Overview

The materiality of human–water interaction in the Caribbean: an archaeological perspective

Niall P. Finneran*

This contribution offers a broad overview of the material evidence (archaeology) of multiscalar approaches to human–water interaction on the islands of the Caribbean from the precontact period up to the present day (i.e., ca 3000 BC–AD 2000). Precontact indigenous hunting/gathering/fishing and early farming peoples relied upon water management technology to mitigate problems of water shortage and drought (and indeed problems of excess of water, flooding). Further, archaeological work linked to other interdisciplinary approaches can demonstrate that their perception of water use was also linked to symbolic behavior as well. After AD 1492 as the newly Europeanized Caribbean islands industrialized in response to developing intensive sugar monoculture systems, more emphasis was placed upon extensive and complex water storage and irrigation works that at once reflected differing environmental demands of island ecologies, and also residual cultural traditions of the European colonial powers regarding water management and conservation. It will be demonstrated that within these socially and culturally diverse islandscapes, novel symbolic approaches to water also emerged, reflecting these many and varied roots of Caribbean cultural traditions.

How to cite this article:
WIREs Water 2017, e1235. doi: 10.1002/wat2.1235

INTRODUCTION

Water, salt and fresh, dominates the socio-economic and cultural fabric of Caribbean islandscapes. The seas surrounding them offer a nexus of human movement and economic bounty. Fresh water even in this predominantly rainy, tropical environment is an important commodity; many Caribbean islanders have evolved elaborate storage systems to store rainfall for domestic use. Water use and management remains an important concern of governmental policy in the region.[1] On the industrial scale, irrigation works are an important factor in optimizing marginal island agricultural economies. This overview focuses upon the historical development of the material traces of water storage and management systems in the insular Caribbean region. In doing so, it takes an explicitly archaeological and long-term perspective on human–water interaction. The first two sections of the overview place the main body of data within (1) geographical, ecological, and historical contexts and (2) theoretical and methodological contexts. Stress here is placed upon viewing the islands as ecologically and culturally dynamic and varied physical entities, and secondly developing the notion that the island populations are historically cosmopolitan (this idea of cultural mixing within the Caribbean historical context is termed 'creolization').[2–4] In very basic terms this process describes the dynamics extensive cultural synthesis, and it is argued herein that creolization is also visible in the material culture traces of human–water interaction. Finally, this opening contextual discussion seeks to define a framework for archaeology of water, and how this analysis can move to understand the symbolic, numinous role of water in Caribbean insular societies.

*Correspondence to: Niall.Finneran@winchester.ac.uk

Department of Archaeology, University of Winchester, Winchester, UK

Conflict of interest: The author has declared no conflicts of interest for this article.

In the second section of the overview, the main data are presented. An examination of the pre-European contact (i.e., pre-Columbian <AD 1492) material evidence for water storage and management strategies across the Greater and Lesser Antilles is outlined, focusing upon technological developments, and then the possible material evidence for more symbolic uses of water is considered. We then move, after the 15th century, to an examination of water management within the European colonial context (i.e., under the framework of Spanish, British, Dutch, French, and Danish rule). The role of irrigation and water storage systems within the industrialized plantation landscapes are studied, and then on another scale, we consider water use within the domestic sphere of European planters and enslaved Africans. Finally, ideas surrounding the symbolic associations of water evidenced by material remains are outlined. Underpinning this overview is the contention that the archaeological analysis of human–water interaction as a whole must move beyond the consideration of the tangible function and embrace the more ephemeral symbolic meaning. Further, within the context of this study area, the application of the idea of creolization allows us to define a multiplicity of cultural traditions coming together, and being refocused within these diverse island environments.

THE CARIBBEAN: GEOGRAPHICAL, ECOLOGICAL, AND HISTORICAL CONTEXTS

The Caribbean Sea extends over a surface area of some 2,750,000 km^2 (Figure 1). Its eastern boundary is delineated by a chain of islands (thus, the insular Caribbean) comprising the Greater and Lesser Antilles running roughly from the north-west to south-east. The Greater Antilles include the islands of Cuba, Jamaica, Hispaniola (comprising the nation states of Haiti in the west and the Dominican Republic in the east), and the US territory of Puerto Rico. Further east, the smaller Lesser Antilles chain curves southwards along the eastern boundary of the Caribbean Sea. This chain is divided into the Leeward Islands in the north and the Windward Islands to the south (the 'hinge' point of the two island groups being between the islands of Guadeloupe and Dominica). The former group, the Leewards, comprises island states such as Antigua, St Kitts and Nevis, and the Virgin Islands. The Windward group comprises islands such as St Lucia, St Vincent, the Grenadines chain, and Grenada, furthest south. Outlying islands include Barbados, Trinidad and Tobago, and further west the three Dutch islands (Leeward Antilles) of Aruba, Bonaire, and Curacao. To the north, between the Leeward Islands and Florida are the Bahamas, not strictly speaking part of the Caribbean.

Island geographies vary dramatically across the chain, and these settings have obvious implications for the discussion presented here.[5] The Bahamian islands, for example, are flat and coraline and often highly developed in terms of tourist resort infrastructure. The larger islands of the Greater Antilles are more mountainous and forested. Eastwards, the Leeward Islands tend to be more rugged while the Windwards are of mainly volcanic geology and heavily covered in rainforest. Barbados offers yet another contrast; flatter, limestone and more densely developed. The climate of each island naturally reflects water management strategies.[6] The predominant winds are the north-easterly trade winds and these bear moisture upon the windward (Atlantic-facing) sides of the islands, leaving in some cases a rain shadow on the leeward coasts. The main rainy season in the region is from August to November when hurricanes develop in the Atlantic and track north-eastwards across the region. In general, the further west the island is the drier its climate. Aruba, for example, will average around 2.5–7.5 cm of rain a month whilst Dominica would average around 5–7.5 cm per month in the drier spring and early summer seasons, peaking at ca 32–38 cm per month in the Hurricane season of late summer and autumn.[7]

Current archaeological, genetic, and linguistic thinking posits that humans settled the insular Caribbean around 6000 years ago.[8] The earliest archaeological sites in the region are found in the south, in Trinidad, and are associated with the hunter–gatherer Ortoiroid culture and date from the sixth millennium BC.[9] The earliest hunter–gatherer phase in the Greater Antilles (Hispaniola and Cuba) is associated with the Casimiroid culture.[10] Later, between ca 800 BC and 200 BC Saladoid peoples introduced pottery and cultivation into the islands from a center of origin in South America.[11] Successive waves of immigrants then followed,[12] and by the end of the first millennium AD the Arawak-speaking Arauquinoid peoples established the complex Taino polities in the Greater Antilles.[13] Further south and west Kalinago 'Carib' peoples inhabited islands such as St Vincent and Dominica, where many of their descendants still live today.[14]

In 1492, Christopher Columbus encountered the complex Taino polities of the Greater Antilles, and this event ushered in an era of European settlement and exploitation of the Caribbean islands. Initially, the Spanish represented the dominant military, political, and cultural presence, as evidenced by the development of townscapes and fortifications on the islands

