An Anthropogenic Shell-Ridge in Barbuda, West-Indies. Results of fieldwork 2011-12

Orri Vésteinsson

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Fornleifastofnun Íslands ses
Institute of Archaeology, Iceland

FORNLEIFASTOFNUN ÍSLANDS
INSTITUTE OF ARCHAEOLOGY
BÁRUGÖTU 3
IS-101 REYKJAVÍK

SÍMI/TEL: 00354 551 1033
FAX: 00 354 551 1047
NETFANG/E-MAIL: fsi@instarch.is
WWW.INSTARCH.IS

COVER PICTURE : PILE OF CONCH SHELLS IN GRAVENOR BAY. THE DEPOSIT IS A MIX OF ARCHAEOLOGICAL (DARKER FROM WEATHERING, WITH HOLES) AND MODERN (WHITE, LESS WEATEHRED WITH SLITS) CREATED BY RECENT BULLDOZING.

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Introduction

In 2011 the northern part of a prehistoric shell-ridge, also called ‘strombus line’, on the west coast of Barbuda in the West-Indies, was surveyed and reported on (Vésteinsson 2011). The ridge could be traced some 2,3 km northnorthwest of the site JA1 also excavated that year (Friðriksson et al. 2011). However only fleeting observations were made about the southeasterly extension of the ridge and in January 2012 investigations were therefore resumed, with excavations on the ridge itself in Burton’s field and adjacent to it in Cattle field (both reported in Rousseau 2012) and further reconnaissance south of the JA1 and River sites, all along the coast to Spanish point and around it into Pelican Bay. The results of the field survey carried out on January 16th-23rd 2012 are described in this report and on this basis a hypothesis is presented about the processes responsible for the ridge’s formation.

This fieldwork was carried out at the invitation of Prof. Sophia Perdikaris and is a part of the *Barbuda Historical Ecology Project* and the *Islands of Change Project* (NSF award no 851727). The author would like to thank Dr. Reg Murphy of Antigua&Barbuda National Parks for his assistance and support, as well as collaborators in the field: Dr. Ágústa Edwald, Frank Feeley, Garðar Guðmundsson, Dr. George Hambrecht, Lilja Björk Pálsdóttir, Prof. Tom McGovern, Norie Manigault Vincent Rousseau, Prof. David Watters and the whole team at the Barbuda Archaeological Research Center. It was immense good fortune to have access to Prof. Watters in Barbuda during the fieldwork and to be able to tap his extensive knowledge and experience of Barbuda and its archaeology. Special thanks also to Mr. Calvin Gore, a fountain of local knowledge, without whose help these results would have been much more meager.

Desrcription of the shell ridge

Additional notes on the northern section. The northern part of the shell-ridge, the part which is north of River and bordered on the western side by the sands of Palmetto Point, was described in the previous year’s report (Vésteinsson 2011) but in 2012 the northernmost extension, the part west of River Road was revisited and some additional observations made which flesh out, and partly revise, the picture already described. Also in 2012 Vincent Rousseau and Ágústa Edwald dug a trench

Fig. 1. Trench in Burton's field after excavation, looking east.

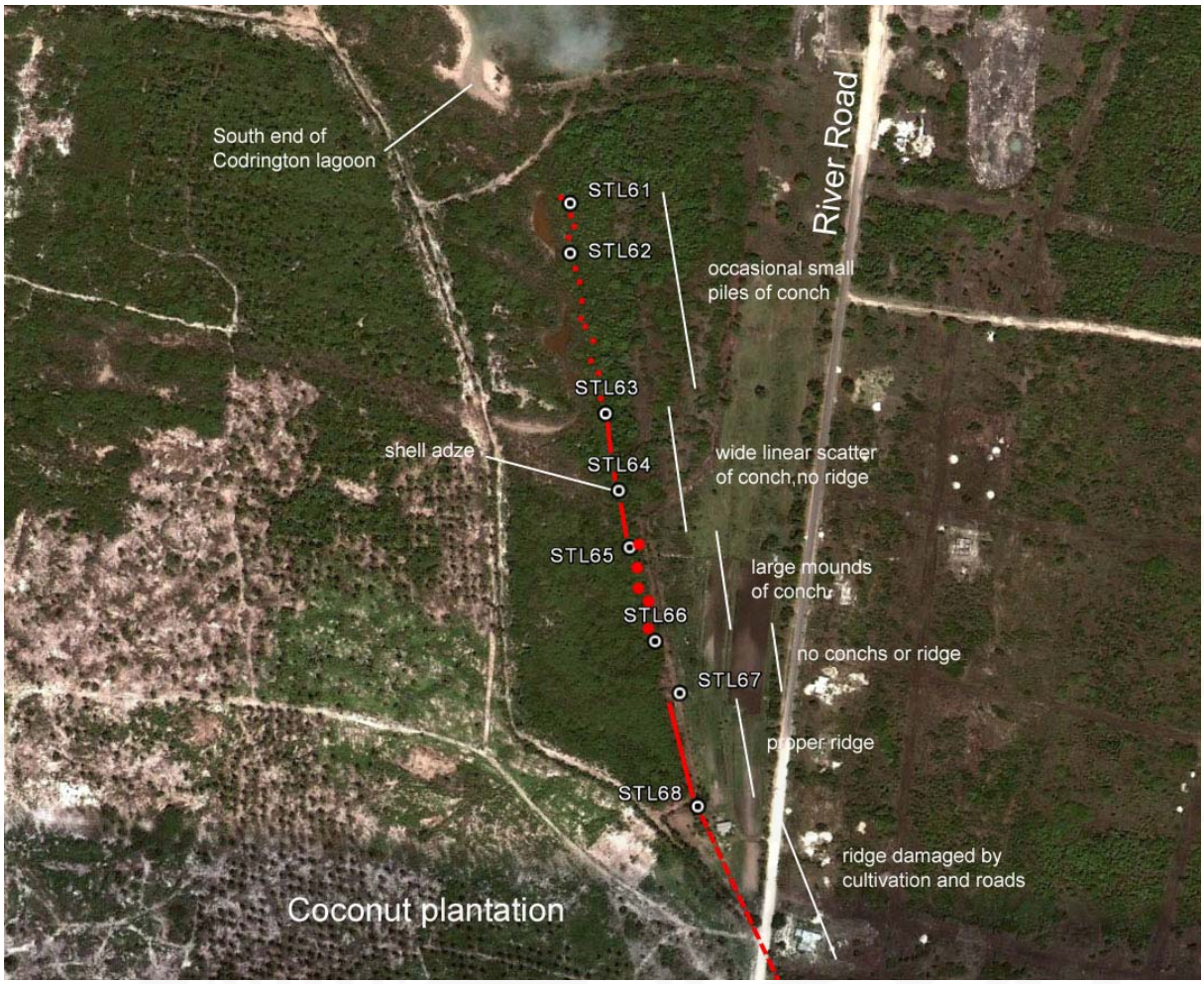
into the ridge by Burton's field which adds important detail, and dates, to the earlier description.

