Journal of Coastal Research | 17 | 1 | 241–242 | West Palm Beach, Florida | Winter 2001

DISCUSSION

Discussion of: Munoz-Perez, J.J.; Tejedor, L., and Medina, R., 1999. Equilibrium Beach Profile Model for Reef Protected Beaches. *Journal of Coastal Research*, 15(4), 950–957.

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INTRODUCTION

We found this paper to be intensely interesting since the topic of the impact of offshore reef structures on the shape of the landwards beach has been of great concern to us, since we first detected the occurrence of local erosion "hot-spots" on our Gold Coast Australia beaches during two major cyclonic attacks in 1972, and also from every other storm erosive event since. Our Gold Coast beaches are predominantly sediment rich, but we do have 6 to 9 nearshore reef structures, generally cresting at their mean seabed levels and with exposed areas of an acre or two, that imprint an indelible erosion response upon the visible beach, landwards to each site. In every case, we have deduced that the submerged exposed reef structures are the cause of the hot-spots, so we should like to add to the author's paper by reportng our own local experiences and observations with exposed seabed reef structures. Some of our conclusions seem to agree with the author's findings, but some do not, so these we report accordingly, noting along the way, however, that we monitor our beach every day, giving now, 11 years of data. We also log the beach variability itself per day, as far as is possible, in shape, width, slope, behavior and changes of all the wave climate, that drive all the beach variabilities in the first place.

STORM HOT-SPOTS

The first tropical cyclone erosion attack on the Gold Coast to be extensively monitored by coastal engineers was that of 1972, when the attack consisted of two major cyclones back to back, and they caused very significant beach and dune erosion over some 40 km of city coastline. In the main, or for over 95% of the beachfront, the eroded beaches and dunes remained parallel with the pre-erosion fine weather beach, *i.e.* the erosion was mostly nearly equal everywhere. But with much alarm, we noted some 8 to 9 local beach areas, where the erosion was much accentuated, and reached 10 to 40 meters more than the general average shoreline, and with along-beach erosion lengths of between 100 and 500 meters. Apparently we had discovered a series of what we later learned to know as "erosion hotspots", but what was causing them eluded us—they remained for some time, a complete mystery.

However, by 1973 it was becoming obvious that Gold Coast City was inevitably turning to beach nourishment as a solution to its then current erosion. In fact, it was only some time later that we discovered that only some of the erosion we were addressing was real. The rest of it was simply a few headland bypassing negative sediment shadows, that we found translating along with the littoral drift, all only to be followed by bypassing sediment slugs of positive volume, and with a net change of zero, in the long term. Nevertheless, the Gold Coast engineers were told to plan for nourishment, so we did. To this end, we carried out a full investigation of our beach system. This included, of course, a full zig-zag underwater seismic survey and two extensive side-scan sonar traverses, with particular attention to exposed seabed reefs and other hard features. Added to the investigation were the usual basic profile surveys and 3D sediment samples from the frontal dunes out to water depths of 30 meters, and 5 meter depth of cores.

One of the first things we did was to plot up the first side-scan sonar data, and this gave us an almost instantaneous explanation for the erosion hot-spot phenomenon. Every hot-spot on the beach was landwards of an exposed offshore reef, and nowhere else, so this must have been the explanation. In fact, the same erosion hot spots have formed on our coast, every time, then and since, under every major cyclone, six in all now, and these also began to appear during the larger, but non-cyclonic storms. The relationship between hot-spot and offshore reef, appeared to be quite explicit, at least on our beach.

Over the years, it has also been a basic tenet of all Gold Coast beach research, that shoaling wave energy is absorbed by soft pervious sediments, and not by submerged impervious immobile hard bottom reef or cohesive clay layers. For simplicity in executing our coastal research, we have always been prepared to accept the approximation that shoaling waves on a sand-rich beach, from deepwater, and right through to reaching the solitary state at the break, consist of nothing but pure energy, half potential and half kinetic. Then if all this wave energy is to be extracted from the waves, the simplest processes to do this are to use the seabed sediments, to do work on the waves by lifting a weight through a distance, and by surface drag between the sediments and the water. Even if the shoaling wave energy abstraction is not exactly like this, it may still give us a reasonable surrogate model. But once you do accept this model, then the processes involved cannot be generated by hard bottom seabed reefs and structures, because these latter cannot be lifted to do work, and their seabed drag in the boundary layer is insignificant. Porous sediments, however, can be readily penetrated by seabed impacting wave orbital forces, and put into at least partial suspension by waves, as we all see, all the time.