AQ2

Color Figure - Print and Online

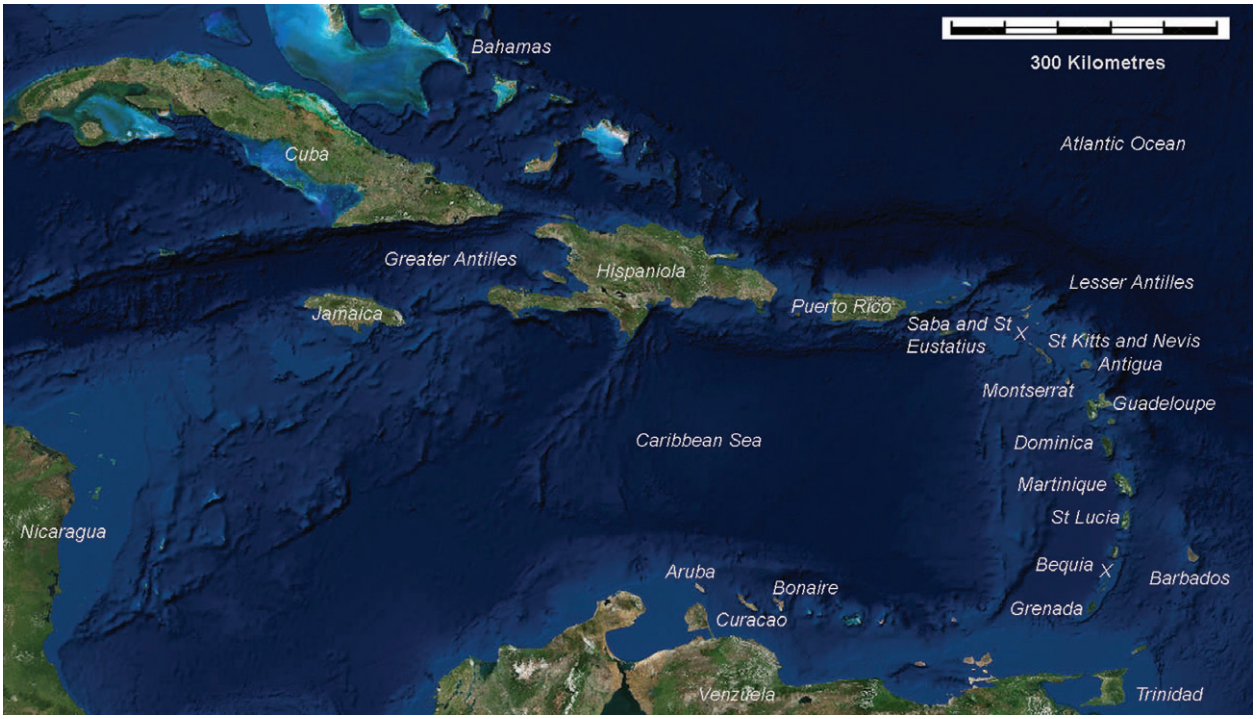


FIGURE 1 | Map of the Caribbean indicating sites discussed herein.

and in the wider region,[15] but were soon joined by other European powers, some of whom still maintain close political control over their island possessions. From the 17th century, sugar replaced tobacco, cotton, and indigo as the dominant cash crop, creating huge possibilities of wealth for the European planters. In order to service these huge and lucrative industrial plantations a source of cheap labor was required. Slaves were sourced from across West Africa and shipped over to the Caribbean plantations. They brought with them a range of African cultural traditions, and soon the Caribbean islands became cosmopolitan social and cultural 'creolized' melting pots.[16]

TOWARDS AN ARCHAEOLOGY OF WATER

Archaeology is broadly defined as dealing with things. As a discipline, it is historical, but history deals with words. Archaeology analyzes material culture, and through this seeks to get into the minds of past peoples. Water is arguably one of the most important resources in human cultural and economic development, as a necessity for human life, and also for washing, for food preparation and for feeding plants. Its uses are diverse and are reflected globally in human material behavior.[17] Many methods of investigation are deployed by archaeologists to investigate material traces of the past and focusing upon a range of different scales.

The study of artifacts within the domestic context can inform our study of historic human–water interaction. Storage media, such as pots, have been historically fabricated to hold and transport water for thousands of years, and humans have also had to evolve means for rendering water potable, a technological process that leaves material traces accessible to the archaeologist. Large-scale water management strategies, such as cisterns or urban sanitation systems[18] and irrigation systems in arid environments[19] and nonarid environments[20] can also be recognized archaeologically through a wider regional, holistic landscape archaeology survey approach. These are, to take just a small sample of possible case studies, adaptive approaches to the material culture record. By this, we mean an emphasis on cultural *adaptation* to ecological conditions, betokening a very fixed and *deterministic* view of human water use.[21]

Archaeologists do more than excavate sites, analyze artifacts, or map irrigation systems in the landscape using increasingly sophisticated survey techniques. Since the early 1980s in the United Kingdom, archaeologists of what we term the 'post-processual' school have sought to widen our horizons by absorbing a range of theoretical standpoints drawn from a number of cognate disciplines.[22] From an epistemological perspective based upon empiricism, a

more rationalist approach prevails, emphasizing an idealist rather than materialist ontology. In general, terms this requires archaeologists to engage more with human thought and emotion rather than just perceiving the mere functionality of the artifact or site. This has important implications for the present overview in moving the archaeological analysis in a different direction. One area of importance is the realization that humans invest natural places with a great deal of symbolic meaning, and in some case, the material traces of these emotional responses might not be immediately apparent.[23,24]

For example, archaeology of Caribbean human–water interaction could reasonably focus, as we shall see, on wells or cisterns, or irrigation landscapes in plantations, but there is the possibility of extending the debate into more imaginative directions.[25,26] Using an interpretative or *hermeneutic* approach, we can start to consider the symbolic role of water in Caribbean societies, water not as a passive material, but one that reflects (figuratively and literally) diverse human belief systems. Some examples of this sort of behavior could include water in wider symbolic and ritual landscapes,[27,28] the use of water in ritual purification contexts,[29] or association of water with votive offerings, shrines or burials, or modified or unmodified landscape features.[30–32] This is what archaeologist's term *phenomenology*; an attempt to access human response to the landscape. This is a term widely critiqued within current archaeological practice,[33] but at least it moves the study of human interaction with the natural world in general (and here with water specifically) away from a narrow conception of water use.[34] A phenomenological framework of understanding is proposed here, an appreciation of the sensuous, numinous, and symbolic qualities of water within the natural landscape and how humans *experience* (the crux of phenomenology) these qualities. With these broader contexts in mind (and admittedly there is much more that could be said in relation to this notion of water and symbolism), we will now consider the archaeological picture in the insular Caribbean, starting with the precontact period.

HUMAN–WATER INTERACTION IN THE CARIBBEAN IN THE PRECONTACT PERIODS

Archaeology is uniquely placed to inform us about the importance of water management and usage strategies among the precontact Caribbean peoples, although in comparison with neighboring mainland areas, the picture of water management strategies on the Caribbean islands remains frustratingly sparse.[35,36] A recent archaeological study of human technological responses to excess of water availability or scarcity in the precontact Caribbean has gone some way to rectify the issue, although the accent remains firmly upon the functionally adaptive rather than the ritualistic aspect of human–water interaction in the Caribbean.[37] The authors make several important points in their analysis. Firstly, they demonstrate that these islands are climatically diverse and offer very dynamic environmental conditions, from flooding to drought, and as such humans have had to adapt ingenious ways of mitigating these problems.

An examination of Caribbean palaeoenvironmental data over the last 2000 or so years (mainly yielded by analysis of isotopic composition in snail shells from the site of Anse à la Gourde, Guadeloupe) bears out this picture of dynamic climatic change; these data suggest broadly a series of wet and dry periods in rapid succession from ca 400 AD to the present day. Against this background, the early island settlers had to adapt their relations with water. Shifts in sea level, which was part and parcel of climatic change, forced abandonment of coastal settlements, for example, changing the availability of certain maritime and fresh water sources. This is certainly clear at the site of Anse à la Gourde.[38] *In extremis*, it is also not unknown for tsunami (or even hurricane) events to also be a factor in influencing human settlement. This is borne out, for example, with the use of stilts to support houses at the Los Buchilliones site, Cuba (dating from AD 1250 to 1500) to mitigate flooding in what was a wet environment (in passing it should be noted that this wetland site, unusual in the Caribbean context, offers excellent scope for organic artifact survival).[39] So, where there are issues of *too much* water, the precontact inhabitants of these islands were forced to adapt ways round the problem.

