Report on Proposed Development, Guana Cay, Bahamas

By

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Preamble: I have been asked by the Committee to Save Guana Reef to comment on the proposed "Passerine" development at the north end of their Cay. I have no financial or personal interest in this matter. I am being paid for my services by the Committee, although I have charged less than my normal rate because I feel these people are in the right.

Re my qualifications for this task: my CV is available to anyone who asks. To sum up: I am a marine biogeologist with 40 years' experience working in coral reef environments, especially in the Caribbean. I have published more than 200 articles in the refereed scientific literature, and my citation rate ranks me in the top 2% of active scientists worldwide, in all fields. I advise US EPA, NOAA, the State of Florida and the Governments of Bahamas, Jamaica, Barbados, Belize, Grenada, Indonesia, Maldives and Tanzania on coral reef monitoring and the problems of land-based stress on coral reefs. My research results have been incorporated into environmental legislation in Costa Rica, Indonesia and Tanzania, and I have testified before the Congress of the USA on the importance of corals.

The material presented herein represents my professional opinion, based on preliminary literature research and Feb. 11-16 spent on Guana Cay doing fieldwork.

1. General observations

A copy of the EIA for the project called Passerine at Guana was provided to me by Dr. Kathleen Sullivan Sealey. The EIA has been done to a high level of professional competence. Sections on terrestrial ecology, water management and solid waste management stand out as being very good. Despite the quality of the EIA, however, I have some concerns about the project as proposed. These concerns may be summarised under the following headings, and will be discussed further on in this report:

1. the degree of marina flushing seems minimal.

2. protection of the marine environment from land-based stresses produced by the project is not well documented, nor have adequate baseline data been taken.

3. there seems insufficient concern re the restriction of traditional access by local

inhabitants to sources of food and income.

Nonetheless, as stated above, if operated according to the standards outlined in the EIA, this project should operate at the highest levels of environmental stewardship. This is as it should be: the development will forever change the Cay, bringing with it a 10-fold increase in population density. Proposed are:

-450 residential units,
-an 18-hole golf course,
-70 additional residential units,
-a 250-slip marina,
-an equity club with 400 members, and
-associated support structures, staff housing, and utility sheds.

Any development of this size on an island this small has to be done extremely carefully, as the consequences could range from the severe to the catastrophic.

Generally speaking, the plan is a first-class one. Invasive plant species will be removed, and wherever possible replaced with more appropriate native vegetation. Planned roadways will be narrow and winding, instead of wide and straight-this makes more interesting vistas, while reducing impacts such as wind-tunneling. Architecture will be appropriate to the Bahamian setting, using native plants. The golf course will use recycled water, resistant turf species and minimal applications of pesticides and fertilizer. There will be a centralized wastewater treatment facility, and a solid waste management plan.

All in all, this plan is an example of what might be termed second-cycle development-more environmentally friendly, less footprint, less impact. On the other hand. The plan, as good as it is, seems to be lacking some critical elements; some of the findings in the plan seem questionable, and others are described in so little detail as to make it hard to evaluate their ultimate effectiveness.

2. The Florida Model

Throughout the EIA, mention is made of legislative guidelines and policies in place in the State of Florida. This seems in keeping with the attitude taken by many foreigners coming to Bahamas, that it is not a sovereign nation but an extension of Florida. In this, and in all developments, it is necessary to compare what is proposed with what is actually done. If Florida has such effective laws and guidelines, then the environmental situation in that State should act as a model for all similar jurisdictions. It is instructive indeed to compare the proposed situation in Florida with what really happens. If similar developments in Florida have had deleterious effects, despite those laws, then it might be expected that the same thing would happen on Guana, no matter what paper guidelines were in place. The best comparison would be with the Florida Keys, because of their

geomorphic similarity to Bahamas.

Marina health in the Florida Keys

Marinas in the Keys, despite EPA regulations on flushing rates, are generally biological dead zones, with fuel spills, toxic chemicals, and anoxic sediments. In addition, virtually all of the virulent human viral and bacterial pathogens may be found in the waters of marinas in the Keys: Hepatitis A&B, cholera, tetanus, the lot (Erin Lipps, pers. Comm. 2004).

