OCRM Natural Hazards Issues Study Group

Information Memorandum

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Planning for Sea Level Rise

Sea level rise (SLR) is the theme of this information memorandum. There continues to be considerable controversy as to the variability of SLR predictions and the potential impacts of SLR to shoreline communities and natural habitats.

While the sea level has risen slowly but relatively constant for the past several thousand years, there has not been great cause for concern until recently. It has become apparent to many that the "greenhouse effect" is causing accelerated SLR, ergo, resource management problems will become more troublesome even in our life times.

There appears to be little dispute that SLR is occurring, but how to project the rate into the future for the next 50 to 100 years is where there is some disagreement. More states are beginning to study and focus on the issue and beginning long range planning preparations. Several states such as Maine and California have conducted SLR studies in an effort to determine what will happen to their shorelines, their coastal resources, and the economy of their states.

The National Research Council concluded in a recent study that SLR should not be a cause for alarm or complacency, and present decisions should not be based on a particular SLR scenario. They suggest that planners and designers should be aware of and sensitized to the probabilities of/and quantitative uncertainties related to future SLR. Options should be kept open, and long term planning and policy development should explicitly consider the high probability of future increased rates of SLR. (NRC; "Responding to Changes in Sea Level - Engineering Implications", 1987)

The experience of the Great Lakes states needing to respond to the quick rise in the Great Lakes levels creating severe erosion problems and damage to property may be a harbinger of the things to come if no preparations are made to minimize the associated impacts of SLR.

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THE INUNDATION OF SOUTH FLORIDA: PAST, PRESENT AND FUTURE

by Harold R. Wanless

Since about 1932 relative sea level has been rising along Florida's shorelines at a rate of 8-16 inches per 100 years. This is more than 6 times the rate of geologic history. This increased rate of rise is already having a significant influence on Florida's shorelines and wetlands and will have dramatic consequences within the next century if continued. Further increases in this rate of rise, as are widely predicted because of the increase in atmospheric carbon dioxide, will further heighten the seriousness of (1) rapid shoreline retreat of our sandy, marl levee, swamp and marsh shorelines, (2) inundation of low-lying inland areas, and (3) loss of freshwater resources through saline intrusion into groundwater. A historical perspective helps to appreciate the reality of these conclusions.

THE PAST

15,000 TO 5,500 Years Before Present

About 15,000 years before present (BP) sea level in south Florida rose from -400 to -20 feet at an average rate of 4 feet per 100 years, slower during the last 2,000 years of that period. During this extreme rate of rise, all shorelines and shallow marine deposits either eroded landward or were left behind on the rapidly deepening marine shelf. Can you imagine developing shoreline property when the sea was rising a foot every 25 years?

5,500 to 3,200 Years Before Present

Between about 5,500 and 3,200 years BP sealevel rose from about -20 to -3 feet at about 10 inches / 100 years in south Florida. This rate of relative rise was still sufficient to cause rapid shoreline retreat. Outer and inner Florida Bay were inundated during this time by repeated overstepping of coastal levees, and the limestone ridge making up the Florida Keys was flooded in low areas providing inlet passes to the reefal shelf to the east. Biscayne Bay, a narrow channel prior to 5,500 years BP, was nearly completely flooded by 3,200 years BP. Mangrove and quartz sand shorelines persistently retreated. The limestone ridge defining the seaward margin of Biscayne Bay was extensively flooded, with only Elliot Key remaining as a significant emergent barrier. Our sandy barrier islands were beginning to form along the east and west coasts but most of these were single shore ridges actively migrating (eroding) landward. Exceptions were sandy capes in areas of longshorecurrent convergence (Sanibel Island; Cape Sable). The landward migration of some sandy barrier islands was halted by limestone ridges (Miami Beach). Had this rate of rise continued, the shallow mangrove, reefal, barrier island, oyster bar, and mudbank environments so characteric and valuable to south Florida would not have formed in such an extensive manner and essentially all of south Florida would have been drowned by 1,500 years BP.

3,200 to 50 Years Before Present

Since about 3,200 years BP, relative sealevel rise appears to have slowed dramatically and average about 2 inches / 100 years. This much slower rate of relative rise during the last meter of inundation permitted many of our coastlines to stabilize or grow and many of our shallow marine environments to build upward to sea level. The beaches of Florida were largely stable during this period, and some were growing seaward (Key Biscayne, Marco Island). The marl levees forming the northern margin of Florida Bay largely stabilized and in the vicinity of Flamingo and Cape Sable have been accreting seaward. The maze of mudbanks within Florida Bay have mostly built up to sea level and set the stage for mangrove colonization. In the 10,000 Islands, the mainland mangrove shoreline stabilized about 3,200 years BP and has grown upwards since. In addition, the shallow nearshore environment became colonized by oyster banks and these in turn by mangroves. This has initiated the expanding 10,000 Islands that could eventually extent this mangrove coastline several miles seaward. Along the mainland margin of Biscayne Bay, portions of the mangrove shoreline stabilized, and portions have continued to gradually retreat - probably because of exposure to winter-storm relative sealevel rise permitted coral reef environments seaward of the keys to catch up to sea level - except where water exchange with coastal bays through newly flooded inlets caused reef demise.