The excavation in Burton's field was located in the middle of the ridge not far from survey point STL11. The 1x1 m trench revealed cultural layers down to a depth of 0,7 m and five distinct cultural layers could be distinguished. The uppermost layer showed signs of disturbance plausibly associated with modern farming activity but the four lower layers were not so affected and represent prehistoric accumulations. The faunal material retrieved consisted almost entirely of Queen conch (*Strombus gigas*), or 99,5% with only a handful of other shell species, but like the small collection of Antiguan flints they were found in all five cultural contexts. There were no finished stone tools among the artefacts suggesting that the shell-ridge itself was not the site of much human activity and in his report on the excavations Rousseau points to the contrast with the other site excavated in 2012, some 30 m east of the ridge in Cattle Field. Here the molluscan species composition was reversed, with the Queen conch making up only 7% of the assemblage. The implication is that the heavy conch shell was dropped as soon as it had been brought ashore and its meat extracted, while lighter shells were brought further inland to sites like Cattle Field.

Fig. 2. A pile of conch at the northern end of the shell-ridge – where it is no longer a continuous ridge. South of STL61.

Two radiocarbon dates were obtained on conch shell from the trench in Burton's Field. They are consistent with other datings suggesting the ridge was forming in the first and second millennium BC but intriguingly they are reversed, with the younger date of 2565±20 BP (uncalibrated) coming from the basal cultural deposit while the older one of 3410±15 BP (uncalibrated) comes from the highest undisturbed layer. This implies that these dates cannot be used to assess the accumulation rate of the ridge in this location and they may suggest that its present composition is more complicated than meets the eye. A date of 3315±15 BP (uncalibrated) from the site in Cattle Field, adjacent to but not on the ridge, supports the idea that the ridge belongs to a more complex cultural landscape with activity areas and possible habitation sites associated with it on the landward side. For more detailed information and discussion on the excavations in Burton's Field and Cattle Field see Rousseau 2012.

In 2011 the northernmost extension of the shell-ridge had been described based on the method of cutting through the bush to hit upon it in several locations, but its length had not been walked. This approach had given the impression that the ridge was continuous to its end at STL24/25, but an examination of the whole stretch



Map 1. Northernmost section of shell ridge (marked in red) re-surveyed in 2012.

in 2012 showed that this is misleading. At the northern end (at STL24/25 and now STL61 and STL62) the ridge is not continuous but rather represented by discrete piles (typically 1-2 m in diameter) of conch, mostly whole large ones with punched holes, possibly suggesting that they are not Archaic. This piles line up along the old shoreline, still reflected by an elongated pond on the seaward side, on a 190 m stretch. At STL63 the piles are replaced by a wide (20-40 m) scatter of conch following the palaeoshoreline but there is only the faintest hint of a ridge. Here many of the conchs have knocked off tips, possibly an Archaic signature, and at STL64 a possible shell adze was found. At STL65 there is a large mound (4 m in diameter) of stone and shell, some of which is water worn, but the feature looks recent and is probably related to modern field clearance. More such mounds are south of this to STL66 but there the shell disappears altogether only to reappear at STL67 where a proper ridge begins. At STL68 the ridge is damaged by a field which extends to River

road. For a description of the ridge east of River Road and southwards to JA1 see the previous year's report (Vésteinsson 2011).

The shell ridge south of JA1. The main results of the 2012 survey along the western coast of Barbuda south of Palmetto Point are that:

a) The shell ridge continues intermittently for 3,7 kms along the coast to the bay west of Cocoa Point.
b) There is a separate nearly 1 km long shell ridge, different in formation and age in Gravenor Bay
c) There are no shell ridges on the western coast, north of Spanish Point.