Health of the Florida Reef Tract

The scale of the Florida Reef Tract (FRT) is immense, compared to Guana Cay. On the other hand, the effective human density on shore is also much greater, so perhaps one could use the Keys as an indicator of what may happen to the Cay.

A regional mass extinction is under way on the FRT. In the past 15 years, coral cover has dropped from 45% to 4%. Coral diseases are rampant, and at least one of the diseases (White Pox) is caused by a fecal bacterium. There are moves afoot to list *Acropora palmata* as an Endangered Species-this is the coral that made most of the framework of the Keys.

Although this decline is by now well-known, pinpointing the precise reasons for the decline has been a long time coming. This may have something to do with the enormous amounts of money tied up in Florida agriculture, tourism and development-there may have been hesitation to produce any bad news that would slow the engine of growth. (It should be said that some Florida scientists, for example Brian Lapointe of Harbor Branch, have been sounding the alarm for years.) The flipside of this, of course, is by the time the causes of reef decline are identified, the resource is gone. There are parallels here with Guana Cay. Gov't. of Bahamas must be extremely careful dealing with developments that can provide economic input at the cost of irreversible damage to community resources. Some recent research has shed light on reasons for the catastrophic decline in of corals on the FRT.

Caribbean reefs are home to *Cliona delitrix*, a bright-orange boring sponge. This sponge attacks live coral, covering the surface with bright orange tissue and elevated papillae. The larvae are one of the very few types that can settle and survive on live coral. The sponge is capable of destroying a metre-wide coral head in 2-3 years (the species name, *delitrix*, comes from the Latin, "to destroy").

This sponge may be found on perfectly-healthy reefs, as a normal component of the biodiversity. What makes this organism so interesting is its diet: it eats bacteria, and is especially fond of fecal bacteria. Rose and Risk (1987) reported on a study of part of the reef at Grand Cayman that was impacted by untreated sewage. They found that a six-fold increase in concentrations of fecal bacteria

was accompanied by a six-fold increase in the amount of boring sponge. This work was of sufficient significance that several reef monitoring programs (especially including the FMRI program, which is the best of the bunch) have adopted the use of *C. delitrix* as an indicator of the presence of fecal bacteria in the water column, and as a bioindicator of stress.

From 1997 to 2001, coral cover in the Florida keys dropped by half. Over that same time period, the amount of *C. delitrix* on the reefs doubled (Ward-Paige and Risk, 2000, 2001, in press). Sponge colonies were found up to 3m wide. The carbonate balance sheet on these reefs has shifted from mostly constructive to mostly destructive.

One of the most powerful indicators of human stress on coral reefs is the ratio of stable isotopes of Nitrogen, usually referred to as $\delta^{15}N$. This number is a measure of position on the food chain: phytoplankton could be -5, zooplankton -3, small fish -1 and so on to humans, at approx. +7. The higher you are on the food pyramid, the higher will be your $\delta^{15}N$ value. This works as a measure of sewage stress on coral reefs simply because there is only one top carnivore that dumps its sewage in the ocean and is present in huge numbers. There is an impressive literature now on the use of $\delta^{15}N$ as a measure of land-based sewage stress on coral reefs.

Gorgonians grow up like trees, and like trees, they have annual rings in their stems. By dissecting the annual rings off large gorgonian stems collected on the FRT, and by analysing these rings for $\delta^{15}N$, Ward-Paige and Risk (2002, 2004, in press) were able to reconstruct a 40-year history of sewage stress on Florida reefs. Reefs close to development had higher values 40 years ago than reefs in "cleaner" waters, and this gap has only widened. There has been a dramatic increase in values at both clean and dirty sites in the last 10-15 years.

The take-home message from both of these studies is that the reefs of Florida, despite all the laws and policies and regulations, are being killed by nutrient runoff and sewage produced by development on land. The resource is vanishing, nibbled away by hundreds of dubious decisions to allow this or that development.

3. The Marina Issue

Great care must be taken in constructing a marina of the size proposed for Guana, so that it does not become a cesspool. Not only would this be a breeding ground for human pathogens, there is a very good chance that the bonefish flats in the adjacent bay would be wiped out.

Flushing rates for the proposed marina were modelled using Mike 21-this is from the Danish Hydraulic Institute family of models: the "2" stands for two-dimensional, depth-averaged. These models are generally very reliable, unless there are any 3D effects that are not well-represented by a 2D model.

