata García Moreno, and Javier Vázquez Negrete
1999 "A Dynastic Tomb from Campeche, Mexico: New Evidence on Jaguar Paw, a Ruler of Calakmul." *Latin American Antiquity* 10:47-58.

Wing, Elizabeth S.
1975 "Animal Remains from Lubaantun." In *Lubaantun: A Classic Maya Realm*, by Norman Hammond, pp. 379-382. Monographs of the Peabody Museum of Archaeology and Ethnology No. 2. Harvard University: Cambridge, Massachusetts.

Woodfill, Brent K.S., Brian Dervin Dillon, Marc Wolf, Carlos Avendaño, and Ronald Canter
2015 "Salinas de los Nueve Cerros, Guatemala: A Major Economic Center in the Southern Maya Lowlands."*Latin American Antiquity* 26:162-179.

Yaeger, Jason, M. Katherine Brown, Christophe Helmke, Marc Zender, Bernadette Cap, Christie Kokel Rodriquez, and Sylvia Batty
2015 "Two early Classic Elite Burials from Buenavista del Cayo, Belize." *Research Reports in Belizean Archaeology* 12: 181-191.