Second, as Hofman and Hoogland also point out, there are also cases of too little water, and this factor resulted in the development of complex water conservation techniques. On Aruba, for example, natural gullies (*rooien*) at the site of Tanki Flip are suggested to be linked to rudimentary man-made water management systems, and date from around AD 1000.[37] Wells are another means of mitigating availability of potable water, particularly on the limestone islands. Coastal pot-lined shallow wells have been found on a number of islands in the south-east of the Caribbean in particular. They take advantage of fresh rainwater running off the land, and sitting on top of the denser saline water just above the water

table. Excavated examples of at least 53 of these wells from the coastal site of Port St Charles in north-western Barbados bear witness to the skill of precontact island dwellers in accessing and storing water.[40] These wells were either lined with wood, which was well preserved in the damp anaerobic environment, or large pots with their bottoms knocked out and arranged to form a longer pipe. These wells date from around ca AD 700 to 1100. The use of large shells of the Queen Conch (*Strombus gigas*) is also reported as being a viable rainwater trapping technique on the Los Roques Archipelago off the Venezuelan coast, and it may be that archaeologists in the future recognize these shells as evidencing actual water storage strategies rather than the remains of beach-side shellfish consumption.[41]

Archaeological reconstruction of the belief systems of these peoples and their ritual association with water remains speculative. There are, however, a few categories of evidence that may betoken deep symbolic attachment to water. The widespread ritual appropriation of caves by the Maya in Mexico and water-filled sink holes (*cenotes*), in particular, may offer a useful analog to the study of sacred water sources in the Caribbean islands.[42,43] These striking natural features are formed by the dissolution of the rocks above, and given the association of prehistoric burials with these sites it seems that they acquired some unknown symbolic importance, perhaps associated with idea of a gateway to the underworld. In the Greater Antilles, a number of distinctive anthropomorphic jars (*potizas*) have been recovered from springs and *cenotes* associated with Taino settlement in the Dominican Republic on the island of Hispaniola (here the sink hole site of Manatial de la Aleta is noteworthy for its extensive evidence for structured deposition in particular).[44] It has been hypothesized that these vessels were water carrying jars used and discarded in a nonritual context, but as VanderVeen demonstrates,[45] their morphology is not an optimum design for carrying liquid over a long distance, but for holding water *in situ*. Furthermore, it is suggested that the decoration of these vessels, with exaggerated anthropomorphic sexual characteristics, suggests some fertility function entwined with water use. Certainly, caves as a whole feature strongly in Taino ritualistic landscapes; their obvious uses as places of refuge or for accessing potable (but poor quality mineral-rich) water sit aside some indefinable function as a *genius locus*, as suggested by the presence of human burials. The intertwining of the natural and cultural worlds thus appears to be vivid in Taino life.[46]

Further north, in the Bahamas, we see a similar association between ritualistic behavior and water-filled caves, although here the caves ('Blue Holes') are associated with seascapes rather than fresh water. Indigenous Lucayan peoples attached a strong symbolic meaning to Blue Holes, seeing them as the abode of the mythical sea creature the '*Lusca*,'[47] as well as using them for human burial. Certainly, the Lucayan peoples invested a great deal of meaning in water imagery, referring, for example, to the primordial ocean (*Bagua*) and the centrality of fish and aquatic life in general in their cosmology.[48] Caves were an obvious place to inter higher status individuals (such as the Stargate Blue Hole on Andros Island, perhaps), and no doubt the connection with water must have been important; certainly these dramatic Bahamian Blue Holes evoked (as they continue to do today) a strong emotional pull to humans who came into contact with them.[49]

The foregoing section has considered water use and symbolism within small-scale island societies. The arrival of Europeans after AD 1492, however, changed cultural and economic character of the islands forever. In response to a growing demand for sugar, European powers converted these islands into industrial-scale farming societies, manned by imported slave labor from Africa. Now a new set of functional and symbolic associations of water emerged, in some cases reflecting the coming together of African, European, and indigenous cosmologies as well as changing economic needs and agricultural regimes.

HUMAN–WATER INTERACTION IN THE COLONIAL PERIODS

The Spanish pioneered the cultivation of sugar cane (*Saccharum* sp.) in the Caribbean. At the site of Sevilla La Nueva in Jamaica, excavations recovered the remains of a 16th century water mill (*ingenio*) set alongside the urban structure of the early Spanish town there.[50] It was more common practice in the Caribbean for the sugar cane to be pulped using a *trapiche*, or basic edge runner mill (powered by animals or indeed slaves) and latterly windmills, so this use of hydraulic technology within a plantation setting is, as Woodward argues, redolent of a direct Spanish-style organization of the agricultural landscape. Unfortunately, Woodward was unable to recover evidence of the leats or channeling systems that fed the waterwheel; these patterns of water use in the landscape may mirror Iberian practice (although historic mapping sources clearly show the extensive use of aqueducts and water mills during this period).[51] In recent contexts, the industrial use of water within plantation settings becomes more apparent.

A recent landscape archaeology study of the Balenbouche Estate in St Lucia has suggested the potential for identification of large-scale plantation water control systems through the use of survey and map analysis. This survey work identified a hydraulic system of leats and channels feeding water mills and an 18th century coffee plantation belonging to the French colonial period.[52] Particular attention attaches to a large stone dam, 5-m thick and 7-m high used to form a reservoir from which a 4-km long stone-lined leat ran to the industrial center. This is hydraulic engineering on a significant scale, and leaves clear evidence in the archaeological landscape (a similar dam feature is also found at the plantation site of Belvedere on St Maarten in the Leewards). It should also be noted that there are still extensive remains of water mills to be found on the island of Dominica, to the north of St Lucia. There are extensive canalization features such as aqueducts on the Rosalie estate, and a working water mill at the Macoucherie rum distillery. As is noted above, Dominica can be an exceptionally wet island, and the use of water technology as opposed to wind or animal powered milling makes eminent sense here.

Wells represent another category of water storage and usage within the wider Caribbean plantation context, although are less visible archaeologically. Recent landscape survey by the author in Barbados, for example, has located a series of very deep stone-lined wells in the vicinity of the fort at Six Mens (St Peter's), and many other wells of this type are reported from sugar plantations across the island. These would have been used to water livestock and slaves. Further landscape survey in the area has also shown other examples of colonial-period human–water interaction, such as clay-lined ponds that appear to have been used to support wildfowl populations for shooting from the 18th century onwards. It is therefore possible to see the manipulation of the natural landscape of an island-like Barbados following trends apparent in the management and enclosure of 18th century English estates. Water was therefore an essential part of 'taming' and acculturating the island landscape, making the unfamiliar familiar. This was not just an English fashion; on the Dutch island of St Eustatius, for example, the country house of the late 18th century Dutch commander, Johannes de Graaf, boasted a large brick-lined duck pond, about 10 m × 3 m in size. Water was being used in the Caribbean colonial context as a formalized landscape feature, a means to assert control and order over the landscape.[53]

Another important plantation cash crop, particularly in the Greater Antilles, was coffee (*Coffea arabica*). In a study of the archaeology of Jamaican coffee plantations, the American archaeologist James Delle points to the intensive use of water in the processing of the coffee berries. Pulping mills were hydraulically powered and required a dependable source of water; large tanks were also needed to steep the coffee pod pulp. In some cases, mapping has revealed channeling and aqueduct systems used to maintain a constant supply of water into the processing areas.[54] Much large-scale irrigation works, comprising canals, aqueducts, and cisterns, can be found at 19th century coffee plantations (*cafetales*) in south-eastern Cuba using techniques developed by French specialists. Such is their historical importance that they have been inscribed as UNESCO World Heritage Sites.[55]

Another—albeit more minor—historical Caribbean cash crop indigo (*Indigofera* sp.) was used for dyeing fabric from the late 17th century and was a feature of earlier French island economies in the Windwards.[56] Processing of this resource is water-intensive; freshly cut plants were steeped in one large tank and were pounded until the mixture fermented. The liquid was then drawn off into a second large vat where it was stirred, and finally the residue was tapped into a third vat. These structures, therefore, have distinctive archaeological signatures, and clearly rely on relatively complex water management. Examples have been surveyed in Bequia, in the St Vincent Grenadines; the complication of this location is that it is an arid island, so water management was problematic. Here the indigo works are sited on the wetter north-eastern coast of the island, and are situated within a system of small run off channels and canals.[57] These complexes bear general similarities to contemporary works found on the French island of Guadeloupe.[58]

It is also important to draw attention to the impact of the Caribbean salt extraction industries (particularly associated with the northern Caribbean islands of St Maarten/St Martin, Anguilla, and Turks and Caicos) on the landscape. These industries require large, shallow ponds of brackish water, and are often associated with canal systems to conduct water through the evaporation system. The salt works of Salt cay on the Turks and Caicos, for example, although now defunct, still retain evidence for canal and sluice systems.[59] This is another example of the historical centrality of water technology to Caribbean industry, and one which has clear implications for the impact upon smaller, marginal island economies where sugar cultivation was never significant.

