Estimated Impacts of Sea Level Rise on Florida's Lower East Coast

Overview

The University of Miami Rosenstiel School of Marine and Atmospheric Sciences geologist Harold Wanless[1] has estimated that sea level rise along Florida's shoreline has accelerated to a rate of 8 to 16 inches per hundred years since 1932. This is more than six times the rate recorded by earlier tide-gauge record and that estimated from geological history for the past three thousand years. However, the recent accelerated rate of sea rise is not unprecedented. Global sea level rise has been occurring at varying rates since the end of the last major ice age fifteen thousand years ago. Average sea level rates as large as 3 to 6 feet per century have lasted for periods of thousands years at a time. It is generally accepted that sea level rise is associated with global warming through several processes including the melting of mountain glaciers and thermal expansion of the ocean waters. Past global warming was likely attributed to such factors as long-term increases in solar energy output and variations of the earth's orbit around the sun. Scientific evidence suggest that in the future anthropogenic activities may also contribute in a significant matter to global warming. Regardless of the cause for the warming, the effects of sea level rise poses a formidable challenge for water resources planning for the future.

The Environmental Protection Agency (EPA) is the lead federal agency for guiding coastal states on planning for sea level rise[2]. This role is particularly difficult because of the scale and complexity of the interaction of processes on several different scales that are involved. However, the EPA has consulted with a large group of leading experts in the fields of climate variability, oceanography and glaciology to estimate the most probable sea level rise that will likely occur in the future[3]. The scientists that contributed to the EPA estimates were generally experts from the National Academy of Sciences and the Intergovernmental Panel on Climate Change. The most probable global sea level rise for the year 2050 was estimated to be 0.5 feet greater than the 1995 level. This EPA estimate does not include the effects of local subsidence, erosion, compression and other tectonic instabilities that may occur at varying rates along the Florida coastlines. These additional factors may cause the relative rate of sea level rise at a particular location to be substantially different and most often at a larger rate than the global rate of sea level rise.

In this regional hydrologic analysis, only the effects of the global sea level rise are being considered. The lower east coast of Florida is generally a stable coastline. In an effort to estimate the effects of expected sea level rise on south Florida's regional water management objectives of the future, the South Florida Water Management Model was modified to re-simulate the 2050 base run with the sea level boundary condition adjusted to be 0.5 feet higher than the base condition. One of the major concerns associated with sea level rise is the potential for saltwater encroachment into the coastal freshwater aquifers. The SFWMM is not designed to address the full spectrum of issues that may arise related to the potential for salt water encroachment with sea level rise scenario. However, by making some rudimentary assumptions an estimate of the potential impacts that sea level rise may have on regional water management issues such as Everglades hydroperiod restoration and impacts to regional water supply can be realized. It was with these intentions that water levels maintained within key coastal canals during dry conditions were increased by 0.5 feet. This perfunctory increase in canal maintenance levels is considered the minimal adjustment that would be required to offset the saltwater encroachment that would otherwise occur. Indeed, preliminary analysis with density-dependent groundwater models suggest that the canals may need to be maintained at even higher levels to adequately offset the projected one-half foot rise in sea level. It should also be recognized that significant infrastructure changes may also be required.

Evidence of Past Sea Level Fluctuation

i. Globally sea level rise has been observed during the last century at a rate between .3 to .8 feet per 100 years. Historical global tide gage records supporting this fact exist at the Permanent Service For Mean Sea Level[4].

ii. It is an observed fact that sea level rise relative to most coastal regions in the world is occurring and causing major problems just at the time when rapid coastal development is taking place[5,6].

iii. The Intra-Americas Sea has experienced sea level rise at similar rates as the global average sea level rise based on 62 tidal gages located in the region of the Caribbean Sea, Gulf of Mexico, the Bahamas and Bermuda.[7]

iv. Sea level rise relative to coastlines is often larger than the eustatic (global) sea level rise due to land subsidence and geological instabilities. Sea level rise observed at Key West from 1913 through 1987 is estimated to be about .07 feet per decade[8]. This site is particularly noteworthy because it is very geologically stable.

Table 1. Relative Rate of Sea Level Rise along the Coastline of Florida[8]

Location	Rate (inches per century)
Key West	9.8
Miami Beach	9.4
Cedar Key	5.5
Fernandina Beach	8.7
Mayport	7.5
St. Petersburg	11.8
Pensacola	9.5

The bottom line is that if sea level along the southeast coast of Florida continues to rise at the same rate that occurred the past 100 years, then the projected sea level rise between 1995 and 2050 will be between .3 and .4 feet. This rate of sea level rise does not include the increase in the sea level rise rate that is expected to occur due anthropogenic effects.

Projections of Sea Level Rise For The Future

In 1987 Congress directed the Environmental Protection Agency (EPA) to be the lead Federal Agency for dealing with the effects of global climate change[2]. Recent research by the EPA reports on a probability-based projection for eustatic sea level change that can be adjusted to local tide-gauge trends to estimate future sea level at particular locations. The projections are based on subjective probability distributions supplied by a cross section of climatologists, oceanographers, and glaciologists. The experts who assisted this effort were mostly authors of previous assessments by the National Academy of Sciences and the Intergovernmental Panel on Climate Change (IPCC).