Of these only point a) can be counted as an addition to existing knowledge. The ridge in Gravenor Bay had been reported by Watters (1999) and the absence of shell-ridges elsewhere is hardly news, although observations of such absences are important to appreciate the characteristics of the conditions under which the shell-ridges do form. Shell-ridges have not been reported for the northern part of Barbuda but neither did the fieldwork on which the present report is based stretch to the areas north of Palmetto Point on the west coast or north of Two Foot Bay on the east coast.

The 2012 field-survey started at JA1, the site which had been partially excavated in 2011 (Friðriksson et al. 2011). The gully where the excavation took place has since been deepened by a bulldozer, further cutting into and damaging the site although deposits remain on either side of the scar. Southeastwards from the scar there are some 10 m of potential deposits but at STL30 the limestone shelf rises by as much as 2 m and southeastwards of this point the shelf is largely bare or covered by very thin soil with a scatter of shell, dominated by conch, but not exclusively. 15 m further southeast (at STL31) there is again a hint of a ridge, 0,2-0,3 m high and up to 10 m wide, but this is made of loose limestone rocks with some shell and soil in between. 70 m further east (at STL32) this mini-ridge ends. It starts again after a 14 m gap (at STL33), or rather the ridge in this area is not continuous but only remains where the limestone shelf is low or there are depressions in it. East of STL32 there is some coral and different types of shell although conch dominates. The shell is more churned where the shelf is high but larger pieces remain intact in the depressions.

Fig. 3. Shell ridge between STL33 and STL34, looking east. As in many other places along this stretch the ridge has preserved best in depressions in the limestone shelf, here visible to the right.

At the junction of the old and new roads (STL35) there is obviously more disturbance (from the road building but also from a new house being built where the road forks). The side of the road is 2-5 m from the break of slope of the limestone shelf but essentially the ridge is no different from further west: hardly any ridge formation and mainly accumulation of shell in dips and depressions and a scatter of shell 20m+ inland. This continues for some 450 metres. At STL36 the road begins to respect a more pronounced ridge which on the seaward site is made largely up of limestone rocks while shell and sand has accumulated on the landward side. The ridge is covered in vegetation, and has the same mix of shell but is not scattered as far inland as further northwest. This speaks against the road having destroyed any ridge further northwest. Rather it seems to respect what little ridge there was and very likely was made with minimal landscaping. This is also supported by the fact that there is no change in the nature of the ridge where the road forks: it is equally low, scattered and confined mainly to depressions, northwest of the road joining the coast as it is to the southeast of that point. It is of course possible, indeed likely, that the ridge has been damaged and reduced by other processes than road-building

Map 2. The shell-ridge (marked in red) along the coast southeast of the site JA1.

between JA1 and STL36, and the ruin of a lime-kiln on the coast midway between JA1 and the River site (Guðmundsson 2012, 17-18) suggests at least one likely reason for such disturbance. Where the ridge has become more prominent again, southeast of STL36 it is in places more like a sand dune, up to 10 m wide and 1 m high. At STL37 a piece of Long Island flint (analysed by Vincent Rousseau, pers. comm.) was found in the middle of the road but careful searching of the vicinity revealed no further remains. At this place the sand dune / ridge is high and covered in shrub. On the landward side of the road there is dense grass and nothing to be seen on the surface. In places the dune is 15m+ wide and 1,5 m high but the larger it is the less visible the shell becomes. Southeastwards of the find place of the flint the frequency of shell diminishes and by STL38 there is practically no conch or other shell, not even in breaches in the dune. There is a gap of 330 m but at STL39 conch is on the increase again, associated with more rock (as opposed to sand) in the ridge. Shell densities are low compared to further northwest and the ridge peters out again after 200 m. By STL40 there is no ridge and a sandy beach covers the shelf-edge. There is more of a dune landwards of the road but practically no shell in it. After another gap of 950 m, at STL41 just south of Uncle Roddy's, there is again a