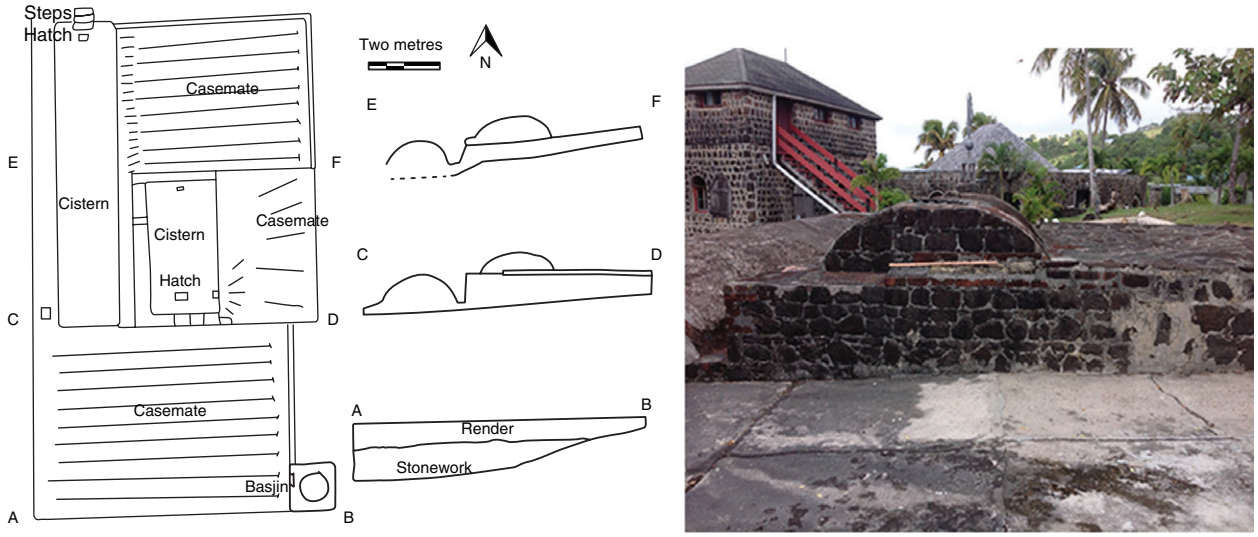
Cisterns used for storing water are a common feature on many of the plantations of the insular Caribbean. To take one example from a well-

researched site, there are at least six cisterns associated with the industrial complex at Betty's Hope in Antigua, hardly a surprise given that the island is quite arid (cisterns are also a key feature of many of the island's fortifications too). One of the cisterns at Betty's Hope is associated with an animal pen, the other with the mid-18th century slave village and at least four associated with the Great House, where the Planter himself would have lived. This hierarchy of provision of water clearly reflects the social hierarchy of the Plantation itself.[60] Away from the large sugar plantations, and in more small-scale island societies, water management techniques were not so much an industrial consideration, more a real factor of life and death.

One of the most detailed archaeological studies of the use of domestic water storage systems in the Caribbean was undertaken by the archaeologist Ryan Espersen at the sites of Palmetto Point and Middle Island on the arid and rocky island of Saba in the northern Leeward Islands.[61] For a time in the 18th century, Saba exported significant quantities of agricultural resources (not so much sugar) to neighboring islands such as St Eustatius. The rugged terrain of the island demanded the use of terracing to increase available land for cultivation. Water management strategies also evolved in the shape of shared cisterns (by 1934 Espersen records there being over 250 such structures on the island). As such, there was a great deal of communal investment in their construction and their maintenance. These distinctive domed structures were attached to flat rectangular catchments for collecting water. In general, each catchment structure measures between 8 and 9 m in length, with an average width of ca 5 m; the domed cistern structures themselves are about half the size and hold a volume of water from about 10,000 to 36,000 L.

Espersen makes the point that these amounts would not be sufficient to store enough water for the inhabitants of these settlements, and water shortages could have provoked male emigration from the island particularly in the 19th century, as is borne out by census record. Espersen's daily estimates of water consumption do not only take into account access to potable water but also the ability to water crops and rehydrate dried food such as 'corned' (salted) fish. In every sense, this was a marginal environment, and even with highly developed water gathering and storage technologies unsustainable for human habitation. It is no wonder that the villages were abandoned. Technology could not keep up with water demand.

It is difficult to physically date these structures. Similar cisterns have, unsurprisingly, been found associated with 18th century dwellings and plantations on the nearby small Dutch island of St Eustatius.[62] Recent work on the island of Bequia in the St Vincent Grenadines offers some potential for drawing conclusions about the transfer of water storage technology between Caribbean islands over a longer distance and across spheres of European cultural interaction. In 2015, a series of barrel-vaulted brick-built cisterns and casemates were recorded at the site of Old Fort, Bequia[63] (Figure 2). As with Saba and St



Color Figure - Print and Online

FIGURE 2 | Brick vaulted cistern and casemate structure, Old Fort, Bequia, St Vincent Grenadines (plan and elevations; scale at right in photograph 1 m).

Eustatius, Bequia is an arid island; in fact a drought here in the 1950s effectively ended marginal sugar cultivation on the island. The water storage units at Old Fort were not unique in the context of Bequia; similar storage tanks existed at the abandoned estates at Belmont and Friendship Bay (although interestingly the cistern at the site of Padget's Farm on the west of the island is subterranean, stone-lined and rectangular in shape, and may date from the earlier French colonization of the island; the masonry is similar to the indigo tanks, noted above). Why were cisterns built upon this *Dutch* pattern present here? A crucial historical source helped to clarify this archaeological problem.[64] This contemporary note explained that after the British had seized Bequia from the French in the 1780s, a request was placed for settlers *from* Saba to be allowed to settle the island. Given the similarities in construction technique, architectural style and volume of the Bequia cisterns it is suggested that here we have direct evidence of a transfer of water storage technology from the northern Leewards into the southern Windwards from as early as the late 18th century.

Water management at an even more archaeologically ephemeral and domestic scale is an important feature of Caribbean material culture. The work of Pulsipher on the British island of Montserrat (which in 1995 was largely destroyed in a volcanic eruption) drew attention to informal small-scale slave garden economies on the fringes of the Galways plantation. Although formalized small-scale water storage, and diversion channels and tunnels were attached to the actual industrial core of the plantation, survey outside these areas suggested that slaves had also constructed smaller scale and more ephemeral structures to help retain rainwater.[65] Her ethnographic work around the archaeological site suggested that small-scale domestic and informal arrangements for managing water supply were still present. For example, large natural boulders in Galways village have been modified to form shallow basins to catch enough rainwater to enable washing or cooking to take place without having to trek to the springs.[66]

Water storage technology is just one part of the archaeological analysis. Other forms of technology emerged in these islands to ensure that water was safe to drink, an important consideration for the upper class of planter society. At the Barbados Museum in Bridgetown, Barbados, one is still able to see a localized island solution to purification of water. Dripstones, made from the local coral limestone were once extensively exported from Barbados to other Caribbean islands (Figure 3). Consisting of two superimposed coral-limestone basins, the water gradually

FIGURE 3 | Limestone dripstones for water purification, Barbados Museum.

Color Figure - Print and Online

seeped through the basins from the top through the porous rock into an earthenware jar below. This type of purification technology derives from Spanish colonial practice (variants can be seen in colonial contexts in houses in the Dominican Republic; in some cases, the hollows in the stones contained charcoal to allow more effective filtration). Recent research has indicated that the filtration process does not reduce all bacterial contamination but can significantly reduce levels of harmful coliform bacteria.[67] Also belonging within this continuum of small-scale water storage and use are pots; in Barbados these are commonly referred to as 'Monkeys' and their unglazed and porous exterior allows evaporation of the liquid inside and keeps the contents of the jar cool. It is probable that this form of technology does not belong to a European, colonial context but may reference imported African ceramic technologies.[68]

The foregoing paragraphs have outlined the importance of water management and storage strategies at a number of different scales in the colonial Caribbean. What can we say about symbolic

associations of water use in this industrialized and cosmopolitan world? Two examples may be taken to indicate the potential directions such studies could take in the future. Belief in the West African water spirit, generically termed 'Mami Wata' and depicted as a mermaid (indeed female water spirits are also an important feature of Haitian Vodou iconography as well)[69] is widespread in Diaspora communities in the New World. In the Santeria cosmology of Cuba she is referred to as Yemaya, and in other French Caribbean islands as Maman Dlo (a clear corruption of *Maman de L'Eau*; another water-related figure in the Haitian system of Vodou, Admiral Agwe, is the master of water and his consort Lasiren is depicted as a mermaid). Mami Wata personifies this idea outlined earlier in the paper of syncretism, or creolization, a meeting of cosmologies.[70] Clearly focused anthropological and archaeological work should aim to study the material representation of this deity, perhaps through recognition of shrines, offerings, and places in the landscape, as is found in West Africa.[71]

Color Figure - Print and Online

FIGURE 4 | Jewish ritual purification in a historic Caribbean townscape: the spring-fed Mikveh, Nidhe Israel Synagogue, Bridgetown, Barbados.

