SEA LEVEL RISE IN SARASOTA BAY

E.D. Estevez
Mote Marine Laboratory
6 November 1991

Sea level has been rising along the west Florida coast, including Sarasota Bay, and is projected to rise at an accelerated rate because of global warming. The Sarasota Bay NEP and Tampa Bay Regional Planning Council desire to know the bay management implications of sea level in 2020, 2065, and 2115 AD. Relative sea level and the absolute vertical position of mean higher high water is derived by two methods.

METHOD 1

The National Research Council's Committee on Engineering Implications of Changes in Relative Mean Sea Level (1987) defines total relative sea level change (T) as the sum of the local (L) and eustatic (E) components, or

$$T = L + E$$

where L equals subsidence or uplift at a place, and E is the sum of eustatic rise unrelated to global warming (E') and eustatic rise attributable to new global warming (E").

$$T = L + [E' + E"]$$

Values of L are highly site-specific and estimated values of E' vary from 0 to 3.0 mm/yr (NRC, 1987). However, components of T may be grouped as

$$T = [L + E'] + E"$$

where [L + E'] is the sum of subsidence and eustatic rise unrelated to global warming, and equals the historical rate of <u>apparent</u> <u>secular</u> sea level rise. This value is not known precisely at Sarasota Bay but can be estimated from sea level trends at nearby sites. Lyles et al. (1988) report a 73 year trend of +2.2 mm/yr ($\pm$ 0.2 mm/yr) for Key West and a 61 year trend of +1.9 mm/yr ($\pm$ 0.2 mm/yr) for Cedar Key, from which a trend of 2.1 mm/yr may be assumed for Sarasota Bay. In 146 years', apparent secular sea level could rise by 30.7 cm because of subsidence and eustatic rise unrelated to global warming.

$$[L + E'] = 30.7 \text{ cm}$$

The value of E" represents the eustatic rise caused by new global warming. The Intergovernmental Panel on Climate Change Working Group 1 (Warrick and Oerlemans, 1990) reports the best estimate for the *Business As Usual* scenario as 66.0 cm in 2100 AD. This extrapolates to 75.0 cm in 2115.

' 2115 minus 1969, the midpoint of the last 19 year tidal epoch for which the National Ocean Survey has determined the relationship of tidal datum planes to the National Geodetic Vertical Datum (1929) in Sarasota Bay.

$$E'' = 75.0 \text{ cm}$$

$$T = [L + E'] + E'' = 30.7 \text{ cm} + 75.0 \text{ cm} = 105.7 \text{ cm}$$

Mean annual sea level in 2115 may consequently be 1.06 m higher than mean sea level as last determined in Sarasota Bay.

Mean higher high water was 31.4 cm above mean tide level during the 1960 - 1978 tidal epoch. Mean higher high water in 2115 AD may consequently be 0.31 m higher than mean annual sea level that year, or 1.37 m higher than mean sea level as last determined in Sarasota Bay.

The National Ocean Survey determined that mean tide level at Sarasota station # 872-6083 was 12.8 cm above the NGVD for the 1960 - 1978 tidal epoch.

THEREFORE, MEAN HIGHER HIGH WATER IN 2115 AD MAY REACH 1.50 M (4.9 FT) ABOVE NGVD AT SARASOTA. BY LINEAR INTERPOLATION, MEAN HIGHER HIGH WATER IN 2020 AND 2065 MAY BE 81.2 CM (2.7 FT) AND 113.9 CM (3.7 FT) ABOVE NGVD, RESPECTIVELY.

A low estimate of 1.13 m (3.7 ft) above NGVD can be made for MHHW in 2115 by combining the low trend for apparent secular sea level rise (2.1 mm/yr minus one standard error of 0.2 mm/yr) with the IPCC *Business as Usual* low estimate of 31 cm by 2100. Likewise, a high estimate of 2.24 m (7.3 ft) above NGVD can be made for MHHW in 2115 by combining the high trend for apparent secular sea level rise (2.1 mm/yr plus one standard error of 0.2 mm/yr) with the IPCC *Business as Usual* high estimate of 110 cm by 2100.

Method 1 was critically reviewed by Robert G. Dean, University of Florida; Bruce Parker, National Ocean Service; Tony Sturges, Florida State University; Harold R. Wanless, University of Miami; and James G. Titus, Environmental Protection Agency. The present form of Method 1 incorporates minor changes recommended by the reviewers.

METHOD 2

This method addresses a widely held concern of reviewers (the incorporation of the historic trend eustatic in the IPCC estimate), and a recommendation by one reviewer (inclusion of groundwater effects).