Marinas built to US EPA standards are supposed to flush sufficiently well as to reduce the concentration of a pollutant to a threshold value within 4 days (96 hours). From the EIA, it is obvious that the proponents had great difficulty producing a marina configuration that met these criteria.

The first iteration, dredging the marina to a depth of -11.5', did not flush well. In order to increase the ratio of tidal water to resident marina water, they ran the model again with a dredge depth of -9'. Flushing rates were still inadequate. In the end, in order to achieve flushing rates that can only be described as minimal, a second channel had to be proposed, meandering through the mangroves and exiting into Crossing Bay, a habitat of great concern and the location of the bonefish flats.

This situation is far from satisfactory, for the following reasons:

-the depth of the proposed second meandering channel is not specified, but the contours in Fig. 3.5 of the EIA suggest it will be shallow. The back (west) side of Guana is a low-energy coast, on which most sediment movement will take place episodically during storms and hurricanes. Air photos show that the predominant direction of sediment movement is to the north. This channel will almost certainly be closed by longshore drift, rendering it ineffective, unless it is regularly dredged out. When this second channel closes, the marina will become the sort of anoxic "marina cesspool" we expect to see in Florida.

-some of the local inhabitants I interviewed, individuals with decades of practical experience on the ocean around Guana Cay, felt the tidal ranges reported in the EIA were too high-perhaps there were extended winter periods of wind run-up. These tidal ranges are, of course, critical to the model results. When comparing traditional ecological knowledge with instrument results, the instruments usually win. In this case, however, given the importance of the calculated flushing rates to the water quality in the marina, it seems this exercise should be repeated, with tidal gauge emplacement during summer months and a 3D water movement model employed.

-opening of the second drainage channel raises the likelihood that the ecology of the sandflats will be compromised; in particular, this area is reported to be one of the finest bonefish flats in the Bahamas.

In short, it appears that the question of flushing of the marina needs to be revisited, ideally by an operator at arms'-length from the proponents.

4. The Golf Course problem and the marine environment in general.

The plan, as described in the EIA, is to be commended for its attention to environmental management. The EIA contains voluminous material on terrestrial

botany and related impacts, and excellent proposals re erosion control, water management and waste management. It is, however, impossible to grow grass without water, and impossible to grow golf course grass without fertilizer. No matter how well the use of these two is monitored, some will inevitably escape to the sea. The use of organic fertilizers will delay but not halt the nutrient release.

The EIA is strangely lacking in detail on the marine environment. There are species lists of the fish seen during surveys conducted using the Roving Diver Technique, RDT (www.reef.org), and a species list of corals. I was provided with no information as to sites, site selection, methods for coral ID.

Recent concern about the decline of the world's coral reefs has prompted introduction of a plethora of "new" survey methods. This has done more harm than good. Risk and Risk (1995) reported that ALL research-grade coral reef surveys give the same results, within acceptable margins of error, while Risk (2000) points out the folly of not intercalibrating any of the methods currently in use. There has also been an increase in surveys that use amateur divers to collect reef data, the most successful of which is REEFCHECK.

Amateur divers on random surveys may be able to collect data of use in simple presence-absence surveys. It is also an excellent way to give purpose and meaning to intelligent tourists who are on diving holidays. It needs to be pointed out, however, that this work is no substitute for proper research-grade reef monitoring. One can only trust this sort of data so far: anyone trusting the long-term health of their coral reef to rapid surveys done by amateur divers would presumably not mind their plumber performing open-heart surgery.

The reefs on the NE coast of Guana Cay are in excellent condition (Field Notes, appended). They are in constant use by divers, fishers, snorkellers. The barrier reef runs off the NE coast of Guana, at a distance of about 200-300m. On the lagoon floor are literally countless patch reefs, ranging in diameter from 100's of metres to metres. Although the set of the open-ocean currents is to the NW, local current residuals in the lagoon are to the SE. Because of the extraordinarily high porosity and permeability of the carbonate sands on the island, any runoff from the golf course will be transmitted rapidly down the length of the island. At the site of the proposed golf course, there are excellent reefs a few 10's of metres from the shore-this is a situation not found in many areas. Nutrient effects on reefs have been traced for more than 15 km. Runoff from the golf course will likely be a death sentence to the adjacent reefs, and a threat to reefs the length of the Cay.