Color Figure - Print and Online

FIGURE 5 | Jewish ritual purification in a historic Caribbean townscape: marble laver or hand washing stoup, Barbados Museum, Bridgetown.

From the European perspective, we are familiar with the use of water as an agent of purification in the Christian Church (e.g., in a stoup or baptisterial font; this is also a feature of some creolized Afro-Caribbean religions too, e.g., in the Cuban rite of Santeria, sacred Bata drums are cleansed with water before ritual use). Christianity is indeed the dominant religion across the Caribbean, but this ignores the significance of the historic settlement of the Sephardic Jewish communities originating from Iberia and arriving in the region via Amsterdam as part of the development of the sugar trade in the 17th century onwards.[72] Extant and ruined synagogues can be found on Nevis, St Eustatius, Barbados, Jamaica, Aruba, Curacao, and Cuba. The oldest synagogue in the western hemisphere is the Nidhe Israel Synagogue in Bridgetown Barbados and in 2007 the ritual bath, or Mikveh, was excavated and restored as part of the development of a Jewish museum on site[73] (Figure 4). This important element in the symbolic architecture of the Jewish ritual was known by Sephardic Jews as a *Bano* and was fed by a spring and used exclusively by female worshippers. Another element of material culture relating to ritual purification, a marble laver, is on display at the Barbados Museum (Figure 5).

This is just a single archaeological example of the symbolic use of water within ritual purification contexts across the Caribbean; archaeology, informed by local oral history and anthropological research has a role in defining many more.

CONCLUSION

The foregoing survey of the material evidence for human–water interaction in the Caribbean has highlighted both the industrial/domestic and symbolic importance of water on these tropical islands over many millennia. This material evidence reflects in turn the rich creolized and syncretic identity of Caribbean peoples, their cultures, economies, and belief systems. Many examples could have been chosen to develop these ideas further, and clearly there is much work to do in this area. It is therefore hoped that several promising directions for future multidisciplinary research have been clearly signposted and that archaeological approaches to human–water interaction can move on in new and innovative directions, and not just in the Caribbean region. In a recent paper, the American archaeologist Mark Hauser has focused upon the politics of the control of water within the context of 18th and 19th century Dominica.[74] Using a variety of categories of archaeological evidence, he has drawn attention to the centrality of the control of access and storage of water. His use of the notion 'water ways' urges us to consider the different human responses to water as a resource. As he has demonstrated, and as has hopefully been shown in more general terms in this article, human capacity to manage water is historically varied and intriguing. Some of these long-lived strategies may point the way to sustainable water management strategies in the Caribbean at a time of ongoing climatic change in the present and future.

ACKNOWLEDGMENTS

Funding for the research underpinning this article has been provided by the University of Winchester. The author would like to thank Dr Federica Sulas for inviting him to contribute to the WIREs Water series, and the input from two anonymous referees, and the constructive and excellent comments of Dr Matthew Reilly is gratefully acknowledged. Any errors remain the author's own.

FURTHER READING

May LA. A brief history of water filtration/sedimentation. *Water Sci Technol* 2013, 13:735–742. DOI: https://doi.org/10.2166/ws.2013.102.

http://www.internationalsteam.co.uk/mills/dominica01.htm. (Accessed May 10, 2017).

Hicks D. *The Garden of the World: An Historical Archaeology of Sugar Landscapes in the Eastern Caribbean*. British Archaeological Reports International Series 1632. Oxford: Archaeopress; 2007, 65.

Curet L, Hauser M. *Islands at the Crossroads: Migration, Seafaring and Interaction in the Caribbean*. Tuscaloosa, AL: University of Alabama Press; 2012.

Gibson C. *Empire's Crossroads: A New History of the Caribbean*. London: Pan; 2015.

Mays L, ed. *Ancient Water Technologies*. New York: Springer; 2010.

Meniketti M. *Sugar Cane Capitalism and Environmental Transformation*. Tuscaloosa, AL: University of Alabama Press; 2015.

Parker M. *The Sugar Barons*. London: Windmill; 2012.

Reid B. *Myths and Realities of Caribbean History*. Tuscaloosa, AL: University of Alabama Press; 2009.

REFERENCES

1. OECD. *Water Governance in Latin America and the Caribbean: A Multi-level Approach*. Paris: Organisation for Economic Co-operation and Development Publishing Paris; 2012.
2. Price R. Créolisation et historicité. *L'Homme Révue Française d'Anthroplogie* 2013, 207:289–312.
3. Finneran NP. 'This islande is inhabited with all sortes': the archaeology of creolisation in Speightstown,

Barbados, and beyond AD 1650–1900. *Antiquaries J* 2013, 93:319–351. DOI: https://doi.org/10.1017/S000358151300022X.

4. Loftfield T. Creolisation in seventeenth-century Barbados: two case studies. In: Farnsworth P, ed. *Island Lives: Historical Archaeologies of the Caribbean*. Tuscaloosa: University of Alabama Press; 2001, 207–233.
5. Richardson BC. *The Caribbean in the Wider World, 1492-1992: A Regional Geography*. Cambridge: Cambridge University Press; 1992.
6. Ekuwe EI. Management of water demand in the Caribbean region: current practices and future needs. *West Indian J Eng* 2010, 32:28–35.
7. Taylor M, Alfaro E. Climate of Central America and the Caribbean. In: Oliver J, ed. *Encyclopaedia of World Climatology*. New York: Springer; 2005, 183–189.
8. Fitzpatrick SM. The Pre-Columbian Caribbean: colonization, population dispersal, and island adaptations. *PaleoAmerica* 2015, 1:305–331. DOI: https://doi.org/10.1179/2055557115Y.0000000010.
9. Boomert A. Gateway to the mainland: Trinidad and Tobago. In: Keegan W, Hofman C, Ramos R, eds. *The Oxford Handbook of Caribbean Archaeology*. Oxford: Oxford University Press; 2013. DOI: https://doi.org/10.1093/oxfordhb/9780195392302.013.0054.
10. Callaghan R. Comments on the mainland origins of the preceramic cultures of the Greater Antilles. *Latin Am Antiq* 2003, 14:323–338. DOI: https://doi.org/10.2307/3557563.
11. Wilson S. *The Archaeology of the Caribbean*. Cambridge: Cambridge University Press; 2007, 59–94.
12. Giovas CM, Fitzpatrick SM. Prehistoric migration in the Caribbean: past perspectives, new models and the ideal free distribution of West Indian colonization. *World Archaeol* 2014, 46:569–589. DOI: https://doi.org/10.1080/00438243.2014.933123.
13. Keegan W. The Classic Taino. In: Keegan W, Hofman C, Ramos R, eds. *The Oxford Handbook of Caribbean Archaeology*. Oxford: Oxford University Press; 2013. DOI: https://doi.org/10.1093/oxfordhb/9780195392302.013.0035.
14. Allaire L. Ethnohistory of the Caribs. In: Keegan W, Hofman C, Ramos R, eds. *The Oxford Handbook of Caribbean Archaeology*. Oxford: Oxford University Press; 2013. DOI: https://doi.org/10.1093/oxfordhb/9780195392302.013.0045.
15. Deagan K. Colonial origins and colonial transformations in Spanish America. *Hist Archaeol* 2003, 37:3–13.
16. Ewen C. From colonist to creole: archaeological patterns of Spanish colonisation in the New World. *Hist Archaeol* 2000, 34:36–45.
17. Tvedt T, Oestigaard T, eds. *A History of Water, Vol. 3: The World of Water*. New Delhi: Viva Books; 2013.
18. Koloski-Ostrow A. *The Archaeology of Sanitation in Roman, Italy: Toilets, Sewers and Water Systems*. Chapel Hill, NC: University of North Carolina Press; 2015.
19. Leone A. Water management in late antique North Africa: agricultural irrigation. *Water Hist* 2012, 4:119–133. DOI: https://doi.org/10.1007/s12685-012-0052-0.
20. Williamson T, Cook H. *Water Management in the English Landscape: Field, Marsh and Meadow*. Edinburgh: Edinburgh University Press; 1999.
21. Hazelwood L, Steele J. Colonizing new landscapes: archaeological detectability of the first phase. In: Rockman M, Steele J, eds. *Colonization of Unfamiliar Landscapes: The Archaeology of Adaptation*. London: Routledge; 2003, 203–221.
22. Shanks M, Hodder I. Processual, post-processual and interpretive archaeologies. In: Whitely D, ed. *Reader in Archaeological Theory*. London: Routledge; 1998, 69–98.
23. Bradley R. *An Archaeology of Natural Places*. London: Routledge; 2000.
24. Tilley C, Bennett W. An archaeology of supernatural places: the case of West Penwith. *J R Anthropol Inst* 2001, 7:335–362. DOI: https://doi.org/10.1111/1467-9655.00066.
25. Oestigaard T. Water. In: Insoll T, ed. *The Oxford Handbook of Ritual and Religion*. Oxford: Oxford University Press; 2011, 38–50.
26. Oestigaard T. Holy water: the universal and the particular. *Archaeol Dialog* 2014, 21:162–165. DOI: https://doi.org/10.1017/S138020381400018X.
27. Finneran N. Holy waters: Pre-Christian and Christian water association in Ethiopia. An archaeological landscape perspective. In: Oestigaard T, ed. *Water, Culture and Identity in the Nile Basin*. Bergen: University of Bergen Press; 2009, 165–187.
28. Tallini M, di Leo A, Rossetti C, Berardi F. The sacred Almone River of the Appian Way Regional Park in Rome: ancient myths, a ritual link between Rome and Asia Minor and water uses in the modern age. *Water Supply* 2013, 13:727–734. DOI: https://doi.org/10.2166/ws.2013.098.
29. Peatfield A. Water, fertility and purification in Minoan religion. *Bull Inst Classical Stud* 1995, 40:217–227. DOI: https://doi.org/10.1111/j.2041-5370.1995.tb02114.x.
30. Yates D, Bradley R. Still water, hidden depths: the deposition of bronze age metalwork in the English Fenland. *Antiquity* 2010, 84:405–415. DOI: https://doi.org/10.1017/S0003598X00066667.
31. Glowacki M, Malpass M. Water, Huacas and ancestor worship: traces of a sacred *Wari* landscape. *Latin Am Antiq* 2003, 14:431–448. DOI: https://doi.org/10.2307/3557577.

