The Impact of Climate Change on The Bahamas – a Review of Early Forecasts

By Neil Sealey

Despite the various rebuttals and objections to the concept of climate change, it is fair to say that this is a generally accepted fact among the scientific community, and by the governments of most countries. The Bahamas has conducted its own study, published in the *Bahamas Journal of Science* in 2001 (Martin & Weech, 2001), and the BEST Committee on Climate Change has posted its first letter on the Internet. (NCCC, 2001)

This article is not about the validity of climate change, even though not all the findings are necessarily accepted or proven. Rather it is about the rush to judgement on the impact that climate change will have on the Bahamian environment (Reilly, 2001). Despite the considerable resources that have been expended on research into climate change, very little has been spent on the impacts, and yet virtually all the reports include statements about these possible impacts. Largely these have been made by persons unqualified in the field, and are not based on specific studies. Nevertheless they carry much weight with the general public, and generally they foretell doom and disaster (Bruce, 1998).

The purpose of this paper is to review some of these statements and to examine where possible threats are likely. In addition a limited attempt, based on local knowledge of the relevant geographical and geological processes, will be made to forecast the realistic impact of the more foreseeable climate change we might expect in the next 50 years.

Nature of Change

The changes that might be expected to affect the environment in the next 50 years are:

1. a rise in temperature of 3-5^{0}F/2-3^{0}C
2. a rise in sea level of 2-8”, or a rate of 1.0 to 4.0 mm/year
3. a change in the frequency of tropical storms

Changes due to Temperature Rise: These focus almost exclusively on the incidence of bleaching in corals, and the resultant death of coral reefs, perhaps globally.

Changes due to Sea Level Rise: Sea level will rise because more polar and glacial ice will melt than is returned to the ice caps as snow each year. Even this is not certain, as although there will be global warming, it is not simply warming that causes glaciers to melt. All glaciers are melting to some degree at their terminuses, but whether they are advancing or retreating is determined by the balance between melting at the foot and accumulation at the head of the glacier. Although many glaciers are retreating, there are also some that are advancing at the present time, both in Alaska and in Antarctica. It may be that global warming will cause increased precipitation – and increased snowfall on the ice caps – and there will be a period when the sea level will **not** rise (Allen, Myles et al: 2001) (Wigley, 1999). Despite this, present measurements indicate mass wasting of ice fields and glaciers, and a rise in sea level of about 3mm per year.

Figure 1. Marjerie glacier in Alaska

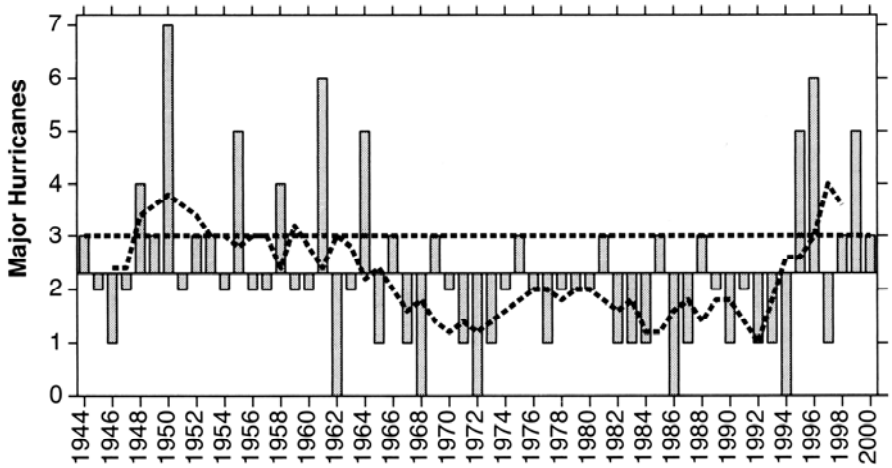

Figure 2. Caribbean hurricane activity 1944-2000 showing periods of above and below average activity. (Goldenberg, Stanley B: 2001, Recent Increase in Atlantic Hurricane Activity, Science, Vol 293, p 474.)

Changes due to Increased Tropical Storm Frequency: Possibly there will be more tropical storms, and more intense ones, because sea temperatures will be higher. The last 8 years have seen the highest level of hurricane activity that the region has ever recorded, but the previous 24 years had generally low activity. (Goldenberg, 2001) (Figure 2). As both these periods fall within the current era of man-induced global warming, this alone is not the cause. The most relevant factor seems to be the El Nino event, but exactly what drives this, and whether it is vulnerable to global warming, is not known.