All in all, this past 3,200 years has been a time when south Florida's marine environments have been shallowing and its coastlines stable or expanding. Most importantantly this has been a time during which an extensive natural coastal dam has been built by the coastal mangrove peats and storm levee marls, separating the landward freshwater environments from the sea.

THE PRESENT

Tide gauges along the Atlantic and Gulf coasts record a dramatic increase in relative sealevel rise beginning in 1932. For Key West, this increase is from a prior rate equivalent to about one inch per hundred years to a post-1932 rate of about 10 inches per 100 years. Miami's tide gauge records begin in the 1930s and also record a rise equivalent to about 10 inches per 100 years since 1932.

The dramatic increased rate of relative sealevel rise since 1932 is equivalent to the rate between 5,500 and 3,200 years BP. The lesson from that equivalent period is that, with few exceptions, all types of coastlines steadily erode and retreat landward. This landward stepping back tends to occur in storm-driven steps so one should not expect immediate response to this recent increase. Thus, it should not be surprising that this recent rise is accurately expressed by the upwards migration of oysters and barnacles on the seawalls but not yet extensively shown by dramatic shore retreat.

THE FUTURE

The simple conclusion for the future is that, if the rate of relative sealevel rise continues even just at its present rate, the sandy, mangrove and levee coasts of south Florida will erode at an accelerated rate, low-lying freshwater wetlands will become saline, and increased saltwater intrusion will diminish freshwater wetlands. A further lesson from the geologic record is that any prolonged rate faster than the 10 inches /100 years will lead to rapid and complete coastal erosion.

All this could be turned into a simple forecast for the future except for two problems: south Florida's limestone topography is complicated; and the capability for rapid upwards growth of our natural coastal dam of mangrove peat and levee marl is unknown.

The Everglades depression is just that--a low-lying swale between the limestone and quartz sand Atlantic Coastal Ridge (on which Ft. Lauderdale, Miami and Homestead are situated) and the limestone ridge associated with the Big Cypress Swamp. The limestone surface is less than three feet above sealevel in much of the southern Everglades drainage basin. Additionally, both the Atlantic Coastal Ridge and the Big Cypress Swamp Bridge are dissected by numerous peat-filled swales or channels. If the coastal dam is eroded back or overstepped, these swales and the Everglades depression itself may become saline. As this happens, our remaining fresh groundwater resources will be further stressed, and undoubtedly there will be accentuated salt water intrusion beneath the remaining upland areas. The swales and channels dissecting the ridges will encourage salt water intrusion, probably as landward jumps as individual ridge segments are breached.

The most important facts about future sea level are (1) we cannot be absolutely certain that sea level will keep rising at the accelerated rate of the past 50 years, (2) it is not certain that carbon dioxide buildup will cause a further accelerated rate of rise, but (3) there is a very high probability that both of these will occur. It certainly is not a time to panic or to start retreating. It is, however, when the public should be demanding that responsible government and institutions are (a) improving our understanding of how various rates of sealevel change have and will change our environment and (b) developing and implementing plans to minimize the effect of future sealevel rises on the health of the shallow marine environment, on our coastal communities, and on our economy.

PLANNING

There is little one can do at a local, state or national level to prevent future relative rises of sea level. Communities that are causing accelerated subsidence by withdrawal of groundwater or resources have the potential to slow their accentuated subsidence. For the rest, proper planning is necessary.

A dike cannot be built around south Florida to keep rising water level at bay. The sand and limestone substrate is much too porous. Planning is, thus, the only way to minimize impacts. Below are some of the key planning elements.

First and foremost is the need for planning programs to protect our fresh surface-water and groundwater resources - both the availability and the quality. What will be our freshwater resources with 2, 4, 6, or 8 foot sealevel rise with various scenarios for coastal retreat and wetland evolution? Are these areas presently being zoned and managed to assure future water availability and quality?

Regional and local zoning and policy for residential and commercial development, waste dumps, wetland management and coastal modification should be completely reevaluated in light of various 50-200 year scenarios for relative sealevel rise and coastal retreat. Building codes, storm water discharge and flooding management should be similarly reevaluated. It must be emphasized that many low-lying inland areas of south Florida will be as seriously impacted by one meter sealevel rise as will the coastal zone.

It will be necessary to carefully reevaluate projected changes in coastal circulation, salinity, environments and marine habitats that will result from various projected rates of sealevel rise and re-evaluate the economic future and viability of various marine resource and development programs.

Any forecast planning must be based on coastal response forecasts based on firm knowledge of how coastal environments will in fact respond and interact. This is presently poorly understood as are the details of sealevel for the past several thousand years from which hindsight knowledge for forecasting will come. Local, state and federal governments must begin funding research to obtain an adequate level of hindsight and knowledge of environmental response.

The federal government needs to increase research support to delineate and monitor worldwide sealevel change and regional subsidence trends.

The cost effectiveness of the various shore protection/ management programs for sandy shorelines needs careful reevaluation in light of the present increased rates of relative sealevel rise, especially beach nourishment versus relocation.

Do not be reactive to short term (less than decade scale) fluctuations in relative sealevel.

Most importantly, it is time to begin obtaining the necessary background information from which to make useful forecasts and to begin serious reevaluation of our coastal regulations, management and policy. This is not yet a crisis problem, and planning can be done in logical progression and rational atmosphere. In twenty years, that may not be possible.

SOUTH FLORIDA SEALEVEL HISTORY