A summary of the EPA's key findings are listed below (all increases in water levels are relative to those at the time the EPA report was published in 1995):

1. Global warming is most likely to raise sea level 0.5 feet by the year 2050 and by 1.1 feet by the year 2100. There is a 10 percent chance that climate change will contribute 1 foot by 2050 and by 2.1 feet by the year 2100. These estimates do not include sea level rise caused by factors other then greenhouse warming.

2. There is a 1 percent chance that global warming will raise sea level by 3.3 feet in the next 100 years and 13 feet in the next 200 years. By the year 2200, there is also a 10 percent chance of 6.5 feet contribution. Such a large rise in sea level could occur either if Antarctic ocean temperatures warm 5^{o}C and Antarctic ice streams respond more rapidly than most glaciologists expect, or if Greenland temperatures warm by more than 10^{o}C. Neither of these scenarios are likely.

4. Along most coasts, factors other than anthropogenic climate change will cause the sea to rise more than the rise resulting from climate change alone. These factors include compaction and subsidence of land, groundwater depletion, and natural climate variations. If these factors do not change, global sea level is likely to rise 1.5 feet by the year 2100, with a 1 percent chance of a 3.7 feet rise.

SFWMM Simulation Assumptions

The specific coastal canal water levels maintained higher for the sea level rise scenario compared to the 2050 Base Run are illustrated in Table 2. In certain cases, when necessary, the initiation of flood control releases were also delayed to allow a higher maintenance level[1]. However, the water level at which maximum releases were made was not altered. Trigger levels for cutbacks were also raised by 0.5 feet except for one interior trigger in Palm Beach County.

Table 2. Special Operations for Coastal Canals for sea level rise (feet, NGVD)

Canal Reach	Flood Control[1]		Maintenance Levels	
	2050 Base	Sea Rise	2050 Base	Sea Rise
C-14 (S-37B)	6.7 - 7.5	7.2 - 7.5	6.5	7.0
C-14 (G-65)	6.6 - 7.5	7.1 - 7.5	6.5	7.0
C-14E (S-37A)	3.5	4.0	3.5	4.0
G-57	4.5	4.5	3.0	3.5
C-13 (S-36)	4.5 - 5.3	4.7 - 5.3	4.0	4.5
G-54	3.6 - 4.5	4.1 - 4.5	3.5	4.0
C-12 (S-33)	3.5 - 4.0	3.5 - 4.0	2.7	3.2
C-9 (S-29)	2.0 - 2.8	2.5 - 2.8	2.0	2.5
C-6 (S-26)	2.5 - 2.8	3.1- 3.2	2.5	3.0
C-7 (S-27)	1.8 - 2.0	2.1 - 2.2	1.5	2.0
C-4 (S-22)	2.85	3.1	2.5	3.0
S-197	2.5	2.5	1.2	1.7
S-18C	2.3 - 3.5	2.3 - 3.5	1.8	2.0
S-165	4.0 - 4.6	4.0 - 4.6	2.8	3.3
S-167	4.0 - 4.6	4.0 - 4.6	2.8	3.3
S-148	4.6 - 5.2	4.6 - 5.2	3.0	3.5
Snapper Creek	4.3	4.3	3.0	3.5

[1] **When a range of water levels are listed, the modeling assumption is that the gate of the downstream structure will be gradually opened wider as the water level in the canal increases.**

Summary of SFWMM Simulation Results

a) Lower East Coast Service Areas water supply

Lower East Coast Water Supply Cutbacks are simulated to increase significantly. This is especially true for LECSA1 and LECSA2, where the number of months of cutbacks more than doubled. Phase two cutbacks occurred more often in LECSA2. The additional number of phase one and phase 2 cutbacks are due to the higher groundwater levels that water use cutbacks are triggered. Deliveries to Lower East Coast Service Area 2 and 3 increased significantly from the 2050 base condition to the 2050 base condition with sea level rise. Water supply deliveries for LECSA2 and LECSA3 also increase. This is due to the higher canal maintenance levels during dry periods in these two service areas.

b) Lower East Coast Flood Protection

The peak stage difference map indicates a significant increase in the number of years that peak stages were more than .25 feet greater than the base case along certain major canals in northern Dade and Broward counties. This indicates a potential increase in flood risk in these areas. Mean water levels were simulated to be higher throughout the same area.

c) Interior Hydrology

The interior of south Florida doesn't appear to be significantly effected by sea level rise. This is illustrated by the Lake Okeechobee, northern ENP, and WCAs performance measures which do not appear to be influenced by sea level rise of 0.5 feet.

d) Coastal Ecosystems

Certain coastal ecosystems (for example mangroves along coastal boundary in Dade county) may be impacted by the intrusion of high saline water. In ENP, if sea level rise occurs at a slow enough rate it is believed that the mangrove ecosystem would be able to migrate inward[7]. However, in more developed areas of the Lower East Coast Service Areas the opportunity for migration may be limited. Estuaries throughout the District may need additional fresh water deliveries to balance increased high saline water trying to enter these valuable habitats. This additional volume, if required, is not known at this time. Therefore it is not included in these sea level rise scenarios.

References

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4. [http://www.nbi.ac.uk/psmsl/pmsl.infol.html). As of August 1997, this data base included over 43000 station-years of record including annual means received from over 1750 tidal gages around the world. This agency is served by an Advisory Group of leading experts around the world.

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