Figure 3. Shoreline erosion at Caves Point after Michelle – nothing to do with global warming

The Impact of Climate Change on the Bahamas

The purpose of this paper is to encourage some rationality in anticipating the impact of the changes likely to occur in the next 50 years. Most of the pronouncements have been made by individuals and agencies concerned with the meteorology and climatology of climate change, who have then gone on to comment on changes to the environment outside their competence. Not all persons or agencies have been so cavalier, and the *Bahamas National Assessment Report on Agenda 21* (BEST, 2002) was more cautious than most when it stated **"there have been no formal studies to evaluate the impact of these changes on the environment, notably for sea level rise and temperature rise"** (P 18). However the *Bahamas First National Communication on Climate Change* (NCCC, 2001) was more alarmist. Some points often emphasized rather misleadingly include the fact that **80% of the Bahamas is within 5 feet of mean sea level** (P43). This ignores the fact that most of the population don't live there as most of this is mangrove swamp in Andros and Grand Bahama, and the Out Islands in general. Also 5 feet is quite a way above a projected 2-8" rise in 2050, so why should it be so significant?

Another example of this kind of hyperbole is that (NCCC, 2001, P 44) the **areas most likely to be directly and measurably affected by climate change are tourism, coral reef resources, water resources, and agriculture**. Again these are questionable. Just how will *tourism* so obviously be affected by 2-8" higher sea level or a few degrees hotter temperatures? Other destinations with hotter temperatures now are showing greater growth in tourism than the Bahamas, such as Cuba, Jamaica and Cancun. It is difficult to imagine any resort or marine activity likely to be put out of business by a small rise in sea level. But the impact on beaches has often been raised and will be discussed further.

The matter of *coral reefs* is more complex, as most reefs are under stress now, but existing research does not support major changes due to small increases of temperature over long periods. This will also be discussed further. *Water resources* will certainly be impacted and this is clear because there is direct relationship between sea level and the volume of water contained

in fresh water lenses. A rise in sea level would effectively shrink the thickness of the lenses by the same amount, but again how disastrous would be the loss of 2-8” be from the top of lenses 30-100 feet thick? While the loss should not be ignored, it is equally not one for which there is no solution, as many countries already rely on reverse osmosis for fresh water, including parts of The Bahamas. Much more relevant to the fresh water situation is the continued damage to water lenses by cesspit pollution, salt water incursion, and over-pumping. Loss of water lenses 30 feet thick, and massive salt water incursion, are well-documented (Sealey, 1996).

Agriculture, despite it’s high cultural profile in Bahamian society, is actually responsible for only about 1% of the GDP, and even then it is not likely to be especially affected by the changes forecast, other than the impact on water resources. By its nature farmland is not particularly associated with coastal locations, and small temperature rises are unlikely to affect existing crops. So why should agriculture be picked out as a critical sector in our economy?

Marine and coastal environment

The most quoted fear among the impact pundits is, to quote (NCCC, 2001, P46) is **“An increase in sea level rise would result in beach and coastal shoreline erosion. This could result in loss of beaches…”**

There is no basis for this claim which shows a fundamental lack of understanding of the nature of beach processes in general and those in The Bahamas in particular, and also in the overall factors involved in shoreline erosion in non-beach areas.

The Bahamas has been exposed to rising sea levels for the last 4 000 years, since the retreat of the last glaciation. Rates for the this period are about 0.4 mm/year, but the last 100 years have seen an increase in the range of 1.0-2.5 mms/year (Hendry, 1993; Williams et al, 1999). This is in fact not much below the projected rate of 4.0 mm/year. So how come there are so many beaches? Why isn’t The Bahamas a nation of cliffed shorelines? Current measurements indicate a sea level rise of 2-3 mm per year over the last ten years (Godfrey, 2003), a value well up with the predicted long-term rate.