The National Research Council's Committee on Engineering Implications of Changes in Relative Mean Sea Level (1987) defines total relative sea level change (T) as the sum of the local (L) and eustatic (E) components, or

$$T = L + E$$

where L equals subsidence or uplift at a place, and E is the sum of eustatic rise from 1969 to 1990 (E') and eustatic rise projected to occur thereafter (E").

$$T = L + [E' + E'']$$

Subsidence at Sarasota is not known precisely but can be estimated from nearby sites. The NRC (1987) adopted a long-term average subsidence rate of 0.8 mm/yr for St. Petersburg. In 146 years, apparent secular sea level could rise by 11.7 cm because of subsidence.

$$L = 11.7 \text{ cm}$$

E' can be estimated as the difference between Sarasota's historic rate of apparent secular sea level rise (see Method 1), and subsidence at St. Petersburg, for the 1969 to 1990 period.

$$E' = 2.1 \text{ mm/yr} - 0.8 \text{ mm/yr} \times 21 \text{ yr}$$

$$E' = 2.7 \text{ cm}$$

The value of E" represents a prediction of future eustatic rise. The Intergovernmental Panel on Climate Change Working Group 1 (Warrick and Oerlemans, 1990) reports the best estimate for the *Business As Usual* scenario as 66.0 cm in 2100 AD. This estimate did not include groundwater contributions.

Meier (1990) used revised data on thermal expansion and glacier contributions in an estimate that also accounted for groundwater effects. For 2050, Meier (1990) calculated a cumulative sea level rise of 34 cm ($\pm$ 42 cm). This extrapolates to 70.8 cm between 1990 and 2115.

$$E" = 70.8 \text{ cm}$$

$$T = L + [E' + E"] = 11.7 \text{ cm} + [2.7 \text{ cm} + 70.8 \text{ cm}]$$

$$T = 85.2 \text{ cm}$$

Mean annual sea level in 2115 may consequently be 0.85 m higher than mean sea level as last determined in Sarasota Bay.

Mean higher high water was 31.4 cm above mean tide level during the 1960 - 1978 tidal epoch. Mean higher high water in 2115 AD may consequently be 0.31 m higher than mean annual sea level that year, or 1.17 m higher than mean sea level as last determined in Sarasota Bay.

The National Ocean Survey determined that mean tide level at Sarasota station # 872-6083 was 12.8 cm above the NGVD for the 1960 - 1978 tidal epoch.

THEREFORE, MEAN HIGHER HIGH WATER IN 2115 AD MAY REACH 1.29 M (4.2 FT) ABOVE NGVD AT SARASOTA. BY LINEAR INTERPOLATION, MEAN HIGHER HIGH WATER IN 2020 AND 2065 MAY BE 69.5 CM (2.3 FT) AND 91.8 CM (3.0 FT) ABOVE NGVD, RESPECTIVELY.

A low estimate of 0.42 m (1.4 ft) above NGVD can be made for MHHW in 2115 by using Meier's (1990) low value of 0.34 m *minus* one standard deviation of 0.42 m. Likewise, a high estimate of 2.17 m (7.1 ft) above NGVD can be made for MHHW in 2115 by using Meier's (1990) high value of 0.34 m *plus* one standard deviation of 0.42 m. In both cases the 2050 AD rates are extended by 65 years.

COMPARISON

Vertical position of MHHW in 2115 AD, in meters above NGVD

Method	Low	Best	High
1 (IPCC)	1.13	1.50 (4.9 ft)	2.24
2 (Meier)	0.42	1.29 (4.2 ft)	2.17

SUMMARY AND RECOMMENDATION

Future sea level was calculated using two methods and the most recent and reliable data. Results differ by 15 percent and fall within the range of published values. Considerable uncertainty accompanies the calculations because of embodied assumptions. Estimates will change as new data become available. These estimates were registered to the National Geodetic Vertical Datum (1929) for ease of mapping and risk assessment. The choice of tidal datum plane will depend on the nature of risk assessments conducted during the study. An NGVD elevation of 4.0 to 5.0 ft is recommended for MHHW in 2115 AD.

REFERENCES

Committee on Engineering Implications of Changes in Relative Mean Sea Level, 1987. *Responding to Changes in Sea Level: Engineering Implications.* National Academy Press, Washington, D.C. 148 p.

Lyles, S., L.E. Hickman, Jr. and H.A. Debaugh, Jr., 1988. *Sea Level Variations for the United States 1855 - 1986.* NOAA/NOS Tides and Water Levels Branch, Washington D.C.

Meier, M.F., 1990. Reduced rise in sea level. *Nature* 343: 115-116.

Warrick, R.A. and H. Oerlemans, 1990. Sea Level Rise, Chapter 10 in J.T. Houghton, G.J. Jenkins and J.J. Ephraums (eds.), *Climate Change: The IPCC Scientific Assessment.* WMO/UNEP Intergovernmental Panel on Climate Change Working Group 1. Cambridge University Press, 365 p.

Postscript

When the North American Vertical Datum (NAVD) of 1988 is adopted, these projections of sea level rise must be adjusted by its difference from NGVD of 1929.