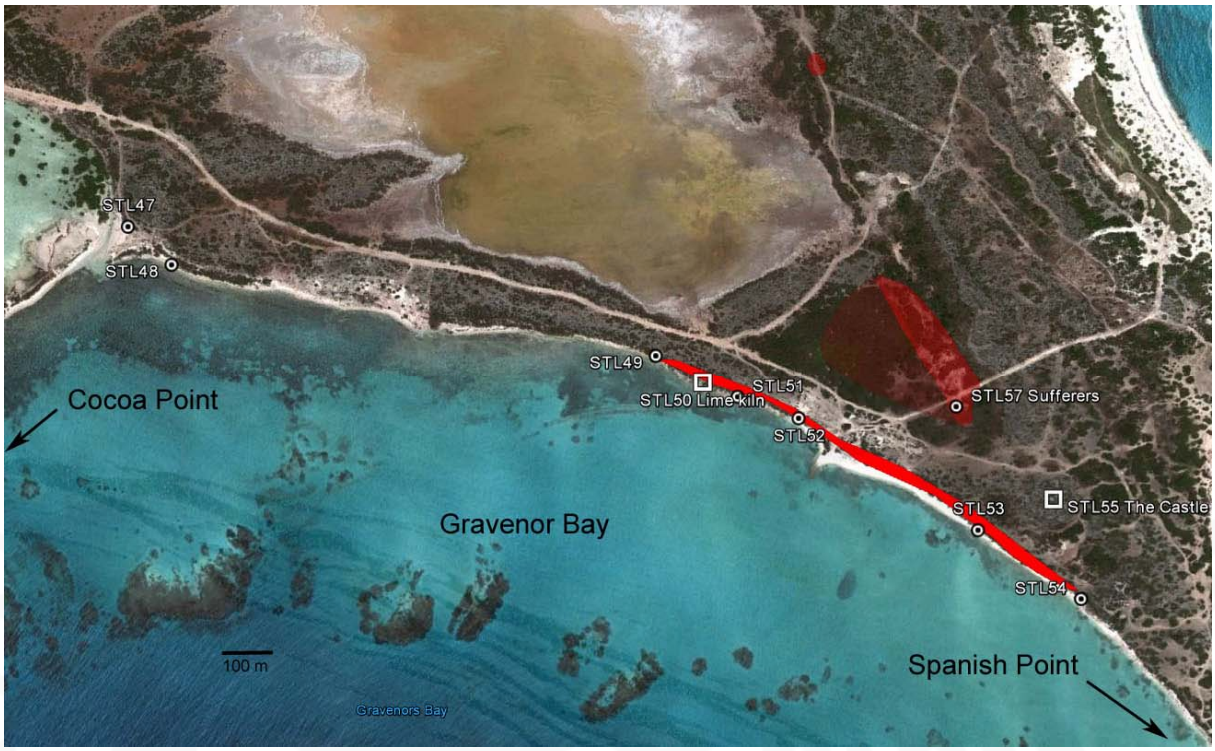
Map 3. Sections of the shell ridge between River and Cocoa Point.

dune with some shell between the road and the beach. Here the limestone edge is low and covered in sand. Here there is more shell in a low ridge north of the road, in front of “Barbuda cottages” and also spread inland more than 50 m east of it, most likely from disturbance associated with Uncle Roddy’s establishment. The ridge here is mainly sand and the shell is on the landward side of it. The increase in conch shell concentrations is associated with a rise in the limestone edge which now crops up again from under the sand-beach. Southeast of Uncle Roddy’s the ridge – full of shell – has been cut into by the road. The scar shows shell deposits, dominated by conchs, more than 3 m in width. By STL42 the ridge has been completely leveled by the road but there is still plenty of shell scattered about. At STL43 – Spanish Well Point – there is again a ridge between the beach and the road and the shell on the surface is more churned. At STL44 there is still a ridge but here it is almost pure sand with less shell. Here there is no edge to the limestone shelf – it slides diagonally into the sea. By STL45 there is no more shell visible, and the ridge has been replaced by a 2 m high sand dune. From this place and all the way out to Cocoa point the sand beach is much wider and has potentially buried the shelf so

either no shell-ridge could form or it is also buried. On this beach there is no shell to speak of but at STL71 there is a pile of conch which has been exposed by a bulldozing scar and contains fragmented but not worn pieces of conch. The whole conchs have no holes or slits but many have their tips knocked off. Many of the conchs in this pile are small (10 cm or smaller) and these have no signs of modification. There are also other species of shell and some coral. Possibly this suggests that there is a shell ridge buried by the sand dune on the western side of Cocoa Point but this is absolutely the only indication of that observed in 2012. The more varied composition of the shells, especially the young conchs unsuitable for eating, may however equally suggest that this is a natural deposit, conceivably derived from the seabed

The tip and eastern side of Cocoa Point is made up of prograding sand dunes, similar to, but on a much smaller scale than Palmetto Point. As there is a clear relationship between shell-ridge formation and the limestone edge it is possible that the shell ridge continued inland of Cocoa Point in the same way as it does landward of Palmetto Point. No unequivocal evidence of this was found during the fieldwork however and it is not clear exactly where the line of the limestone-edge lies although it is clearly south and west of the brackish ponds north of the air-strip. Supporting this Mr Calvin Gore remembers a shell-ridge on the east side of Cocoa Point. Before K-Club was established there was a salt pond which extended all the way past the gate on the northern side of the property but this was filled in and then the ridge disappeared. Further possible evidence for the shell-ridge having stretched further southeast, inland of Cocoa Point is the presence of a well-preserved lime-kiln by the road north of the airstrip (Guðmundsson 2012, 19-24). Not a single shell is to be seen on the surface in the vicinity of the kiln site, but it is located at the head of a causeway crossing the brackish ponds separating Cocoa Point from the mainland and it may be that the shell mined for the lime-burning was brought across it from some location now buried under the airstrip or south of it. Of course the kiln may have utilized the limestone which is plentiful and easily accessible here as elsewhere, but given that copious supplies of shell were to be found in other locations it seems strange to locate the kiln in a place where no shell was to be had.

The limestone edge can be seen again at STL47 and at STL48 it joins the present beach at the head (or northwest end) of Gravenor Bay but although there is



Map 4. The shell ridge in Gravenor Bay. The approximate extent of the Sufferers site is shown in a red shade.

considerable shell on the beach at this point there is no ridge. For 1 km to the east of this point there is no ridge but several piles and scatters of conch were found on the beach, some quite fresh, evidently remains of recent conch gathering and on-shore butchery (see Figs. 6 and 7). There is a clear gradient in the degree of weathering of these conchs, with the ones lowest on the beach freshly brown and shiny while the shells are more weathered and whiter the further up the beach they have been brought. This clearly indicates that shells dropped within reach of the waves are less likely to remain and only those deposited highest on the beach stand a chance of remaining long enough to become weathered. Why this has not lead to the formation of a shell-ridge in this area might be explained by the low elevation of the beach allowing storm waters to occasionally wash away conch concentrations. Wave patterns are no doubt also determined by currents and seabed morphology which it is beyond the present author's capacity to comment up on.

In the western part of Gravenor Bay the limestone bedrock slides diagonally into the sea with no or very little beach ridge of any kind. There is very little soil landwards more or less along the whole bay and the vegetation along the beach is denser than beyond although it picks up again around the site of Sufferers at the northeastern side of the Bay. In the western part there is some sand on the beach

Fig. 4. An undisturbed section of the shell ridge in Gravenor Bay, looking west. Conch shell is not only found on top of the beach-ridge but also under and among the stones.

which in places has formed a low dune. The conchs on the beach look recent, mainly with slits although holes become more frequent towards STL49 where there is no longer any sand but a stony ridge on top of the limestone. Generally there is more coral on the beach and in associated dunes/ridges in Gravenor Bay than west of Cocoa Point. From STL49 eastwards there is more old conch (and other species of shell) in the stone ridge and this conch is very grey and worn with punched holes predominating. No soil has visibly formed in this ridge although there is vegetation on it. It is formed of large (+20 cm) limestone blocks. At STL50 there is a lime-kiln ruin (Guðmundsson 2012, 25-26) suggesting that the shell deposits were mined here in the past, although here there is much more conch left than around the other two lime-kiln ruins already mentioned. East of the kiln the stone/shell ridge is less prominent but continues nevertheless. At STL51 there is again a sandy beach but the stony ridge continues above it, still with a high frequency of very worn shell with holes. At STL52 the ridge has been disturbed by a beach hut – beginning a stretch of some 250 m where there are several such huts and the preservation of the ridge is

generally poor. It is in this area that Watters did his transect survey in 1992 (Watters 1992) and it is clear that considerable damage has been inflicted on the ridge here since then. Interestingly however bulldozing for the huts has created piles of conch and stones with modern refuse, the one closest to STL52 is 1,5 m high, 2-4 m wide and +40 m long. There is more recent shell also in this pile (and similar ones further east) suggesting on site consumption in the present, but these piles also suggest something about the quantity of conch in the ridge, partly obscured by the stones in those parts which have not been bulldozed. East of STL52 the sand beach widens and the stone ridge is partially covered in sand and also is further from the watermark. By STL53 the stone/shell ridge is again practically on the beach which now has little sand. In the Gravenor Bay ridge the conchs are larger, made up of more whole specimens, than in the shell ridge by Palmetto Point. At STL54 the stone/shell ridge ends fairly abruptly as the limestone shelf rises. East of this there are occasional concentrations and spreads of conch but no ridge. On Spanish Point there are spreads of conch far inland, almost across the peninsula. It is possible these have been carried by storms but they may also be related to consumption by humans although no material culture which would suggest archaeological deposits could be observed.

The Gravenor Bay shell-ridge is nearly 1 km long and shares some similarities with the shell-ridge west of Cocoa Point but it is also different in significant aspects. It shares the association with the edge of the limestone shelf but here the ridge is made of much coarser material, larger stones and larger, more frequently complete shell. There are shells almost black from weathering suggesting that they may have been lying on the surface for a very long time, centuries even, but there are no unequivocal cases of knocked-off tips, butchery marks being represented by punched holes and slits only. This along with Watters' dates on shell from the later first millennium AD (Watters 1999, 184) suggests that the Gravenor Bay shell ridge may be significantly more recent than the ridge northwest of Cocoa Point. Watters' suggestion that the Gravenor Bay ridge is coterminous with and a part of the economic activities of the Sufferers Ceramic Age site makes perfect sense.

The east coast of Spanish Point is very different from the western side in Gravenor Bay, with heavy waves pounding the shore. The conditions here are conducive neither for conch harvesting, bringing them ashore nor for their accumulation on the shore. Further north however, in Pelican Bay, a broad sand reef

has formed in front of two coastal lagoons, the landward side of which marks the edge of the limestone shelf. The slightly more sheltered conditions here could have resulted in the formation of a shell ridge but no traces of such were found, neither on the edge of the lagoons nor on the sand bar, although it is conceivable that there is a ridge buried under it. On the beach in Pelican Bay occasional conch shells were observed, clearly deposited by the waves rather than humans. Some have been carried up to 100 m from the watermark but they are characterized by being not very weathered (still white) and being broken differently than the shells in the ridges, the lips frequently intact but other parts broken in random ways.

Discussion

As a result of the fieldwork in 2011-2012 it can now be stated that remains of the Barbuda shell ridge can still be seen along a 6,4 km stretch, from just south of the south end of Codrington lagoon to just south of Spanish Well Point. It is not continuous along this stretch, and possibly never was, especially not at the northern end and possibly not either along the present coast between JA1 and Spanish Well Point. Including the northern end where the ridge is represented by a scatter of conch-piles lined up along the palaeoshoreline, the preserved shell-ridge is 4,5 km long in total, in five main sections. Its preservation is variable, from complete obliteration in the area of the sand-pit by the jetty (and possibly at Cocoa Point), to more general disturbance related to modern agriculture and road building. Although the ridge is possibly nowhere in a completely pristine condition there are also long stretches where significant parts remain intact.

It is possible that the ridge stretched even further southeastwards and that it is buried under sand dunes on the west side of Cocoa Point, and that further east it has been obliterated by a combination of mining for lime burning and extensive landscaping in relation to the resorts on Cocoa Point (David Watters and Calvin Gore pers. comm. 2012). The location of the lime kiln north of Cocoa Point is certainly difficult to account for unless there were shell accumulations in the vicinity when it was in operation (presumably in the 18th-19th centuries, cf. Tweedy 1981, 138-39), but more intensive research would be needed to verify this. Further indications of archaeology in this area now disappeared are found in the Antigua & Barbuda sites and monuments record. The ceramic find site Salt Pond Cloutier (BA-015) is, based on the grid reference, on the landward side of the reef where K-Club is now, on the edge of the limestone. Here a “Grinding stone (986-08-116) & shell.” were found and the database gives the date 700 AD, which presumably is based on typology. This may be evidence for habitation in conjunction with the shell ridge. At another site called ‘Coco airstrip’ (BA-017) ‘prechristian’ remains (“No surface remains, shell & flint, found by JEF, Jan 88.”) were found, again a possible indication of habitation on or in the vicinity of a now disappeared ridge.

In the eastern part of Gravenor Bay there is a 1 km long shell-ridge which clearly has resulted from the same sort of processes as the ridge northwest of Cocoa

Map 5. Overview map showing preserved and visible stretches of the shell-ridge marked in red.

Point but has generally much younger dates. If it can be considered a part of the same feature, shell ridge formation can be said to have taken place along a nearly 12 km long stretch on the southwestern coast of Barbuda. Of these 12 km a shell ridge is now visible along 5,5 kms, and has been completely removed in recent times on two stretches totaling at least 0,5 km. Potential shell ridge, now buried or obliterated, can be estimated to have stretched to a maximum of a further 3,5 kms, but this must remain hypothetical for the time being.

The Barbuda shell ridge has been the subject of considerable discussion and research, especially by David Watters (Watters & Donahue 1990; Watters et al. 1992, Watters 1999, see summary in Vésteinsson 2011, 4-5) and lately by the present author and collaborators in the *Barbuda Historical Ecology Project*. A few excavations have taken place on and adjacent to the ridge and a significant number of conch shells collected on the surface have been subjected to radiocarbon dating (Fig. 5, Annexe). These allow the following observations:

- The shell-ridge along the palaeoshoreline east of Palmetto Point formed in the first and second millennia BC. At present the single late 4th millennium BC

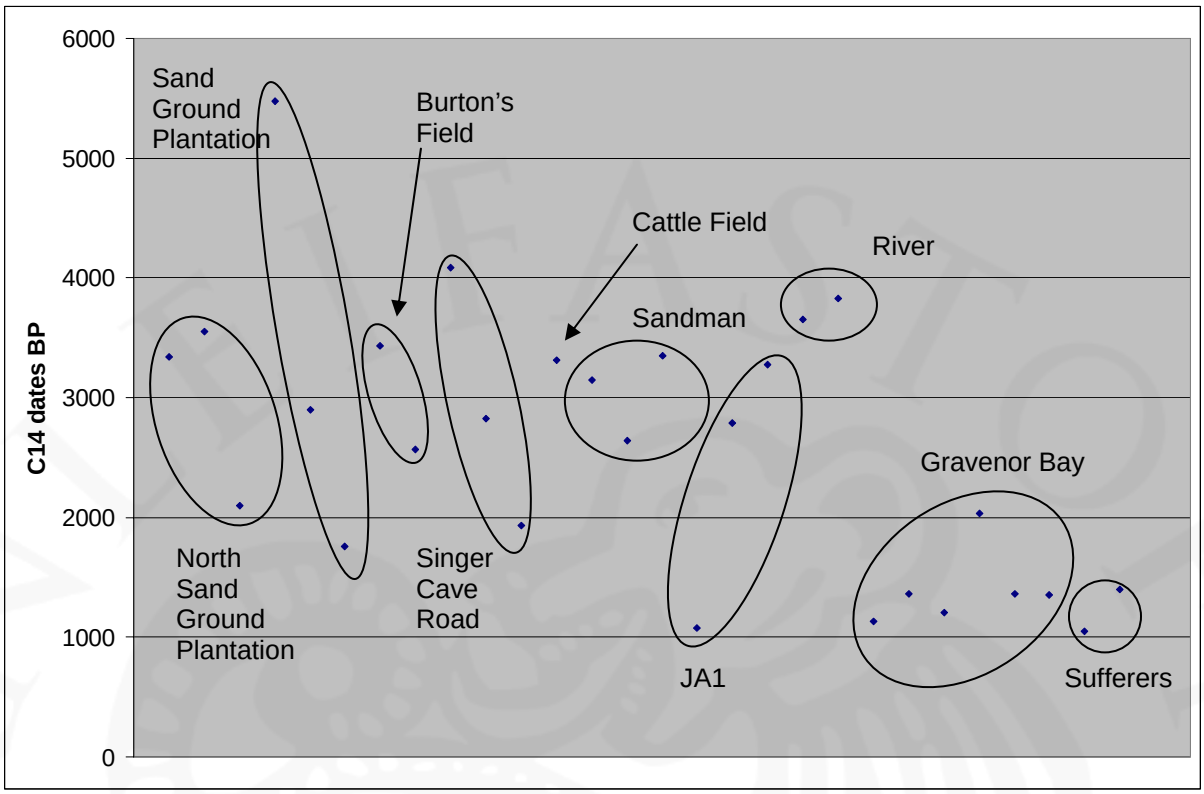


Fig. 5. Radiocarbon dates (uncalibrated) associated with the shell-ridge. See also Annexe.

date looks like an anomaly. The distribution of the dates does not suggest that the Palmetto Point sands prograded gradually, but rather that the entire length of the palaeoshoreline became buried rather quickly after the beginning of the first millennium AD.

- Along its northern stretch the ridge is associated with at least two probable Archaic habitation sites (River and Cattle field) and Archaic material culture has also been observed on two locations on the ridge itself (Burton's field and JA1).
- Shell ridge formation is however not essentially or even primarily an Archaic feature but has been continuous since the initial colonization of Barbuda to the present day. The erroneous impression that the shell ridge is an Archaic phenomenon is an effect of most of the available dates being on that part of the ridge which became fossilized as a result of the prograding of Palmetto Point beginning in the early 1st millennium AD, shortly after the transition from the Archaic to the Saladoid Ceramic Age (the earliest Barbudan Saladoid dates from Seaview are from the first century BC). That the ridge formation continued through the Ceramic Age and historic times is suggested by the

single Ceramic Age date from JA1 and the dates of the ridge and associated Ceramic Age site of Sufferers in Gravenor Bay. It may be significant that the only outlier among the Gravenor Bay dates is on the only conch shell not with a punched hole which otherwise were selected for – that shell may be earlier than the introduction of the punching technique and there may be many more such in Gravenor Bay. In the same vein the latest dates from Singer Cave Road, Sand Ground Plantation and North Sand Ground Plantation cluster around 2000 BP, i.e. well into Barbuda's Ceramic Age, suggesting that shell ridge formation does not relate directly to technological or cultural change. Queen conch is harvested and consumed by the present population of Barbuda, as can be seen from recent remains on Gravenor Bay and is confirmed by locals (Calvin Gore pers. comm. 2012), and has been a part of the Barbudan diet through historical times (Hambrecht 2011, 21 (table 1)). It is possible however, likely in fact, that the relative significance of conch in the diet of Barbudans was greatest in Archaic times, less so during the Ceramic Age and even less in historic times, and that this development may be reflected in the ridge accumulation and the dates.

- although shell-ridge formation has most likely been continuous from the initial colonization of Barbuda to the present day the rate and location of accumulation is also affected by where people lived in different periods. In this there seems to be a general southward shift from the Archaic, when settlement seems to have been concentrated in the area east and south of present day Palmetto Point, to the southern end of the island, to Sufferers and Welches, and possibly also northeastwards to the middle of the eastern coast, where Seaview and Indian Town Trail seem to represent continuous occupation from the end of the first millennium BC to the middle of the second millennium AD. Among many future research questions is where the Seaview/Indian Town Trail inhabitants got their Queen conchs from; whether they also collected their conchs on the western shore, and if so where, and how this might reflect on their relationship with the people of the south coast.

During the fieldwork in 2012 it was observed frequently how closely shell-ridge presence was associated with beach morphology. Where there is a low limestone shelf defining the shoreline, usually bare but in some places broken up and buried in

Figs. 6 and 7. To the left recently harvested conch shells discarded at the lowest point of the beach with waves lapping over them, waiting for the next high tide or storm to wash them out to sea. To the right more weathered and fragmented shells 4-6 m higher on the same beach in Gravenor Bay. These shells, already embedded in sand and stone, are liable to eventually form a shell-ridge.

stones and/or sediments, and where this creates a bank of 2-3 m above the high-water mark, there is almost everywhere a shell-ridge. Where the limestone shelf slides diagonally into the sea, making the beach incline more gradual, and where there are wide sand beaches with a similarly limited incline, there is no shell-ridge. This relationship is explained by the tendency to butcher and discard the conch shell at the earliest possible opportunity once it has been brought out of the water. Because the shell is heavy (mean weight is 1,8 kgs among old animals – Randall 1964, 252) and large, a conch collector is liable to extract the meat and drop the shell as soon as is convenient. Where there is a wide sandy beach or bedrock sliding gradually into the sea this place is likely to be the first one after the collector is out of the water. The shells are then discarded where the waves, or at least the next storm, can easily get at them and wash them out to sea again, eventually braking them apart and gradually fragmenting them until they become beach sand if they don't get buried in the seabed. Where however the collector has to climb onto a bank or ledge, out of reach of the waves, before the conch shell can be butchered (likely requiring tools left on the shore well out of reach of the waves), then the shell is liable to accumulate in that spot. Rousseau's observation of the completely different

mollusk species composition on the ridge itself (in Burton's Field) on the one hand and on a possible habitation site (Cattle Field) adjacent to it on the other, where the ridge mollusks are almost entirely Queen conch while the conch is only a small part of the much more variable species composition of the habitation site, supports this interpretation. All sorts of mollusks were brought ashore but on account of their weight and bulkiness only the Queen conch was dropped on the beach or beach ridge. The weight, bulkiness and immense durability of the Queen conch also means that they are less liable to be dispersed or become degraded than any other type of faunal food remains. An accumulation of Queen conch will soon become a permanent feature of the micro-environment, trapping soil and sand and thus attracting vegetation, but also changing wind patterns potentially influencing beach sand movements and dune formation. The anthropogenic element necessary for shell-ridge formation is limited to the initial selective discard of this large shell. Thereafter the shell-accumulations will have been subject to a variety of natural processes, and the resulting shell-ridges can only be seen as natural formations albei ha hey involve anthropogenic material. Different sorts of processes have affected the conch accumulations in different places. In the northern segment of the ridge, the degree of fragmentation is considerable and the shell has frequently been observed to be water-worn. This is plausibly related to root-action, suggestive of a mangrove environment which may have been there when the shell was discarded but may also have developed long after the ridge initially formed. A completely different type of process was observed at the southern end of the ridge, west of Cocoa Point, where the shell-ridge forms a part of a large sand-dune, the shape and development of which is determined by wind patterns, storm-waves and resulting sand-movements. A third type of process is evident in the Gravenor Bay ridge where the shell are embedded no in soil but large stones, a beach dune of sorts but one behaving differently from a sand-dune and affecting i.a. the fragmentation of the shells differently.

Recognition of the shell-ridge as the result of natural processes involving anthropogenic material is important as it affects how its study is approached. It seems for instance that although layers have been identified in the ridge, both at JA1 and in Burton's field, these cannot be equated with conventional cultural layers. An indication of this comes from Burton's field where the much lower layer produced a much higher date, and also from the fact that the majority of dates, spanning

thousands of years, are on shell collected on the surface of the ridge. A potentially similar phenomenon has been observed in a coastal shell deposit in Hawaii (Khaweerat e al. 2010) and although there the mixing is assumed to be human induced it is possible that such mixing is in fact more correctly attributed to natural processes.

As a result it can now be proposed that in the debate initiated by David Watters and Jack Donahue (Watters et al. 1992, 35-37) both sides turn out to have been right. Donahue was right that the homogeneity of the species composition in the ridge can only mean that the shell were selectively deposited by humans but Watters was also right that the ridge is in all other aspects essentially a natural feature.

To sum up, a shell ridge forms where:

- Queen conch is naturally abundant
- such abundance is found in shallow coastal waters accessible to humans wading or diving
- harvested conch can be brought ashore with relative ease (e.g. neither high waves nor high cliffs)
- beach morphology dictates that the conch will only be discarded out of reach of the waves

These are only the preconditions. Once they are met the ridge will be subject to a variety of natural and taphonomic processes which will affect its chances of long-term survival and its eventual shape and condition.

Annexe: Radiocarbon dates on the shell-ridge and associated sites

	Shell-ridge date BP (uncalibrated)	Associated site date BP (uncalibrated)	Lab reference	Published in
North Sand Ground Plantation	3340±70		SI-6695	Watters & Donahue 1990, 376; Watters et al. 1992, 39
North Sand Ground Plantation	3555±45		PITT-0590	Watters et al. 1992, 39
North Sand Ground Plantation	2100±35		PITT-0718	Watters et al. 1992, 39
Sand ground Plantation	5480±100		SI-6879	Watters et al. 1992, 39
Sand ground Plantation	2900±50		PITT-0592	Watters et al. 1992, 39
Sand ground Plantation	1755±75		PITTT-0719	Watters et al. 1992, 39
Burton's field	3430±15		UCIAMS-107938	Rousseau 2012
Burton's field	2565±20		UCIAMS-107937	Rousseau 2012
Singer Cave Road	4085±85		SI-6696	Watters & Donahue 1990, 376; Watters et al. 1992, 39
Singer Cave Road	2825±75		PITT-0591	Watters et al. 1992, 39
Singer Cave Road	1930±65		PITT-0720	Watters et al. 1992, 39
Cattle field		3315±15	UCIAMS-107939	Rousseau 2012
Sandman	3150±55		SI-6880	Watters et al. 1992, 39
Sandman	2645±50		PITT-0593	Watters et al. 1992, 39
Sandman	3350±55		PITT-0721	Watters et al. 1992, 39
JA1	1075±60		PITT-0589	Watters et al. 1992, 39
JA1	2790±35		SUERC-33605	Friðriksson et al. 2011, 20
JA1	3280±35		SUERC-33604	Friðriksson et al. 2011, 19

River		3650±35	PITT-0717	Watters et al. 1992, 32
River		3825±25	PITT-0731	Watters et al. 1992,
Gravenor Bay transect	1135±50		Pitt-1233	Watters 1999, 196
Gravenor Bay transect	1365±45		Pitt-1234	Watters 1999, 196
Gravenor Bay transect	1210±60		Beta-103890	Watters 1999, 196
Gravenor Bay transect	2030±60		Beta-103891	Watters 1999, 196
Gravenor Bay transect	1360±60		Beta-103892	Watters 1999, 196
Gravenor Bay	1350±60		Beta-103892	Watters 1999, 196
Sufferers		1050±30	PITT-1231	Watters 1999, 196
Sufferers		1400±60	Beta-103894	Watters 1999, 196

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