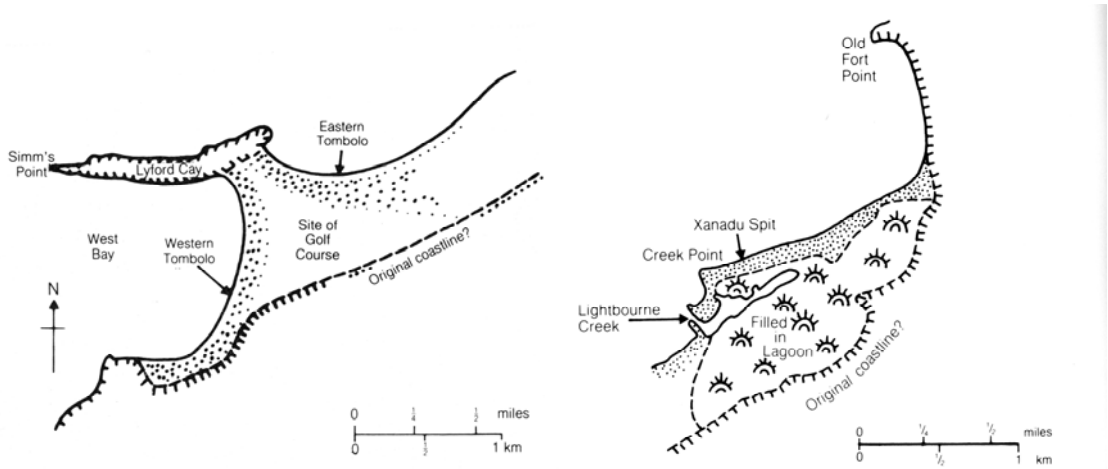

Figure 4. Two examples of shoreline accretion on New Providence formed during a rising sea level. (Sealey, Neil, 1996, Bahamian Landscapes, 2nd ed)

Certainly beaches can erode, and the many rocks and rocky cays that were once larger islands abound to show us that shoreline erosion exists, but here the time span is thousands of years and hundreds of feet of sea level rise, not 50 years and 2-8” of change. In fact virtually all

contemporary research indicates continuing progradation of beaches over the last 1000 years despite continued sea level rise. This has resulted in shoreline extension along many coasts, such as the north shore of New Providence (Sealey, 1996) and the east coast of many islands, most notably Long Island, Andros and San Salvador (Brill et al 1993; Beavers et al, 1995).

Figure 5. Lyford Cay, an example of recent coastal deposition.

Beaches in The Bahamas are fed by sand from offshore, generally from large oolitic sand banks on the shallow banks, or, where barrier reefs exist, from a mixture of oolitic and skeletal sands. Long term monitoring of San Salvador's East Beach show an average annual net addition of 10 000 cu metres/km of sand (Beavers et al, 1995). If sea level rises the production of sand does not stop, the winds and currents that move the sand to our beaches do not not stop, and the beaches will still be there. Increased temperatures could possibly increase oolite production, which is a product of temperature differences between the open ocean and our shallow banks, but either way there is no reason to suppose it will be diminished. At present many of our coral reefs are at the lower limit of their temperature range in winter, when sea level temperatures drop due to the passage of cold fronts. Much more critical to their response to temperature rise will be the number of cold fronts, and there has been no research or even speculation on this important aspect of the Bahamian climate.

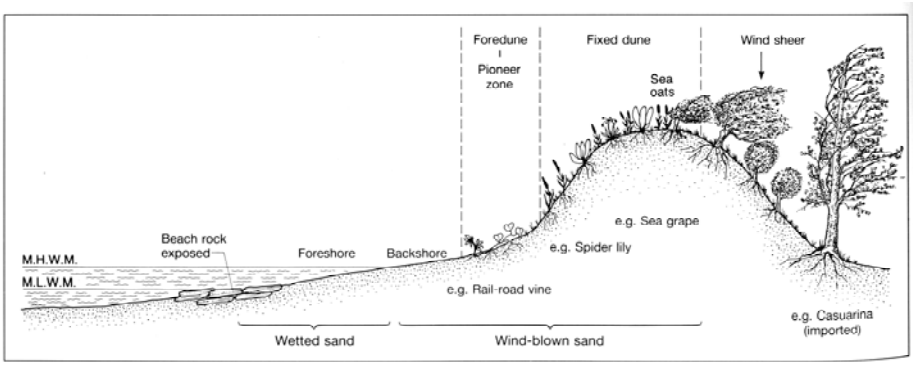

Figure 6. Idealized profile of a Bahamian beach and dune system. (Sealey, Neil, 1992, Caribbean World, Cambridge Un Press, P 52)

Apart from the fact, much overlooked, that the anticipated sea level rise would be *gradual*, and that beaches will be subject to many other stresses during the next 50 years, even if it is assumed that an existing beach was suddenly faced with a 8" sea level rise, there is no reason to expect that it would recede or even shrink. The high water mark would be temporarily higher, but the dynamic beach processes and continual supply of sand from offshore would simply create the same width of beach from fore dune to low water mark, the width of the beach being a function of sand supply, longshore drift, and wave action. It is not a function of height of sea level. Virtually all beach erosion is due to loss of sand caused by some manmade construction, or sand dredging. However, the presence of seawalls is a complicating factor, as the presence of a wall changes wave action to a scouring one, as opposed to a gentle breaking and constructive action on a sloping shoreline. In this case the sand will be redistributed offshore and lost to the beach, a phenomenon widely evident along the north coast of New Providence today. Similarly road-building that trespasses on protective dunes ahs similarly caused severe erosion on many islands. In fact most natural beaches are prograding, and the rate of progradation has continued despite the existence of sea level rise, so there is no reason to anticipate even minor retreat due to a small rise in sea level in the future. All the major shoreline damage, on inspection, can be clearly identified as the result of initial interference by man with natural beach processes. Examples include Rock Sound, and Long Bay, San Salvador, both the subject of costly road and marine works at the present time.