32. Richards C. Henges and water: towards an elemental understanding of monumentality and landscape in late Neolithic Britain. *J Mater Cult* 1996, 1:313–336.

33. Brück J. Experiencing the past? The development of a phenomenological archaeology in British prehistory. *Archaeol Dialog* 2005, 12:45–72. DOI: https://doi.org/10.1017/S1380203805001583.

34. Harmansah O. *Of Rocks and Water: Towards an Archaeology of Place*. Oxford: Oxbow Books; 2014.

35. Scarborough V. Ecology and ritual: water management and the Maya. *Latin Am Antiq* 1998, 9:135–159.

36. Lucero L, Fash B, eds. *Pre-Columbian Water Management: Ideology, Ritual and Power*. Tucson: University of Arizona Press; 2006.

37. Hofman C, Hoogland M. Beautiful tropical islands in the Caribbean Sea. Human responses to floods and droughts and the indigenous archaeological heritage of the Caribbean. In: Willems W, Van Schaik H, eds. *Water and Heritage: Material, Conceptual and Spiritual Connections*. Leiden: Sidestone Press; 2015, 99–120.

38. Beets CJ, Troelstra SR, Grootes PM, Nadeau MJ, van der Borg K, de Jong AFM, Hofman CL, Hoogland MLP. Climate and pre-Columbian settlement at Anse à la Gourde, Guadeloupe, north-eastern Caribbean. *Geoarchaeology* 2006, 21:271–280. DOI: https://doi.org/10.1002/gea.20096.

39. Pendergast D, Graham E, Calvera RJ, Jardines MJ. The houses in which they dwelt: the excavation and dating of Taino structures at Los Buchilliones, Cuba. *J Wetland Archaeol* 2002, 2:61–75. DOI: https://doi.org/10.1179/jwa.2002.2.1.6.

40. Drewett P. *Above Sweet Waters: Cultural and Natural Change at Port St Charles Barbados c. 1750 BC–AD 1850*. London: Archetype; 2007, 49–51.

41. Antczak A, Posada J, Schapira D, Antczak MM, Cipriani R, Montaño I. A history of human impact on the Queen Conch (*Strombus gigas*) in Venezuela. In: Antzak A, Cipriani R, eds. *Early Human Impact on Megamolluscs*. British Archaeological Reports International Series 1865. Oxford: Archaeopress; 2008, 49–64.

42. Brady J, Prufer K, eds. *In the Maw of the Earth Monster: Mesoamerican Ritual Cave Use*. Austin, TX: University of Texas Press; 2005.

43. Coggins CC, Shane OC. *Cenote of Sacrifice: Maya Treasures from the Sacred Well at Chichén Itzá*. Austin, TX: University of Texas Press; 1984.

44. Beeker CD, Conrad G, Foster J. Taino use of flooded caverns in the east National Park region, Dominican Republic. *J Caribb Archaeol* 2002, 3:1–26.

45. VanderVeen J. Water storage jars and the human figure: a reanalysis of Taino symbolism. *Caribb Connect* 2011, 1. Available at: http://fieldresearchcentre.weebly.com/uploads/1/8/0/7/18079819/vanderveen_2011.pdf. (Accessed December 28, 2016).

46. Morton S. The Taino use of caves: a review. *Caribb Connect* 2015, 4. Available at: http://fieldresearchcentre.weebly.com/uploads/1/8/0/7/18079819/morton_a_2015.pdf. (Accessed December 28, 2016).

47. Schwabe S, Carew J. Blue Holes: an inappropriate moniker for scientific discussion of water filled caves in the Bahamas'. In: *Proceedings of the 12th Symposium on the Geology of the Bahamas and Other Carbonate Regions*, 2006. Available at: https://blueholes.org/The%20Rob%20Palmer%20Blue%20Holes%20Foundation/Publications_files/12th%20Inappropriate%20name.pdf. (Accessed December 28, 2016).

48. Schaffer WC, Carr RS, Day JS, Pateman MP. Lucayan–Taíno burials from Preacher's cave, Eleuthera, Bahamas. *Int J Osteoarchaeol* 2012, 22:45–69. DOI: https://doi.org/10.1002/oa.1180.

49. Sealey N. Bahamian Blue Holes: windows on the past, resources for the future. In: Barker D, McGregor D, eds. *Environment and Development in the Caribbean: Geographical Perspectives*. Barbados: University of the West Indies Press; 1995, 35–45.

50. Woodward RS. Feudalism or Agrarian Capitalism? The archaeology of the early sixteenth-century Spanish sugar industry. In: Delle J, Hauser M, Armstrong D, eds. *Out of Many, One People. The Historical Archaeology of Colonial Jamaica*. Tuscaloosa, AL: University of Alabama Press; 2011, 23–40.

51. Higman B. *Jamaica Surveyed: Plantation Maps and Plans of the Eighteenth and Nineteenth Centuries*. Kingston: University of West Indies Press; 2001.

52. Hicks D. *The Garden of the World: An Historical Archaeology of Sugar Landscapes in the Eastern Caribbean*. British Archaeological Reports International Series 1632. Oxford: Archaeopress; 2007, 54–57.

53. Barka N. *The Archaeology of the Dutch Elite: The Country Estate of Johannes De Graaf*. St Eustatius Archaeological Research Series 8. Williamsburg, VA: Department of Anthropology, College of William and Mary; 1996.

54. Delle J. The landscapes of class negotiation on coffee plantations in the Blue Mountains of Jamaica, 1790-1850. *Hist Archaeol* 1999, 33:136–158.