Accordingly, our explanation for our beach hot spots is that they are caused by shoaling waves that roll over hard bottom zones, on their way to the shores, but in so doing, they lose much less energy than their adjoining waves that shoal all the way over a sediment rich "soft" seabed. Thus, when the hard bottom shoaling waves reach the shore, the "extra" energy that they contain causes more erosion than their adjoining soft bottom brothers. It might also follow that if you are an aficionado for the equilibrium profile postulate, you would expect that soft bottom and hard bottom seabeds would produce differently shaped shoaling profiles, and the seabed landwards of a hard bottom would be significantly closer to the shore (more eroded?), exactly as the authors show for each case of their Figure 3. All their actual profiles are landwards of the $y = ax^{2/3}$ predicted shapes, even with the reef structures in place, and without them the "equilibrium" shape could be quite different, particularly to the right hand side of each of the profiles. The $y = ax^{2/3}$ shapes appear to cut through the reefs landwards of their seaward termination. We wonder why? Incidentally, we gain the impression that in their Figure 1 the authors transposed their locations of their "reef protected" profiles and their "standard" profiles as compared with their Figure 3 plots. Again, we wonder why, or *are* they as the prototype?

SHOALING WAVE HEIGHTS

We are most aware that our hot-spot postulate wherein the waves shoaling ashore over a hard bottom, are larger and more powerful than their brothers that shoal up over a soft bottom, is apparently completely contrary to the author's conclusions. That is, that they elected to accept the very reverse, being that the waves that shoaled up over the hard bottom would be much less than for a soft bottom. Indeed, their appreciations are most explicit. They said "... it can be concluded that the wave height that reaches the sand beach toe ... less than the wave height that would reach that particular depth in a beach without a hard shelf. Consequently the total energy that has to be dissipated by the sandy profile is minor ...". It appears that here, the authors invoked HORIKAWA and KUO (1966) because they had computed suitable "... theoretical curves ..." that the authors accepted, as it supported their equation (7), which they then used for the quote above.

These two appreciations of wave behavior are so opposite, that you would not think that we are looking at the same thing, and the answer, most likely, is that we are not. Our Gold Coast hot-spots are only generated during major storms, when normally the whole seabed is in motion, and if there are no hard bottom zones, storm bars build instead. The authors' conditions on the other hand, appear to be for calm conditions and a quiescent sea bed, or very different conditions. But then *we* also have periods on our Gold Coast where the height of a shoaling wave train reduces as it approaches the shore. This is common for a markedly oblique sea that in deepwater has a low crest to gap ratio, *i.e.* the percentage of gaps is high. When these waves shoal up the seabed, the waves significantly refract or bend towards the shore. Then centrifugal force spills water from the crests of the waves into the gaps so the waves become more even and regular, and the mean height of the wave fronts decreases, and the more so the more refraction and the more closeness to the final break. Indeed we can often see the crest of a refracting sea "jiggle" up and down, just before it breaks. All as if it can't decide to either lift itself or slump!

REEF COVER

We observe from the author's Figure 3, that in each case the reef structure is shown as being buried in a light covering of sediment. We should like to report then, that this is also a common phenomenon of our Gold Coast hard bottom zones. The covering is often quite thin, 0.5 to 2.0 meters, but it only appears over the reefs during fine mild wave conditions, and it is rapidly swept off the hard bottom as soon as a storm arrives. It only returns again with calm weather. This can be seen if you fly over the reefs, as soon as possible after a storm abates, provided you get clear post-storm water, or you can deploy side-scan sonar. Another allied reef feature that we note concerns their adjoining natural sediments. Where we do have a clear reef, we find the sediments resting against the reef, particularly on the landward shore parallel edge, are remarkably coarse and often extremely rich in large, thick shell fragments, quite unlike anything else in a normal seabed. Our natural interpretation is that around a seabed reef, nature winnows out the sediments by getting rid of the fines and leaving the coarsest particles available behind, because the coarser the sediment, the higher its energy capacity under wave attack. We presume that this would be a natural response to the otherwise dearth of energy capacity of the impervious reef itself, and perhaps go some way towards making good the deficit. Nature, we think, *is* kind of like that, and perhaps much more often than we think.