There are plans in the EIA for progressive monitoring of groundwater (this section of the EIA is quite good), and the innovative use of on-site web-cams. There seems to be no process-response model, no system of checks and balances via which construction may be halted should part of the system break down. In fact, there is a statement in the EIA to the effect that the worst

environmental damage would be done if this project were not completed. This seems like a veiled threat, and carries the implication that, once begun, the process cannot be stopped. Given this situation, it is absolutely essential that research-grade baseline monitoring of the reef resources be undertaken, before the project commences.

Methodology here is relatively unimportant. The FMRI protocol, which results in the best monitoring program in Florida, would be excellent but may be overkill. The line-intercept transect method first described by Risk (1972) gives good results, and has been the basis of the vast majority of scientific papers reporting reef surveys. Whatever the method, it must erect permanent transects that can be revisited on a regular basis. Surveys must be capable of determining diameters of coral heads to $\pm$ 1cm, and include data on bioindicators and associated fauna. There should be baseline data on inorganic nutrients, and a survey of tissue levels of $\delta^{15}N$. Fish fauna should be quantified using the belt-transect timed-swim method used by, among others, Peter Sale.

These data should NOT be taken on a rapid reef assessment basis, and especially not by amateurs. These surveys need to be run by professionals who know their stuff. To illustrate this point: Dr. Risk would be the first to admit he is a long, long way from being a coral taxonomist-yet, in one 30-minute dive near the proposed golf course, he identified more species of coral than are listed in the EIA. This work needs to be done by a group at arms'-length from the developers.

5. The present situation on Guana Cay

The EIA comes down fairly hard on the present residents of Guana Cay, condemnation which, to a certain extent, they deserve. They are described as being NIMBY's (Not In My Back Yard-ers). The EIA points to examples where shoreline setbacks have not been observed, and where construction has resulted in buildings inappropriate to the setting. The inhabitants are criticised for using "soakaways" for septic waste, and for not having organised solid waste management plans.

In these respects, however, the local residents are no worse than everyone else in the Bahamas-soakaways are universally used to deal with septic waste and, as long as population densities and rainfall are low, this is a solution that works by default. There is some evidence that the local residents are undergoing a consciousness-raising. The citizen's association has begun to hold meetings to discuss feasibility of installation of proper septic systems. In many ways, a properly-maintained septic system, consisting of a two-chamber tank, feedlines and a leach bed, is the ultimate solution to this problem. Breakdown of wastes is total, and it all takes place on the property.

The local inhabitants conserve water, and are conscious of litter. This is not a badly-run island, so far, although there are signs that this is changing for the

worse. The Orchid Bay gated community under way on Guana Cay is a classic example of shoreline abuse: setbacks are not observed, lots are bulldozed with no erosion control, native vegetation is not preserved. The residents of Guana Cay were against this development, and were powerless to stop it. They are disturbed by the pace of inappropriate development, and are not convinced that the Passerine developers will keep to their lofty promises.

6. Traditional use of island resources

Bahamians live near and with the sea and its resources. I was impressed by the sense of stewardship felt by Guana residents, some of whom have been on the Cay for generations. The lee beach at the north end of the island, on the site of the proposed golf course, is used periodically as a communal meeting ground, and used during festivals. The marine resources provide the livelihood of people who fish for a living. In these environments, fishers need be adaptable: when the reef is raging, they need to fish the lee side. When the fish are scarce, they need to go crabbing. (The EIA mentions evidence of digging for land crabs, and condemns the practice-this may have been someone's weekly income.)

"Junior" Sands, who is a long-term Guana resident and whose family goes back generations on Guana, described to me how they would take their boats up through a channel in the mangroves to a central pool, 6-9' deep and 200' long, in which they could shelter from hurricanes. With construction, of course, this shelter would be gone. So, too, would acres of mangroves. This would be especially silly.

We know now how important mangroves are to the health of a coastline, and to the ability of an island to withstand damage from circular storms-hurricanes and cyclones. Reefs are the breakwaters, and mangroves the shock-absorbers. To give just one example: most of the coastal mangroves of India were deforested since about 1970, to make room for development. The Boxing Day Tsunami rushed inland without hindrance, and loss of life was catastrophic. India has now undergone a crash program to replant mangroves all along her coast.