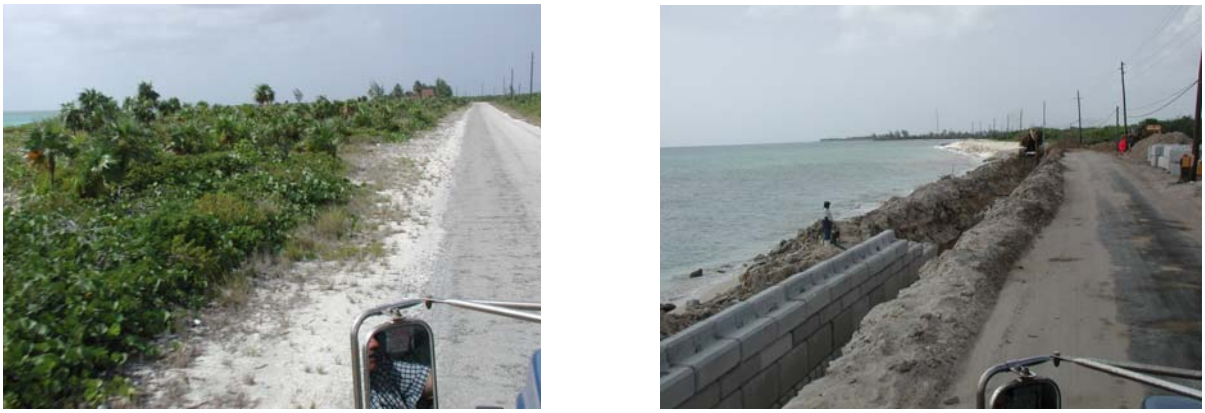

Figure 7. Shoreline erosion due to road-building, Long Bay, San Salvador, 2003.

More important than sea level rise would be the advent of increased *hurricane activity*. As we have seen with the last two hurricanes in 1999 and 2001, immense damage can be done to the shoreline by hurricanes, in many cases the equivalent of a century of normal erosion can occur in 24 hours. The case for more hurricanes is not yet made, but if it were this is an area that would have to be considered much more seriously.

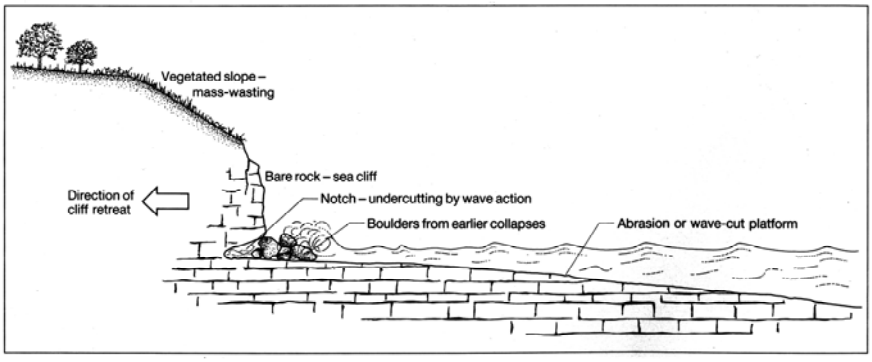

Figure 8. Erosion along a rocky shore. (Sealey, Neil, 1992, Caribbean World, Cambridge Un Press, P 48)

Aside from beaches the Bahamian coast consists of rocky shores ranging from mere ledges to massive cliffs; and mangrove swamps. How will these respond?

Erosion along a *rocky shore* can be likened to a saw cutting horizontally at the base of the rock face. The width of the cut will be approximately equal to the tidal range, about 2-3 feet in The Bahamas. With time a deep cut develops and the overhanging rock breaks off, and the process starts over, often interrupted for a considerable time by the protection offered by fallen blocks. This erosion is both physical and biological. If sea level jumped up to a new level, the same amount of erosion would take place at a different level. In the very long term there would be less land to erode, so technically erosion of the land mass would be accelerated, but in reality nothing much would change in the short term.

Figure 9. Typical development of a mangrove shoreline. Bahamian shorelines are actually much shallower than this on the leeward sides of the islands, this succession being more typical of creeks and higher energy shorelines. (Pernetta, J C: 1993. *Mangrove Forests, Climate Change and Sea Level Rise*: A Marine Conservation and Development Report, IUCN)

Mangrove swamps, tidal flats and other wetland constitute major portions of the coastlines of virtually all The Bahamas islands. These are mainly depositional areas that are outbuilding. A gradual rise in sea level as projected over the next 50 years would have very little visible impact, the trees would continue to grow as before, they would trap silt, and gradually land would be reclaimed from the inshore outwards.(Figure 9). Possibly there would be some retreat of the outer edge in swampy areas facing deeper water, but generally the very presence of the vegetation itself would prevent recession except under storm conditions. Red mangroves have a very fast growth rate, as much as two feet per year was measured in one Andros study (Whipp et al, 2003). Recent studies on San Salvador do in fact show a highly sensitive reaction to salt water intrusion among species, with black and white mangroves dying off to be replaced by red mangroves in inland lakes (Godfrey, 2003). This is in response to a calculated rise in the water table of about 3cms in the last 10 years. However the seaward margin remains unaffected.

An IUCN report (Pernetta,1993, P 14) emphasized the complexity of wetlands: "The combined effect of changes to several variables may be either positive, neutral, or negative depending on the magnitude of the changes and the nature of the individual species response." They stressed **"the futility of attempting to assess climatic change impacts on a sectorial basis, as the possible consequences of a rise in sea level cannot be assessed in isolation from other sources of change."**

Although *coral reefs* are only one element in our marine environment that is important to us, it is the most notable. Nevertheless the impact of climate change on sandy bottoms, sea grass beds, algal plains and so on also need to be considered, and their absence from discussion is typical of the limited scope of the present debate.

Despite the slow growth rate of coral species, and the lack of long-term studies which are endemic in the discipline, scientists and commentators alike have been quick to foretell doom for coral reefs. The most notorious proclamation came in 2001 from a marine biologist addressing the British Association for the Advancement of Science (Cropley, 2001), who claimed that all of the world's coral reefs would be dead within 50 years because of global warming! The reason for this was the belief that warmer seas cause coral bleaching, which even in 2001 was still a hypothesis that could not be proven. **"The connection of worldwide bleaching events with anomalous seawater temperatures is a contentious issue because of the lack of long-term, high quality temperature data to support ecological observations."** (Brown, 1997). In fact years before this studies in The Bahamas and the Caribbean had identified *Aspergillus sp.*, a fungus carried in Sahara dust, as a possible cause of bleaching, and this has received more and more support as it has been studied. "*The hypothesis proposed here is that many coral reef events, algal infestation, white band and black band disease, sea fan disease, sea urchin die-off and possibly mass coral bleaching are somehow related to dust from North Africa*." (Shinn, 2002).

With regard to *sea level rise*, the general opinion is that reef ecosystems can keep pace with a 6mm/year rise, which is easily more than the 2-8" in 50 years forecast, which is equivalent to 1.5–4.0 mm/year.

Temperature increase is a stress factor for coral reefs, as are many other things. Quoting Brown again **'The extent of the ability of reef corals and their zooxanthellae to genetically adapt to higher temperatures, and the meaningful timescales involved, are not known."** (Brown, 1997). However, she also suggested that **"hardy reef flat and shallow water species may show considerable scope for non-genetic adaptations to increased temperatures".** Certainly there is no case for anyone to claim the loss of coral species as a result of a predicted slow rise in sea water temperature over the next 50 years. Much more concern should directed at

the input of other stress factors, such as physical damage to reefs by boats and divers, nutrient loading due to pollution, and overfishing of selective reef species which alter the ecological balance on the reef. All of these are known to cause rapid loss of coral and death to reef systems, they are present now, and they will make the reefs even more vulnerable to whatever stresses may be placed on them in the future.

Conclusion

The strident predictions of death to coral reefs due to global warming are the ones that are the most easily refuted, yet corals and reefs are dying around us right now. Similarly it is not the future loss of beaches and wetlands that should concern us, but their ongoing destruction at the present time. Along with the fact of global warming has come the paranoia of imminent doom, and to some extent a distraction from where our true priorities lie. It is not so much the next 50 years we should be clamouring about, it is preserving what we are willfully or carelessly destroying today. If we don't take care of the present there will be nothing to worry about 50 years from now.

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Neil Sealey, Nassau, June 2003