55. UNESCO. Archaeological landscape of the first coffee plantations of south-east Cuba. Available at: http://whc.unesco.org/en/list/1008. (Accessed January 7, 2017).

56. Beeson K. Indigo production in the eighteenth century. *Hisp Am Hist Rev* 1964, 44:214–218.

57. Bradford M. Blues from Bequia: survey of two historic indigo processing ruins. In: *Paper Presented at the 22nd Conference of the International Association of*

Caribbean Archaeology, Kingston, Jamaica, 23–29 July, 2007.

58. Delpuech A. Historical archaeology in the French West Indies. In: Farnsworth P, ed. *Island Lives: Historical Archaeologies of the Caribbean*. Tuscaloosa, AL: University of Alabama Press; 2001, 21–59.
59. Kennedy CM. The other white gold: salt, slaves, the Turks and Caicos Islands, and British Colonialism. *Historian* 2007, 69:215–230.
60. Wells EC, Waters C, Tricario A, Fox G. Agroindustrial soilscapes in the Caribbean: a geochemical perspective from Betty's Hope, Antigua. *Environ Archaeol* 2016. DOI: https://doi.org/10.1080/14614103.2016.1258130.
61. Espersen R. Water use at Palmetto Point and Middle Island, Saba, Dutch Caribbean: a modeled approach for settlement variability. *Int J Hist Archaeol* 2013, 17:806–827. DOI: https://doi.org/10.1007/s10761-013-0243-0.
62. Harper R. An ethnoarchaeological study of the cisterns in Oranjestad, Sint Eustatius, Netherlands Antilles. Unpublished MA dissertation, College of William and Mary, Williamsburg, VA, 1990, 51.
63. Finneran, N The Island of the Clouds: landscape ordering and socio-economic change in a small-scale Caribbean island setting (Bequia, St Vincent Grenadines c. AD 1700–1900). *Int J Hist Archaeol*. In press.
64. Kew, National Archives T 1/442/91-4 1765 West Indies, Grenada, Governor Melvill to Governor Higginson, enclosing a petition from 15 inhabitants of Saba for a grant of 30 acres of land each on the island of Bequia 1765.
65. Pulsipher L. "Getting to the essence of it" Galways Plantation, Montserrat, West Indies. In: Farnsworth P, ed. *Island Lives: Historical Archaeologies of the Caribbean*. Tuscaloosa, AL: University of Alabama Press; 2001, 165–203.
66. Pulsipher L. Our maroon in the now-lost landscapes of Montserrat. *Geogr Rev* 2001, 91:132–142.
67. Mathison G, Barker D. Do traditional coral dripstones remove harmful bacteria? *J Barbados Museum Hist Soc* 2002, 48:79–86.
68. Hauser M, DeCorse C. Low-fired earthenwares in the African Diaspora: problems and prospects. *Int J Hist Archaeol* 2003, 7:67–98. DOI: https://doi.org/10.1023/A:1023279320141.
69. Houlberg M. Sirens and snakes: water spirits in the arts of Haitian Vodou. *Afr Arts* 1996, 29:30–35.
70. Drewal HJ. Mami Wata: arts for water spirits in Africa and its diasporas. *Afr Arts* 2008, 41:60–83. DOI: https://doi.org/10.1162/afar.2008.41.2.60.
71. Drewal HJ. Mami Wata shrines: exotica and the construction of self. In: Arnoldi M, Geary C, Hardin K, eds. *African Material Culture*. Bloomington, IN: Indiana University Press; 1996, 308–433.
72. Schreuder Y. A true global community: Sephardic Jews, the sugar trade and Barbados in the seventeenth century. *J Barbados Museum Hist Soc* 2004, 50:166–194.
73. Watson K. 1806 Plat of the Nidhe Israel Synagogue in Bridgetown, Barbados. *J Barbados Museum Hist Soc* 2015:82–85.
74. Hauser M. A political ecology of water and enslavement: water ways in eighteenth century Caribbean plantations. *Curr Anthropol* 2017, 58. Available at: http://www.journals.uchicago.edu/doi/abs/10.1086/691053.

Graphical abstract

The materiality of human–water interaction in the Caribbean: an archaeological perspective

Niall P. Finneran[1]

Dean's Blue Hole, Long Island, Bahamas. A striking 200-m deep natural water feature. Blue Holes are common to these islands and are laden with rich symbolic meaning, as evidenced by their association with precontact Lucayan human burials.

QUERIES TO BE ANSWERED BY AUTHOR

IMPORTANT NOTE: Please mark your corrections and answers to these queries directly onto the proof at the relevant place. DO NOT mark your corrections on this query sheet.

Queries from the Copyeditor:

AQ1. Please confirm that given names (red) and surnames/family names (green) have been identified correctly.

AQ2. Please check whether the given short title is appropriate, if not provide a suitable one.

AQ3. Please check the heading levels given for the article and confirm that they are correct.

AQ4. Refs 38 and 41 in the manuscript seem to be identical. Hence one of them has been removed and the subsequent references have been renumbered accordingly.

AQ5. Please provide Page range for ref. [45].

AQ6. Please provide Page range for ref. [46].

AQ7. Please provide Volume number, Page range for ref. [60].

AQ8. Please provide Publication year, Volume number, Page range for ref. [63].

AQ9. Please provide Volume number for Ref. [73].

AQ10. Please provide Page range for ref. [74].

Funding Info Query Form

Please confirm that the funding sponsor list below was correctly extracted from your article: that it includes all funders and that the text has been matched to the correct FundRef Registry organization names. If no FundRef Registry organization name has been identified, it may be that the funder was not found in the FundRef registry, or there are multiple funders matched in the FundRef registry. If a name was not found in the FundRef registry, it may not be the canonical name form, it may be a program name rather than an organization name, or it may be an organization not yet included in FundRef Registry. If you know of another name form or a parent organization name for a "not found" item on this list below, please share that information.

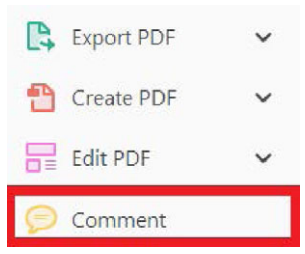
Funding Agency	**FundRef Organization Name**
University of Winchester	University of Winchester

WILEY

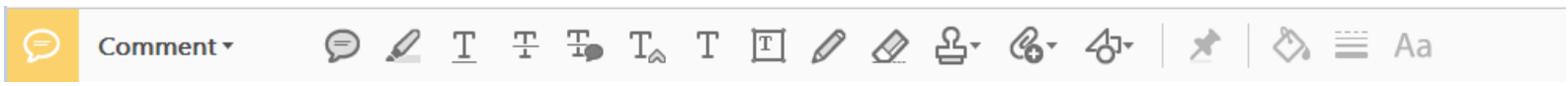
USING e-ANNOTATION TOOLS FOR ELECTRONIC PROOF CORRECTION

Required software to e-Annotate PDFs: Adobe Acrobat Professional or Adobe Reader (version 8.0 or above). (Note that this document uses screenshots from Adobe Reader DC.)
The latest version of Acrobat Reader can be downloaded for free at: http://get.adobe.com/reader/

Once you have Acrobat Reader open on your computer, click on the Comment tab (right-hand panel or under the Tools menu).



This will open up a ribbon panel at the top of the document. Using a tool will place a comment in the right-hand panel. The tools you will use for annotating your proof are shown below:

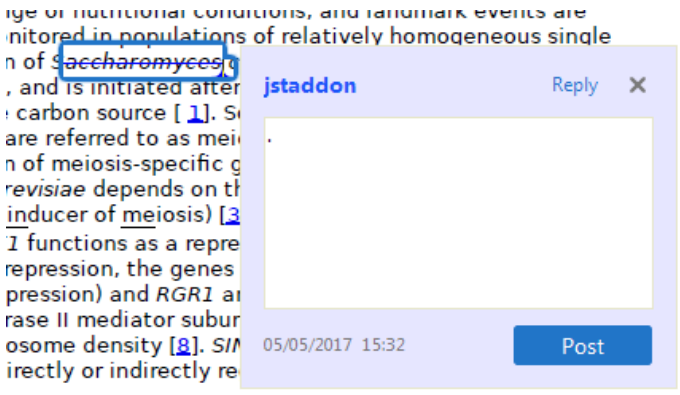


1. Replace (Ins) Tool – for replacing text.

Strikes a line through text and opens up a text box where replacement text can be entered.