So Passerine at Abaco would remove from the local community the hurricane shelter, the crabbing grounds, the meeting site, the bonefish flats, the breakwater and the shock-absorbers. No wonder the locals are concerned! In this case, the sea IS their backyard-and their livelihood.

7. Geological aspects of construction

Guana Cay has the "layercake" structure produced the interplay between reef growth and large changes in sea level during the Pleistocene. The Ironshore outcrops that may be seen along the shoreline are remnants of an older, higher stand, and the NW-SE ridge that forms the backbone of the island is from a previous interglacial period, perhaps equivalent to the 100,000 YBP terrace on

Barbados. Soil cover is thin, because of the slow soil development on carbonate sands, and removal by hurricanes. Terraforming this property for the golf course, marina, etc. may not be a trivial venture. It may involve blasting outcrops out of the way. I note that some geotechnical work is proposed, and this should include shallow seismic investigations.

Sediment movement along the west coast of the island will be episodic, but nonetheless appreciable-one need only observe the sandspit at the north end, which will some day reach the adjacent Cay. Dredging for the marina will be a continuous operation, with ongoing chronic sediment stress.

Australian Pines (*Casuarina sp.*) have been introduced on coastlines worldwide, in many cases to arrest soil erosion. The EIA is dead wrong when it suggests *Casuarina's* **cause** soil erosion (Fig. 6.1). The misconception seems to stem from the belief-unsupported by any data-that aeolian sand transport is the dominant method by which sand is advected out of the foreshore into the backshore. (This theory-that *Casuarina* causes erosion-needs to be subjected to the normal scientific peer-review process.) Most sand removed off the beach by storms and hurricanes is stored offshore, and moves back to the beach via wave transport. On the beach, it is retained by *Casuarina* roots.

To illustrate that this wheel has already been invented: Mauritius, in the Indian Ocean, suffered episodes of coastal erosion in the past, and imported *Casuarina*'s. Now they are everywhere on the coast. Their rootballs stabilise the beaches, and the trees provide shade to people holidaying on the shore. Ministry of Environment wants to remove them and replace them with native species of beach vegetation-the Beach Protection Agency has recommended a slow, careful, phased-in replacement program, whereby no pine is cut until the replanted native vegetation has taken hold enough to protect the beach. This is the preferred approach (recommended in the Baird &. Associates and M. Risk Report on Shoreline Erosion).

To remove all the *Casuarina* from the Cay would be truly a Herculean task, taking years and destabilising the shoreline. To replace them with palms would be truly stupid. As the EIA states (p. 16): "The overuse of palm trees eliminates any visual identity with the Bahamas."

8. Reef augmentation and restoration

It is clear that some reef degradation will accompany construction. The EIA refers to amelioration efforts, such as the use of Reefballs.

Reefballs has become a successful commercial venture, due largely to indefatigable promotion. The structures themselves look un-natural, they are made of concrete (a major contributor to atmospheric CO_2), they are expensive, and they are not as effective as locally-made artificial reefs made from rock and a

few scattered concrete blocks.

Reefballs have often been used in areas where the natural reef has died. This is a stopgap solution, at best. Until the conditions that killed the original reef have been corrected, corals will never recruit into the area.

Risk (1977) describes a series of artificial reefs made in Discovery Bay, Jamaica. Their construction varied, from boulders emplaced in a pile on the bottom, to boulder piles veneered with blocks, to highly-organised reefs made solely out of blocks, with large internal cavities. Each type attracted large numbers of juvenile fish. They all looked more "natural" than Reefballs. The block reefs were better at attracting lobsters, and the veneered reef had more large fish. Local fishers were potting around these reefs within weeks. Corals settled on the reefs within the year.

Thirty years later, after the reefs have survived a series of the largest hurricanes to hit Jamaica, they are covered with corals and indistinguishable from a true reef. The take-home lesson here is that Guana should not need Reefballs. It would be far better to employ some local inhabitants in constructing "artificial" reefs out of natural-appearing materials, such as coral boulders. (There have been many studies of the best substrate to induce settling of coral larvae. The best is old coral.) These could be emplaced at suitable locations along the lee side of the island, and would become quite an attraction. Tourists would come to them, on days when the sea on the weather side was raging. Fishers could use them-although the recommendation would be, no fishing for the first five years. Studies have shown that, after approx. four years, protected areas start feeding the surrounding areas with fish larvae and juveniles.

Eventually, these substrates will attract coral larvae. These larvae will settle preferentially on elevated surfaces, avoiding the murky waters of the near-bottom resuspension zone. It may be possible to jump-start the process.

In the aftermath of hurricanes and major storms, one can always find broken, detached pieces of coral on the bottom: "orphan" *Acropora* heads sitting on the sand, broken pieces of *Porites*, overturned heads of *Montastrea, Diploria.* These corals will eventually die-they can be taken to the artificial reefs, and tied on with nylon twine or plastic cableties. About 80% of such transplants survive. No healthy live corals should ever be sacrificed to "seed" a reef, but normal reef processes will in time produce a number of transplant candidates.

So the potential exists to utilise some of the organic production represented by the *Thalassia* beds on the lee side to produce a tourist attraction and a fisheries resource, while at the same time employing local people.

9. The problem of the "Disney Lands"

The abandoned "Disney" property is an eyesore. Dredging for the channel destroyed seagrass beds and fish habitat, and created a spoil heap (Shell Island) which is now covered by non-native vegetation.

It did not have to be this way. The EIA quite properly points out that a distinguished coral reef scientist, Judy Lang, raised objections from the start, and predicted the disaster which ensued. This only points up the critical need to seek out arms'-length scientific opinions BEFORE embarking on major developments.

As far as the damage to the marine offshore environment is concerned, it is hard to arrive at a perfect solution. To demolish Shell Island and fill in the dredged channel would simply create further problems. The unpleasant truth here is that this situation should be accepted as a mistake, and a warning to Bahamas that large projects need a large degree of attention to the impacts.

The situation on land and in the nearshore is far from irretrievable. The pressure-treated pilings and timbers are valuable, and can be salvaged. Local inhabitants have "recycled" much of the hardware off the site-wiring, fixtures, electrical components-so that little is left. The major problem lies with the fuel containers and the transformers, and these have to be dealt with by trained professionals.

Cleanup of this site has been delayed by the all-too-typical corporate buck-passing. It may be that Disney is protected from direct liability by intervening corporations. On the other hand, the site is referred to as the "Disney Site", and to a corporation that size, cleanup costs are small change compared to the bad publicity. The Save Guana Reef Committee has been in touch with Disney, with the intention of having them fund a cleanup of the site.

10. The Sea Turtle Issue

I was struck by the relative abundance of turtles near the site of the proposed golf course (see Field Work). There are few things more calculated to give tourists thrills than sighting one of these marvelous creatures on a dive.

Turtles nest up on the foreshore in loose sands, generally at or near the storm berm. They come in at night, after a few hours' reconnaissance, and orient themselves according to light levels. Gumelemi Cay and the beaches at the north end of Guana Cay are known to be turtle nesting areas.

The EIA that I have contains a long checklist of sensible things people can do to minimise disorientation and disturbance during nesting-the usual litany of motion-sensor lights, shielded and directed lights, no dogs, etc (although the suggestion that nesting turtles are disturbed by the sight of nude people, p. 112, is somewhat strange). The EIA is strangely mute on the subject of habitat destruction.

Bahamas is a signatory to CITES, and as such is pledged to protect habitat of species of concern, such as sea turtles. Clearly, the golf course will be the end of any nesting sites on that end of the Cay, as will any construction on Gumelemi Cay. This one factor alone should signal the end of the proposed golf course.

(As an aside: I advise the Barbados Government on shoreline rehabilitation. That government is relocating several major developments, including a Hilton Hotel, in order to preserve ONE of the turtle nesting sites they have left.)

11. Summary and Recommendations

The proposed development is enormous by Bahamian standards-indeed, by any standards. The EIA suggests that this will be done in a responsible fashion, with minimal disruption to the environment. The EIA is deficient in several key areas, and is far from an objective document. In addition, there is evidence that Discovery Land Corporation is not a model citizen, they have not responded to requests for dialogue, and the residents of Guana Cay are not inclined to take their word about anything. The potential exists for another environmental disaster, one from which Guana Cay would be a long time recovering-if at all. Statements such as "As far as the reefs are concerned there is absolutely nothing in the development that will impact them on either shore" (Neil Sealey, 2004) are obviously incorrect, contradict statements in the EIA, and cause one to question both the author's background and motives.

The first thing that needs to be done before any development is contemplated is to address the deficiencies in the EIA.

(a) Baseline marine data.

The EIA provides species lists of corals and fish. Both are of little use without site locations. It may be possible to obtain a reasonable estimate of the biodiversity of fish by using one of the rapid assessment methods, although such methods should always include night dives. On the other hand, we have known for more than 30 years that the underlying structure of the reef controls the diversity of the fish (Risk, 1972). The reefs of Guana Cay can recover from events such as major hurricanes, but may not be able to survive the onslaught this development represents.

There needs to be a thorough, research-level description of the reefs near the proposed development. This would include data on coral cover, associated fauna, and biodiversity. In addition, there should be baseline inorganic nutrient data taken (the nitrogen species, SRP, Chlor. A) as well as a baseline survey of levels of $\delta^{15}N$ in coral and algal tissue all around the Cay. This work has to be performed by a group at arms-length from the developers.

(b) Marina design

There are concerns with the design of the present marina, and model calculations of the flushing rate. As this marina will destroy large areas of mangroves, and impact fish habitat, this issue needs to be resolved.

The marina design, and the estimates of flushing rates, needs to be re-evaluated by a high-level firm of coastal engineers, again at arms' length from the developers. If necessary, a 3D model should be used to validate the results from Mike 21.

(c) Protection of sea turtle habitat

Bahamas is bound by international treaty to protect habitat of endangered species, such as sea turtles. Development proponents need to come back to the community with a revised plan that leaves nesting sites untouched, both on Guana Cay and Gumelemi Cay.

(d) Loss of traditional fishing grounds

Development proponents need to come up with a plan to compensate Bahamians for the loss of their traditional fishing and crabbing grounds.

Field work

Feb. 12: Risk, Troy Albury (Guana Dive), Junior Sands and Erin Noyes, to the lee side of the island, with particular focus on coral communities on the hardgrounds, the mangrove stands and the abandoned Disney site.

The north end has extensive shallow beds of *Thalassia*, dense stands, short fronds, few epiphytes. Scattered heart urchins and *Trypneustes* seen-no *Diadema.* (In fact, I saw no *Diadema* in my whole time on Guana, although I am told they exist.) Harground outcrops nearshore contain scattered but abundant coral colonies, ranging from patches to >20cm diam, down to recruits of a few mm. Species seen included *Porites astreoides, Diploria clivosa, Siderastrea radians.* Gorgonian colonies were frequent, ranged in height up to 0.5m, and were disease-free. In fact, the reefs on Guana Cay were remarkably free of signs of coral disease.

Hurricane debris was everywhere on the bottom-pieces of trees, lumber, household junk. The fish fauna was good, comprising, in 1-2m, 6-8 species.

There was one small colony seen of *Cliona delitrix*.

The abandoned Disney site is a mess. There are networks of pressure-treated pilings in the water, outlining various pens and holding areas. The bottom is littered with pieces of chain-link fencing, old pipe, rope, etc. Part of an old boat has been sunk in amongst the pilings as a tourist attraction. It is now covered by a dense growth of algae, and supports several coral colonies. The wreck itself, although only in 3-4m of water, supports an impressive fish fauna of parrotfish, grunts, some large snappers and spadefish, a large puffer, and a large number of *Abedufduf saxitilis.*

On land, the site is troublesome but not impossible. Some of the buildings themselves are being dismantled for use elsewhere, after the large pressure-treated timbers are gone, growth of the underbrush will take care of the rest. Wooden buildings do not take long to disintegrate. The biggest problem environmentally lies with the fuel dumps and the generator facility. There are several large tanks, which once held gasoline-these are probably empty now, but still need proper disposal-as will the generator equipment, what is left of it.

This section of coastline is used as a fallback fishing ground when the weather face is raging. It is also good lobster grounds, and the mangroves afford excellent crabbing.

Feb. 13: Risk, Troy Albury, Erin Noyes: dives at White Hole and Cathedral dive spots, off the NE coast of the island adjacent to the proposed golf course.

White Hole:
Off-reef, in 25' of water, there are large fields of standing starved ripplemarks, with the troughs floored with coarse (probably hurricane-derived) debris. There is an abrupt transition from the lagoon floor to the patch reefs, which are highly reticulate in shape and heavily bioeroded. Some of the colonies of *Montastrea* were perched on such slender stalks that it is hard to see how they survived the hurricane, whereas others had been toppled over. By looking carefully at the structure of the reef, it was possible to discern corals overturned by hurricanes years ago-these now have become part of the reef framework. Some of the massive corals showed evidence of sandblasting from the recent hurricane.

There were 3-4 species of gorgonians seen, the vast majority of them disease-free. The fish fauna was not as impressive as at the Disney site, perhaps because these patch reefs are regularly visited by fishers and spearfishers. There is some algae on these reefs, but not enough so as to be worrisome. Coverage by CCA is high and, although there were no *Diadema* seen, the grazing niche seems to be filled by the abundant parrots and tangs. Calcareous greens are common, as is *Padina*.

Coral species seen in a 30-minute dive (in no particular order):

Montastrea faveolata
Diploria strigoas
Diploria clivosa
Diploria labyrinthiformis
Siderastrea siderea
Siderastrea radians
Dendrogyra cylindricus
Millepora alcycornis
Millepora complanata
Dichocoenia stokesii
Eusmilia fastigiata
Agaricia agaricites
Porites astreoides
Porites furcata
Porites porites
Manicina areolata
Meandrina meandrites
Favia fragum
Acropora cervicornis
Mycetophyllia ferox
Tubastrea sp

To see this many species on a reef this close to shore without really trying to build a species list indicates exceptional biodiversity. I saw several 1cm *Diploria* post-hurricane recruits. This is a very nice little reef, a snorkeller's delight that needs to be maintained.

Cathedral:
Acropora palmata framework, with the coral all dead some years ago. The upper surfaces are pockmarked and pitted by exposed galleries of boring sponges (probably *Cliona laticavicola*). It is impossible to tell when these corals died, but from the degree to which grazing has opened up the sponge boreholes on the upper surfaces of the fronds, I would estimate the corals died perhaps 5-10 years ago.

Live *Acropora* is recruiting into the dead stands, with patches of live tissue from mm to cm. In addition, there is extensive development of healthy *Acropora* on the seaward margins of this patch.

This is a classic *A. palmata* thicket, reminding one of the way Florida was 20 years ago. Many of the heads have been blown over (by hurricanes, most likely), the tips have rooted to the bottom, and new growth has surged upwards from the rooted fronds-this is how *Acropora* extends reef tracts. Many of the corals show hurricane sandblasting. None of the gorgonians showed any disease.

This dive was punctuated by the sighting of two young Hawksbill Turtles, one about 50cm in carapace length, the other a juvenile of about 15 cm carapace length. There was also a sighting of a large Spotted Eagle Ray, one of a group of six that Troy Albury said frequented the area. (This one will be recognizable in future-some predator, probably a shark, had recently taken a bite out of the proximal trailing edge of the left wing. This will heal into a scalloped edge.)

In summary, these are very healthy fringing reefs, bouncing back from the hurricane, and with fauna capable of gladdening the heart of the most jaded tourist.

Feb. 14: snorkel reconnaissance, Risk: "Aquarium Reef", 75m off Nippers Bar.

I entered the water 50m north of Nippers Bar. At the time (approx. 9am, EDT) I could detect a general, faint odour of sewage. This suggests some of the soakaways are not soaking well enough.

Nearshore outcrops are heavily sandblasted by normal swell waves, with hurricane overprints. Very little lives on the inshore surfaces, except an algal turf. The outcrops themselves are orthogonally jointed, and made up of crossbedded ancient beach deposits. In the swales between outcrops, large windrows of *Sargassum* roll to and from in the waves. This is likely a hurricane leftover. *Sargassum* can live for long periods of time after being ripped from its rock holdfasts, as witness the Sargasso Sea. It is likely that the hurricane ripped all the *Sargassum* from the nearshore rocks, dumped it on the bottom, and it has been rolling back and forth since, gradually breaking down.

Further offshore, one encounters increasing numbers of encrusting coral colonies, mostly *Diploria clivosa* and *Siderastrea radians*, and moderate numbers of gorgonians. Despite possibly leaking soakaways, and despite spending 30 minutes looking, no colonies of *Cliona delitrix* were observed. There is no evidence of sewage stress on these nearshore reefs.