THE ISLAND OF THE PALISADOES?

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The Windward Palisadoes, November 14, 2004 (photo: Marine Geology Unit)

Hurricane Ivan

On the night of September 10th, 2004, Hurricane Ivan passed close to the south coast of Jamaica, leaving behind a trail of destruction not seen in Jamaica since the passage of Hurricane Gilbert, almost exactly sixteen years before. One of the more significant destructive aspects of Ivan was the storm surge generated along the south coast of the island. It caused the sea level to rise as much as 2 metres above the highest it usually comes, and perhaps more in places. Early Saturday morning, the fury of the storm surge became evident, when it was realized that the road to the airport along the Palisadoes was impassable. Ivan had blocked the road with immense quantities of sand and debris. The sand had also formed, what would later be called the "Palisadoes New Beach," new strips of land on the Kingston Harbour side up to 50m wide (Figure 1). The stretch of road between Harbour View and the airport is on the narrowest part of the Palisadoes. Before the storm, it was partly protected by sand dunes about 2m high. Now, since the storm, the dunes' average height above sea level is probably less than a metre. Had Ivan delivered a more severe blow, it is possible that the sea would have broken right across the road to form a channel from the open sea side through to the harbour.

Figure 1. Aerial view of the narrow part of Palisadoes, looking towards Harbour View, taken just after Hurricane Ivan (photo, J.S. Tyndale-Biscoe Ltd.)

Although beach systems gradually recover naturally from such storm events, this part of the Palisadoes is in a precarious state, having lost much of the sand and rocks that protected it from the sea. If another category five storm like Ivan were to hit us soon, say next year, would this part of the Palisadoes be able to resist its onslaught, or would it be breached by the sea? Will the airport and Port Royal become separated from the rest of Jamaica to form an island, the island of Palisadoes?

Palisadoes Island

To hazard a guess (pardon the pun), at what will happen to the Palisadoes tomorrow, one needs to how it got to the stage it is at today. As is well known, The Palisadoes is a strip of land, some 14 km long, that almost completely encloses Kingston Harbour (Figure 2). Scientists have called it both a spit and a tombolo. A spit is a long narrow bit of land made up of beach sediment carried by the current along the shoreline beyond a point where the coastline orientation changes abruptly. One end of a spit is attached to the shore and the other sticks out into the sea. A tombolo is a spit of sand linking an island to the mainland or to another island, usually forming on the sheltered side of the island (Keary, 2001). Let us call Palisadoes a spit complex as it is evident that more than one spit has existed in the past.

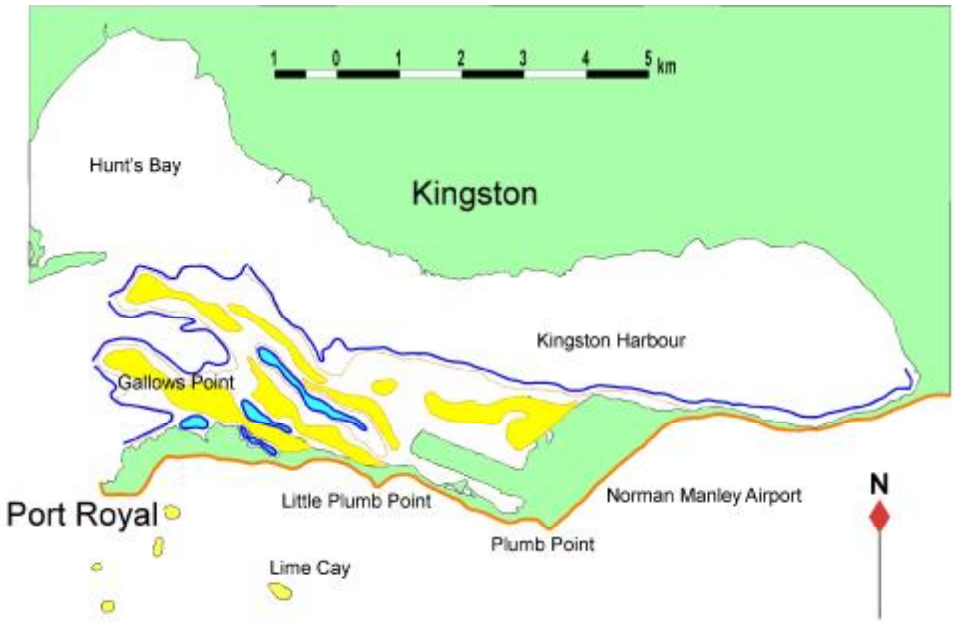

Figure 2. Map of Palisadoes. Green, land areas; yellow, shoals inside the harbour, cays outside the harbour; blue line, edge of deeper water inside the harbour; peach line, extent of shallow water; orange line, southern side of Palisadoes spit complex.

When did the Palisadoes first form?

No one is sure when the Palisadoes first originated. In its present form it probably dates back some 4000 years to the time when the present sea level was more or less established, following the ending of the last ice age, some 12,000 years ago. Historical records show that Port Royal was once an island totally cut off from Jamaica. The island of Port Royal and other cays (little islands) were probably linked together and to mainland Jamaica by a series of spits to form what is now the Palisadoes. Southeast stretches of the Palisadoes (such as in front of the Norman Manley airport and Plumb Point, and Rocky Point), could possibly be zones covering former cays. However, we have no direct evidence that this is the case. Figures 3 to 8 are somewhat speculative interpretations of how the Palisadoes complex may have developed. Some of these stages may have resulted from conditions during high sea levels that existed, perhaps about 120,000 years ago, before the last major ice age.

Step 1.

Westerly longshore currents developed a spit extending from the mouth of the Hope River.

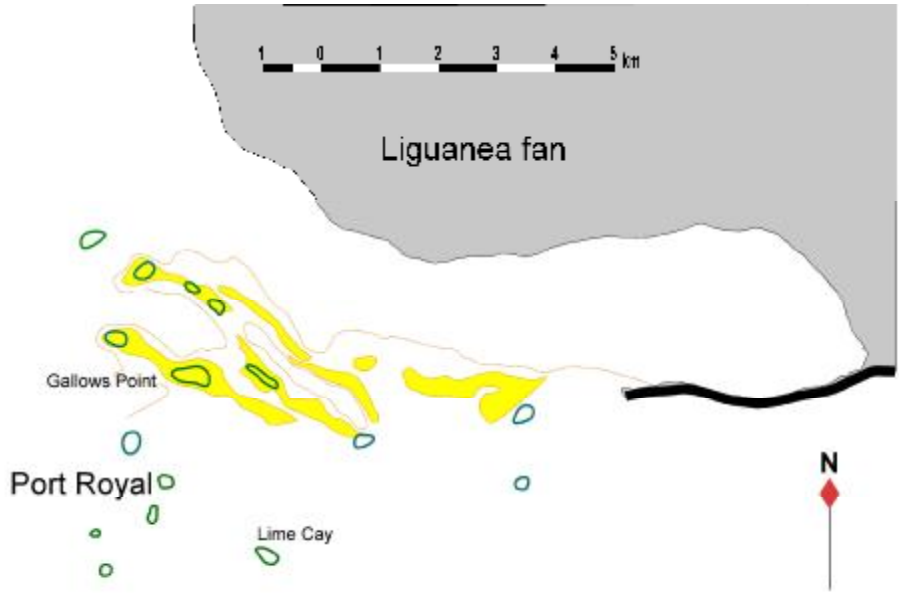

Figure 3. Initial Development of the spit (black line). Green, cays; yellow, shoals; peach line, extent of shallow water.

Step 2.

Continued supply of sediments extended the spit into the region of what is now the airport. From here spit growth possibly followed the course of the shoals extending northwesterly from the airport.

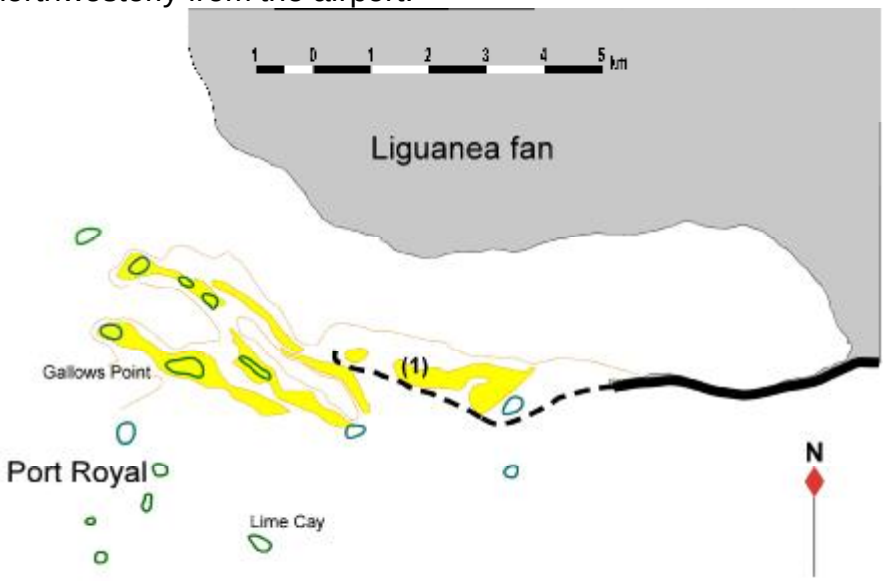

Figure 4. Extension of spit 1 (black line) over shallows northwest of the present airport. Green, cays; yellow, shoals; peach line, extent of shallow water.

Step 3.

The axis of drift then switched to a more westerly direction, extending the spit complex as far as Little Plumb Point, which was then a cay. The extension beyond Little Plumb Point probably was initially also directed northwestwards, along the line of the mangrove islands that extend today as far as the deepwater channel.

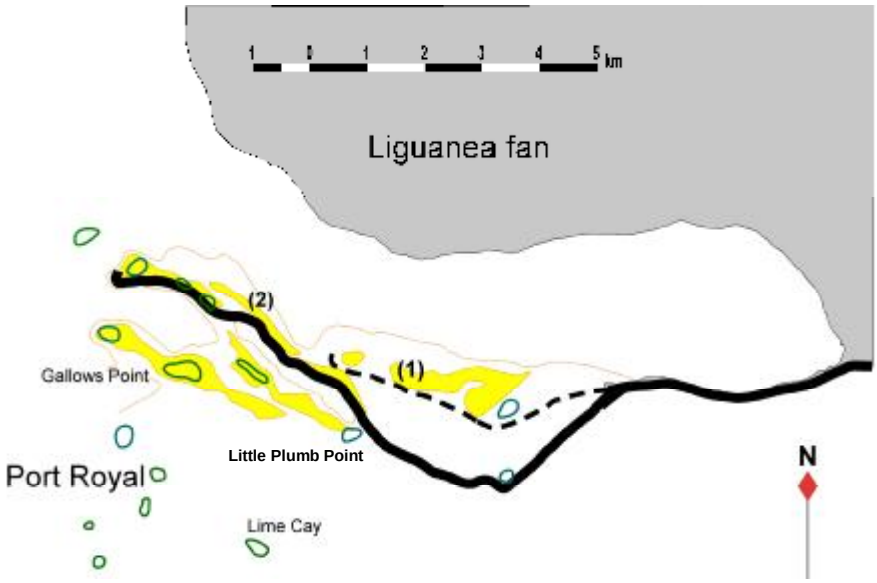

Figure 5. Evolution of a new spit (2) extending from what is now Plumb Point and capturing the sediment supply from the previous spit (1). Black line, spit; green, cays; yellow, shoals; peach line, extent of shallow water.

Step 4.

Later, a new spit evolved as far as Rocky Point cay. Further westward extension of this spit reached the present position of the hurricane refuge. Each new westerly development of the spit cut off supplies of sediment, in turn, to the older spits, resulting in their degradation to form the shoals and banks now colonized by the mangroves.

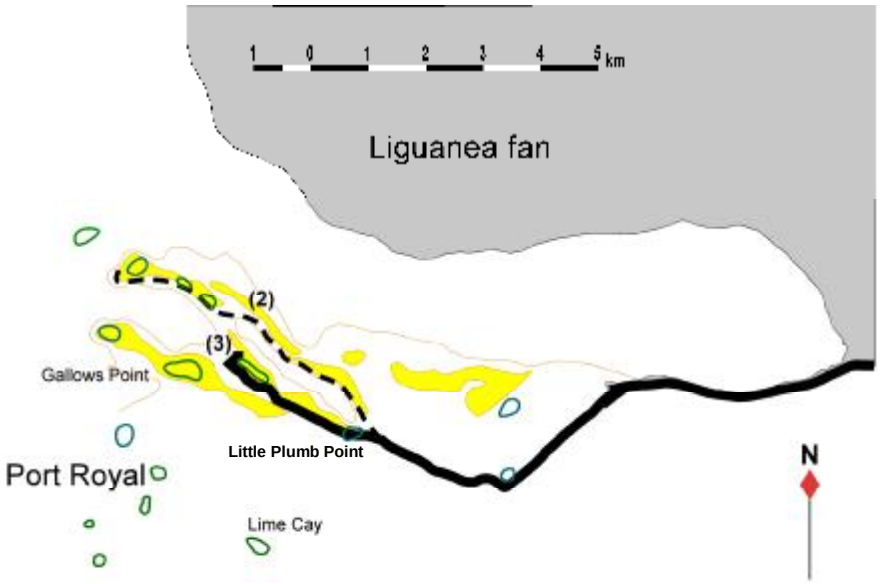

Figure 6. A new spit (3) developed from what is now Little Plumb Point, embracing the shallows associated with the hurricane refuge. Black line, spit; green, cays; yellow, shoals; peach line, extent of shallow water.

Step 5.

A similar change in orientation formed a spit that extended from Rocky Point beyond Gallows Point to the shipping channel.

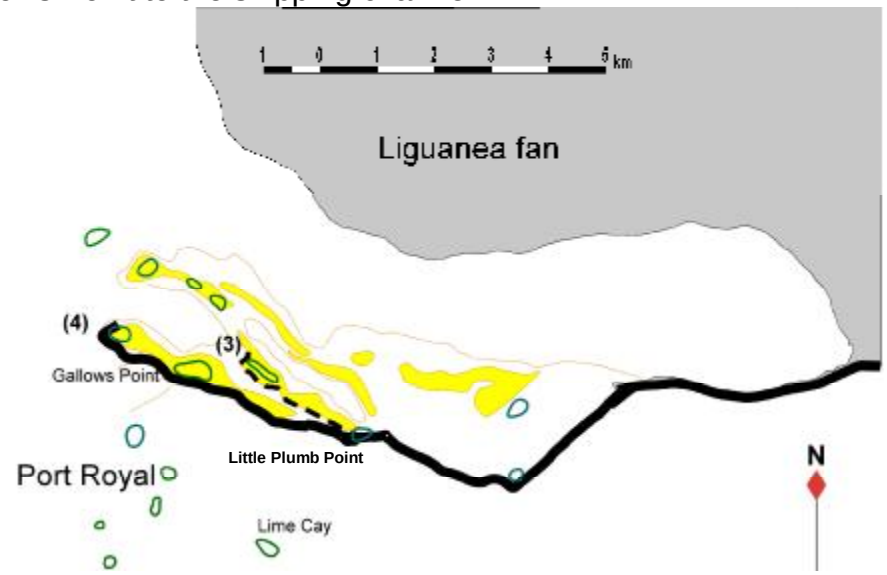

Figure 7. Later, longshore drift extended a spit (4) from Little Plumb Point put past what is now Gallows Point to the edge of the deep channel. Black line, spit; green, cays; yellow, shoals; peach line, extent of shallow water.

Step 6.

The final stage in the formation of the Palisadoes was the extension of the spit westwards to Port Royal cay. This was still a cay at the time of the Spanish conquest (Long, 1744), but by natural evolution, assisted by man, is now firmly joined to the rest of Palisadoes. The earthquake of 1692, although catastrophic for the inhabitants of Port Royal, was merely a temporary setback to the spit producing process.

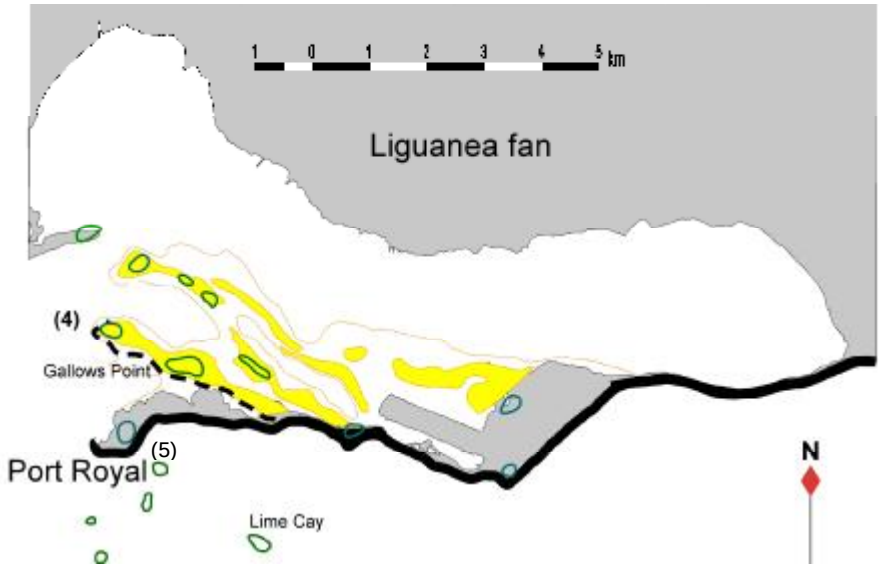

Figure 8. The final stage in the development (5) of the Palisadoes through extension of the spit complex to Port Royal. Black line, spit; green, cays; yellow, shoals; peach line, extent of shallow water.

What moves the beach sediment?

Beaches, and the spits their sediments help to construct, are dynamic systems in which the beach sediment, be it sand or pebbles, is in a continuous state of movement, in reaction to the force of breaking waves, currents near the shore, and the wind blowing over the upper, dry part of the beach. The dominant waves approaching the Palisadoes come from the southeast resulting in a current which moves the beach sediment gradually westward along the shore. This gradual movement of sediment from east to west does not occur at a steady pace. During stormy periods the energy of large waves breaking on the beach is able to move large sized pebbles and boulders, whereas in times of calm seas longshore movement of sand predominates and the whole process of transport along the shore will be slower.

On stretches such as that fronting the airport, the waves approach the beach and carry sediments in and out at right angles to the shore. Along here too the wind has generated sand dunes that were 5 to 6 metres high before Ivan.

What is the source of the sediment?

At the Harbour View end of the Palisadoes beach materials must be replaced by supplies of sediment coming even further from the east. If the Palisadoes were not replenished by sediment, it would become detached from the mainland getting smaller and smaller through progressive loss of its eastern end, and eventually cease to exist. The Hope (Figure 9), and Cane Rivers and possibly other sources further east, bring sand and gravel down to the coast, where it is added to the beach system and is gradually moved west to the Palisadoes. Landslides from human-induced denudation of the hillsides add to the sediment load. The Hope and Cane Rivers are seasonal (flow in the Hope River reaches the sea less than once a year on average), and the sediment only gets to the Palisadoes when they are in flood and even then most of the sediment goes out to sea. Some of the sediment is removed by mining before it gets to the Palisadoes. Apart from the rare, catastrophic hurricane events, the coastline is subject to a variety of weather systems that generate waves of varying size and energy at the beaches, as well as rainfall of varying intensity and duration over the river basins. In some years the weather conditions may be such that beaches will accumulate more sediment and become more extensive. In other years weather conditions may be stormier on average, leading to erosion.

These several factors of varying sediment supply and alternating cycles of calm and stormy weather in the zone nearest to the sediment source, i.e. the eastern Palisadoes, could lead to conditions in which sediment supply to this part of the beach system might be severely curtailed over an extended period.

Figure 9. The mouth of the Hope River post Hurricane Ivan (photo: Marine Geology Unit)

Rare destructive events.

These are mainly tropical cyclones, with earthquakes playing a locally important, but infrequent role. From the point of view of damage to Port Royal and the Palisadoes, the worst earthquakes in historical times have been that of 1692, which destroyed much of Port Royal, with largely unknown effects on the rest of the Palisadoes (Pawson & Buisseret, 2000; Long, 1774), and the well-documented event of 1907. Photographs taken after the 1907 earthquake show damage, due to liquefaction effects, to buildings at Port Royal and fissuring of the ground at the eastern end of the Palisadoes, near to where the Donald Quarrie school now stands (Figure 10). In 1907 part of the beach system at Port Royal collapsed into the sea.

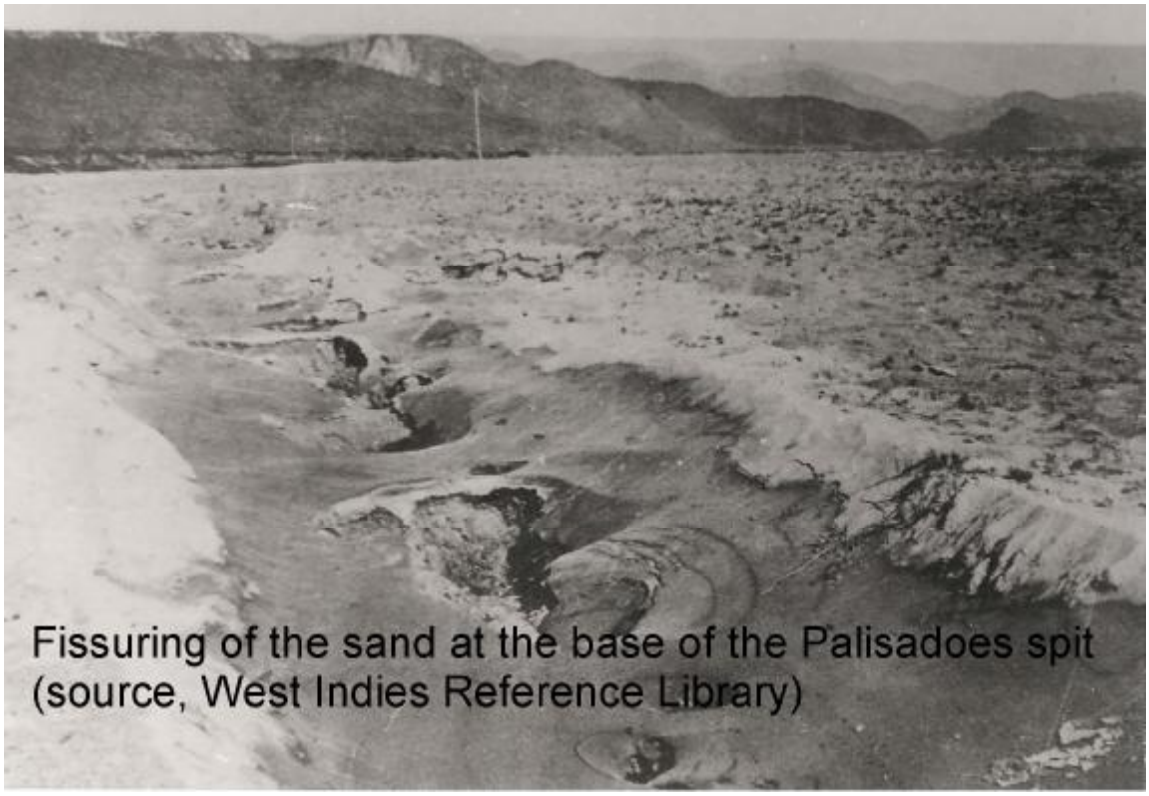

Figure 10. Fissuring of the ground after the 1907 earthquake, due to liquefaction. This site is close to the eastern end of the Palisadoes (photo, West Indies Reference Library).

The worst hurricane on record appears to be that of 1722. It lasted 14 hours, raised a reportedly five-metre storm surge in Port Royal, made that town a temporary island again, and created five breaches or channels through the eastern part of the Palisadoes (Long, 1774; Hendry, 1987). On a map of Palisadoes made by Gascoigne in 1728 the locations of these channels can be matched closely with current topographic and bathymetric maps of the Palisadoes (Figure 11; Ewbank & Partners, 1960). The undersea depths on the harbour side show anomalies that we interpret to be the remnants of sediments deposited by surges through the channels in the 1722 event, in much the same way as happened with Ivan.

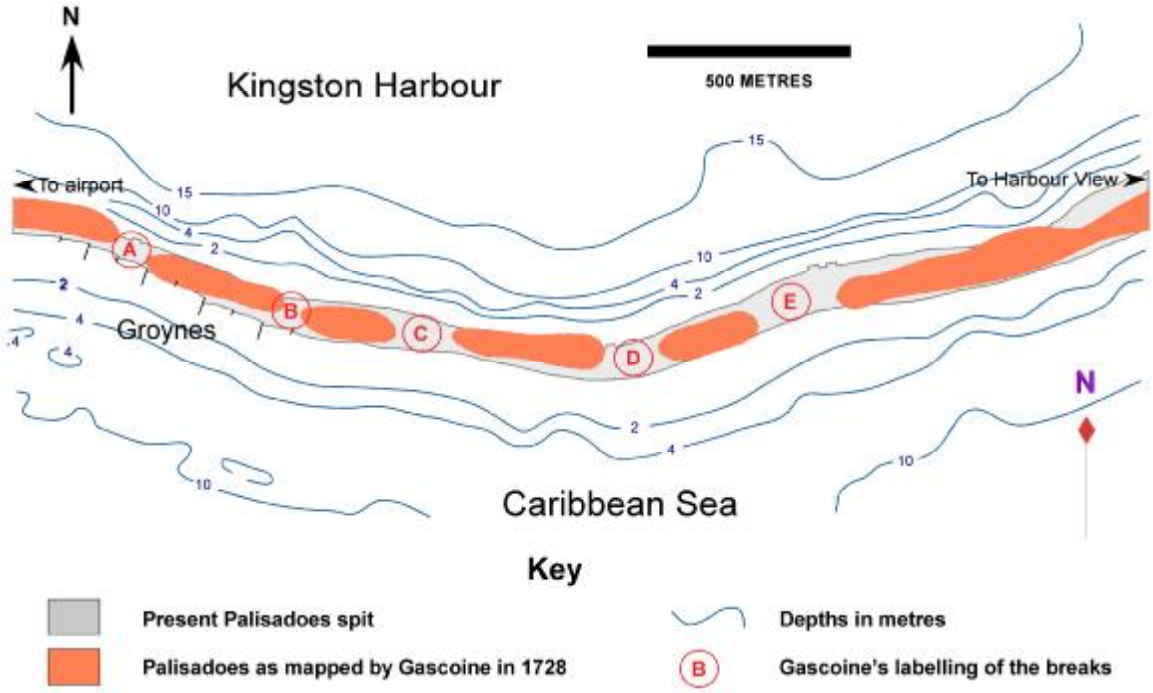

Figure 11. Approximate positions of breaks in the Palisadoes (A to E) resulting from the 1722 hurricane. Depths inside the harbour from the 1960 Kingston Harbour study; depths outside the Palisadoes compiled from British Admiralty surveys.

Despite their widths, the four easternmost breaches from the 1722 hurricane were healed within a few years and certainly by about 1750 (French Marine, 1750). By contrast, the western breach persisted, was reopened on two subsequent occasions, is today one of the narrowest parts of the Palisadoes, and sports a groyne field which is supposed to protect this spot (Figures 12, 13, 14). The wave action and rate of longshore transport in this corner of the spit probably include components that favour erosion. Overall, the groynes along here seem to have helped in minimising erosion problems, although they received a hard blow from Ivan.

Figure 12. Groyne on Palisadoes as they appeared post Hurricane Ivan on September 13, 2004. (photo, Marine Geology Unit).

Figure 13. Looking towards the airport from the groynes, October 11, 2004 (photo, Marine Geology Unit).

Figure 14. The Palisadoes groynes as they appeared before Hurricane Ivan, in July, 2002 (photo, Marine Geology Unit).

Tsunami threat

We have all seen the harrowing pictures of the tsunami disaster that has hit the Indian Ocean region. Does the threat of tsunami exist for Jamaica and the Palisadoes? It does, although the likelihood of an event of the magnitude of the Indian Ocean one is very small. There are several records of tsunami that have occurred in the Caribbean (e.g. Lander & Whiteside, 1997) and in Jamaica particularly (e.g. Shepherd, 1971).

A tsunami can be likened to a hurricane storm surge in some ways, except that it is a sudden, unexpected, very short-lived but potentially very destructive surge consisting of several waves breaking in quick succession. The warning time potentially available for a tsunami originating in the Caribbean, be it resulting from an earthquake, an exploding volcano, a submarine landslide, or even a small meteorite splashing down in the sea, would range from a few minutes to as much as two hours, depending on location. There is presently no warning system in place. Its effect on the Palisadoes would be the creation of washovers, similar to those from Ivan, in a severe case, perhaps also the creation of channels across the narrow part of the spit.

Rising sea level

It is now widely accepted that sea level has been rising gradually over the past century, and will continue to do so at an increasing rate in the future. A rise of at least half a metre, perhaps much more, will occur by the end of this century (see, e.g. http://news.nationalgeographic.com/news/2004/11/1109_041109_polar_ice.html#main). How significant will this rise be for the Palisadoes, where the ground elevations are frequently less than half a metre? Because the beach sediments of the spit are continually being moved around by the sea, it is more than likely that the beach would rise in elevation to keep pace with rising sea level. On the other hand, areas that have been paved over, like the Palisadoes highway, and the airport runways, do not have the natural means to cope with a sea level rise and would be flooded. Man would need to intervene to raise the levels of these periodically. In other words, the spit should survive, even though it may get holes punched through it in bad storms, but man-made structures will require periodic attention. These include the groynes at the narrowest part of the spit. Any new groynes put in place here will have to cope with rising sea level.

What of the future?

Here the story becomes entirely speculative. A glance at the map of Palisadoes shows that the shape of the spit at Port Royal mimics the probable shapes of the spit at former positions in its development, at Plumb Point, Little Plumb Point and Rocky Point. Does this mean that future extension of Palisadoes will try to take a northwesterly course? Perhaps this is what was beginning to happen before the disaster of the 1692 earthquake caused the northwest section of Port Royal to slip below the sea.

On the other hand the spit can only extend so far before the currents associated with tidal flow in and out of the harbour, and the flow of the Rio Cobre prevent further westerly extension. This is what must have happened in the case of Steps 2 and 3 above. I suspect that Port Royal is the end of the line for this particular development of the complex.

As I have suggested, in the past, new spit extensions have been to the seaward of the existing spit when a change in direction of development occurred. Each time this happened the new spit captured the sediment supply from the previous one, which gradually degraded to form the banks of mangrove stands in the harbour today. Perhaps future developments will generate a spit complex embracing some of the cays now outside Kingston Harbour. It may be that Gun Cay will be the next candidate for incorporation into the Palisadoes complex.

Acknowledgements

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http://www.jamaicaobserver.com/news/html/20050101t210000-0500_72432_obs_can_palisadoes_survive_another_hurricane_.asp .

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