How to use it:

- Highlight a word or sentence.
- Click on .
- Type the replacement text into the blue box that appears.

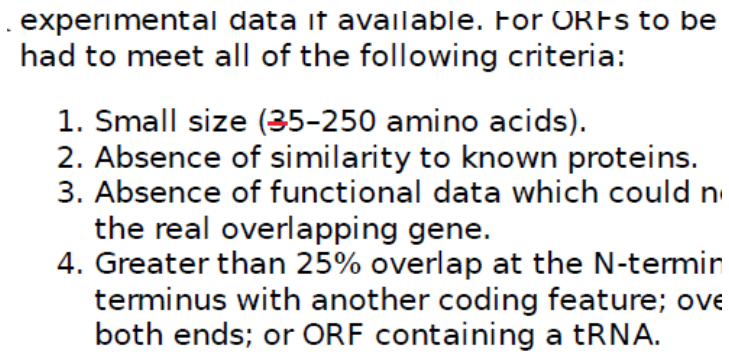


2. Strikethrough (Del) Tool – for deleting text.

Strikes a red line through text that is to be deleted.

How to use it:

- Highlight a word or sentence.
- Click on .
- The text will be struck out in red.


experimental data if available. For ORFs to be had to meet all of the following criteria:

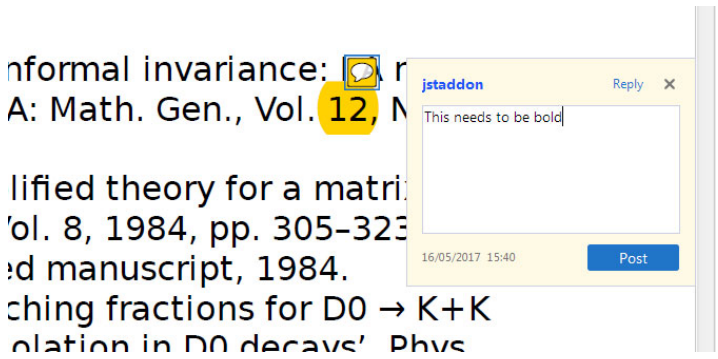
1. Small size (~~3~~5–250 amino acids).
2. Absence of similarity to known proteins.
3. Absence of functional data which could n the real overlapping gene.
4. Greater than 25% overlap at the N-termir terminus with another coding feature; ove both ends; or ORF containing a tRNA.

3. Commenting Tool – for highlighting a section to be changed to bold or italic or for general comments.

Use these 2 tools to highlight the text where a comment is then made.

How to use it:

- Click on .
- Click and drag over the text you need to highlight for the comment you will add.
- Click on .
- Click close to the text you just highlighted.
- Type any instructions regarding the text to be altered into the box that appears.

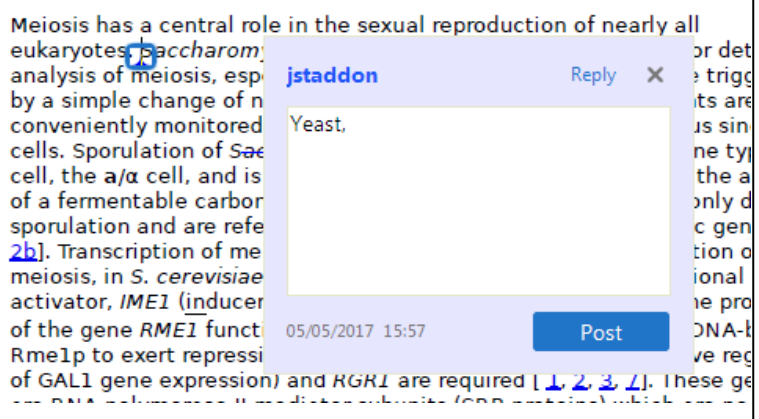


4. Insert Tool – for inserting missing text at specific points in the text.

Marks an insertion point in the text and opens up a text box where comments can be entered.

How to use it:

- Click on .
- Click at the point in the proof where the comment should be inserted.
- Type the comment into the box that appears.



WILEY

USING e-ANNOTATION TOOLS FOR ELECTRONIC PROOF CORRECTION

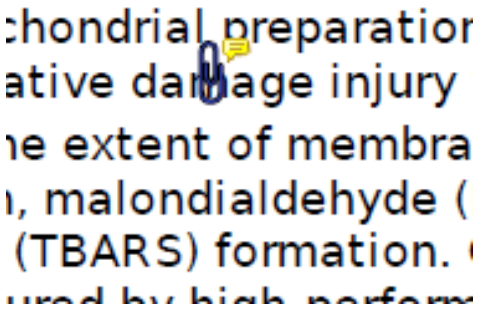
5. Attach File Tool – for inserting large amounts of text or replacement figures.

Inserts an icon linking to the attached file in the appropriate place in the text.

How to use it:

- Click on .
- Click on the proof to where you'd like the attached file to be linked.
- Select the file to be attached from your computer or network.
- Select the colour and type of icon that will appear in the proof. Click OK.

  The attachment appears in the right-hand panel.

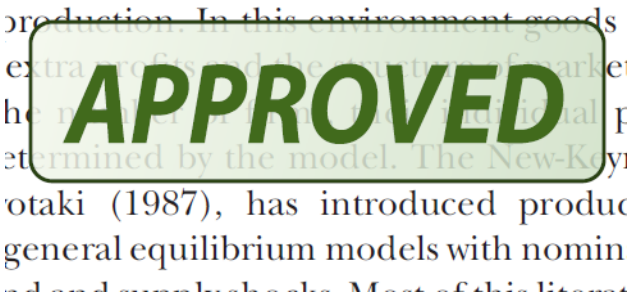


6. Add stamp Tool – for approving a proof if no corrections are required.

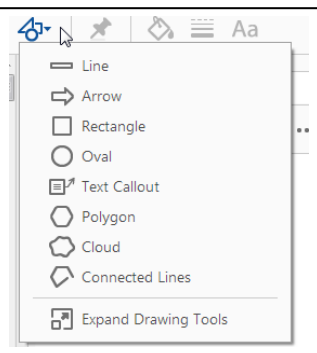
Inserts a selected stamp onto an appropriate place in the proof.

How to use it:

- Click on .
- Select the stamp you want to use. (The Approved stamp is usually available directly in the menu that appears. Others are shown under *Dynamic*, *Sign Here*, *Standard Business*).
- Fill in any details and then click on the proof where you'd like the stamp to appear. (Where a proof is to be approved as it is, this would normally be on the first page).



Drawing tools available on comment ribbon

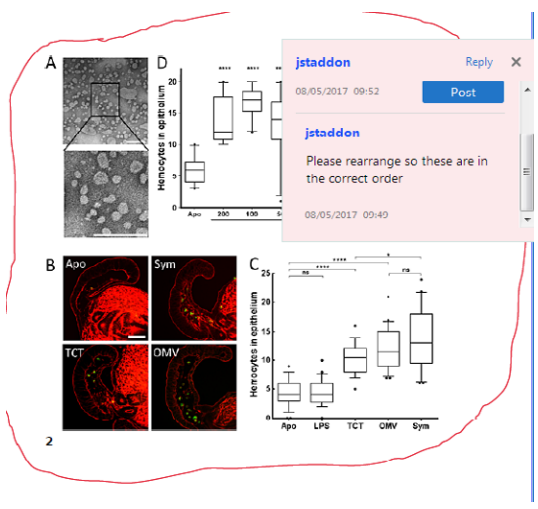


7. Drawing Markups Tools – for drawing shapes, lines, and freeform annotations on proofs and commenting on these marks.

Allows shapes, lines, and freeform annotations to be drawn on proofs and for comments to be made on these marks.

How to use it:

- Click on one of the shapes in the Drawing Markups section.
- Click on the proof at the relevant point and draw the selected shape with the cursor.
- To add a comment to the drawn shape, right-click on shape and select *Open Pop-up Note*.
- Type any text in the red box that appears.



For further information on how to annotate proofs, click on the Help menu to reveal a list of further options: