RECOMMENDED PROJECTION OF
SEA LEVEL RISE IN THE TAMPA BAY REGION

Tampa Bay Climate Science Advisory Panel

August 2015

Introduction

The Tampa Bay region, with nearly 700 miles of shoreline[1] and 3.2 million residents - many of whom live near Tampa Bay or the Gulf of Mexico - is highly vulnerable to the potential effects of sea level rise (SLR). Citizens, emergency managers and regional leaders have been accustomed to thinking of coastal hazards in terms of the episodic effects of hurricanes or coastal storms; however, it is also important for local governments and regional agencies to consider the long-term, sustained effects of SLR on real property, natural habitats, and our ability to sustain growth in the regional economy.

The Tampa Bay regional economy is closely tied to both the Gulf of Mexico and Tampa Bay. It is valued at $170 billion, with $51 billion directly influenced by the bay itself[2]. In a report recently published by the World Bank, Tampa was identified as one of the ten coastal metropolitan areas most vulnerable to sea level rise and subsequent flooding. The report rated cities in terms of the overall cost of potential damage and assumed that no adaptation strategies would be implemented in response to SLR[3]. Regional measurements show that the Tampa Bay region is already experiencing sea level rise and there is broad scientific consensus that this trend will continue on into the next century. Cities that choose not to implement adaptation strategies, including those in the Tampa Bay region, may experience the following conditions which will likely incur substantial social and economic costs:

- Flooding of streets, homes, businesses, hospitals, schools, emergency shelters, etc.,
- Shoreline and beach erosion,
- Impacts to the operations of coastal drainage systems,
- Impairment of coastal water supplies including saltwater intrusion of groundwater and threats to coastal water treatment facilities and infrastructure, and
- Shifts in habitats and reduced ecosystem services.

The economic costs of inaction in the face of SLR must be weighed carefully against the potential (and equally substantial) costs of implementing adaptation strategies, technological solutions and infrastructure investments. However, local governments in the Tampa Bay region should feel confident that there are viable opportunities for implementing adaptation strategies that increase the region's resilience to sea level rise and other coastal hazards. These opportunities benefit from a common projection of regional SLR that enables coordinated planning and policy efforts to protect public safety, health, and quality of life; providing the scientific rationale for the most appropriate projection(s) of SLR in the Tampa Bay region is the purpose of this recommendation.

The Tampa Bay Climate Science Advisory Panel (CSAP), formed in spring 2014, is an ad hoc network of scientists and resource managers working in the Tampa Bay region (Pinellas, Hillsborough, Manatee, and Pasco counties). The goal of the advisory panel is to develop

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[1] http://www.tbrpc.org/mapping/pdfs/sea_level_rise/Tampa%20Bay%20-%20Sea%20Level%20Rise%20Project%20Draft%20Report%20without%20maps.pdf
[2] https://tbeptech.org/TBEP_TECH_PUBS/2014/TBEP_04_14_%20FinalReport_Economic_Valuation_of_Tampa_Bay_Estuary.pdf
[3] http://www.worldbank.org/en/news/feature/2013/08/19/coastal-cities-at-highest-risk-floods

recommendations for local governments and regional agencies as they make decisions about responding to climate change and associated SLR. The CSAP has assessed the best available scientific data to determine a regional set of SLR projection scenarios through 2100. With this shared projection, local governments can coordinate, develop, and implement appropriate coastal adaptation and risk reduction strategies. This document briefly explains the technical methods used to produce SLR projections and offers the CSAP's rationale for the most appropriate SLR projections to use for planning and policymaking throughout the Tampa Bay region.

Figure 1. Map of the four county region served by the CSAP.

Technical Methods and Recommendations

Estimates of future SLR are typically expressed by plotting or tabulating a quadratic function. This function is used because it is the simplest function that can effectively capture a wide range of possible SLR scenarios, including constantly increasing, rapidly increasing or even decreasing sea levels. Defining a specific SLR scenario requires three numbers: a datum, the point in time sea level is defined to be zero; a rate of change, how rapidly sea level is changing (increasing or decreasing) at time zero; and a projection, the amount global sea level is expected to change between time zero and some point in the future[4].

Both the datum[5] and the rate of change[6] are defined using present day observations from a tide gauge proximate to the region of interest. Local rates of sea level change reflect a variety of factors, including vertical land motion (subsidence or uplift), changes in estuarine and shelf hydrodynamics, regional oceanographic circulation patterns, and hydrologic cycles (river flow). So, while global measurements and projections are important for estimating SLR, local measurements and projections are needed for realistic local planning efforts. For the Tampa Bay region, the CSAP recommends using data collected from the tide station located near downtown St. Petersburg as the basis for adjusting the first two parameters that are needed to predict regional SLR. The St. Petersburg tide station[7] has the longest reliable period of record (1946 to present) in the region and is consistent with other nearby tide stations, including one located in the Gulf of Mexico at Clearwater[8]. Data measured at the St. Petersburg tide station shows that water levels in Tampa Bay have increased approximately 6.6 inches or approximately 1 inch/decade (see Figure 2).

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[4] Most often, this point in the future is the year 2100. However, this does not mean that we only know what the predicted sea level will be in 2100. The quadratic function can show possible sea levels at any point along the curve, between now, 2100 and beyond.
[5] http://tidesandcurrents.noaa.gov/datums.html?id=8726520
[6] http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8726520
[7] http://tidesandcurrents.noaa.gov/stationhome.html?id=8726520
[8] http://tidesandcurrents.noaa.gov/stationhome.html?id=8726724&name=Clearwater Beach&state=FL

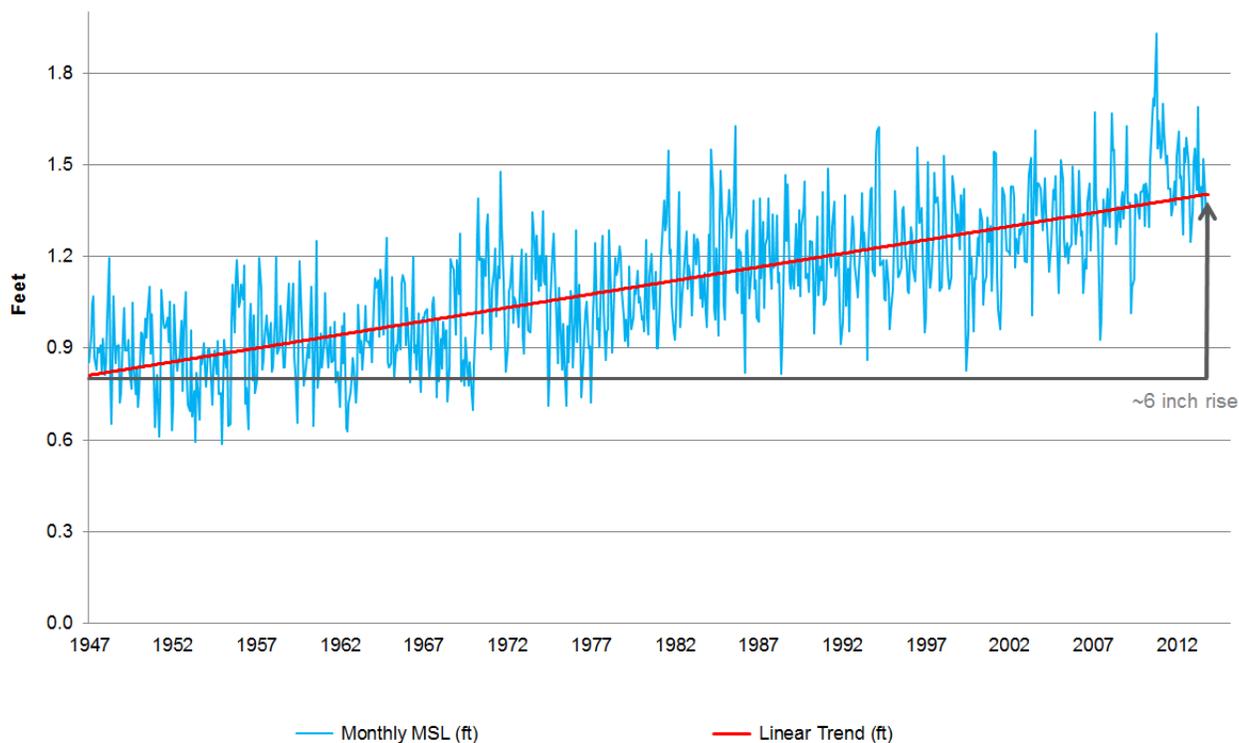**Mean Sea Level Trend St. Petersburg, Florida**

Figure 2. Mean Sea Level Trend (relative to Mean Lower Low Water) in St. Petersburg, Florida, NOAA Tide Gauge #8726520

The final parameter, projections of how much sea level will change globally over the next 100 years, is derived from experts engaged in climate science. Currently, there are two primary sources of information regarding sea level rise projections: the Intergovernmental Panel on Climate Change (IPCC) and the US National Climate Assessment (NCA). Although these assessments employ different methods (IPCC relies upon numerical process models; the NCA uses semi-empirical models), both produce estimates of SLR that are consistent with the other. This implies that the results obtained through either approach are robust and should provide practitioners with a higher degree of confidence in using the recommended projections for planning purposes.

The 2012 National Oceanic and Atmospheric Administration (NOAA) Technical Report, *Global Sea Level Rise Scenarios for the United States National Climate Assessment,* was produced as a coordinated, interagency effort to identify nationally agreed upon estimates for global SLR. The report synthesized the scientific literature on global SLR, included input from national experts in climate science, physical coastal processes and coastal management, and produced a set of four plausible SLR scenarios that can easily be adjusted for regional conditions throughout the United States. The projections included in the report will be reviewed every five years in concert with the NCA and the projections use the most current science available. For

these reasons, the CSAP recommends that local governments and regional agencies use the set of four global SLR scenarios included in the NCA (hereinafter the NOAA SLR projections[9]), adjusted to local conditions, to inform adaptation and infrastructure planning efforts in the Tampa Bay region.

Future SLR estimates can be calculated for the Tampa Bay region, integrating data from the local St. Petersburg tide gauge, using a flexible, well-supported tool developed by the United States Army Corps of Engineers (USACE)[10]. The tool takes the three parameters discussed above (datum, rate of change, projection) and produces the plots or tables that describe how sea level will change in the future, such as those included as Figure 3 and Table 1[11].
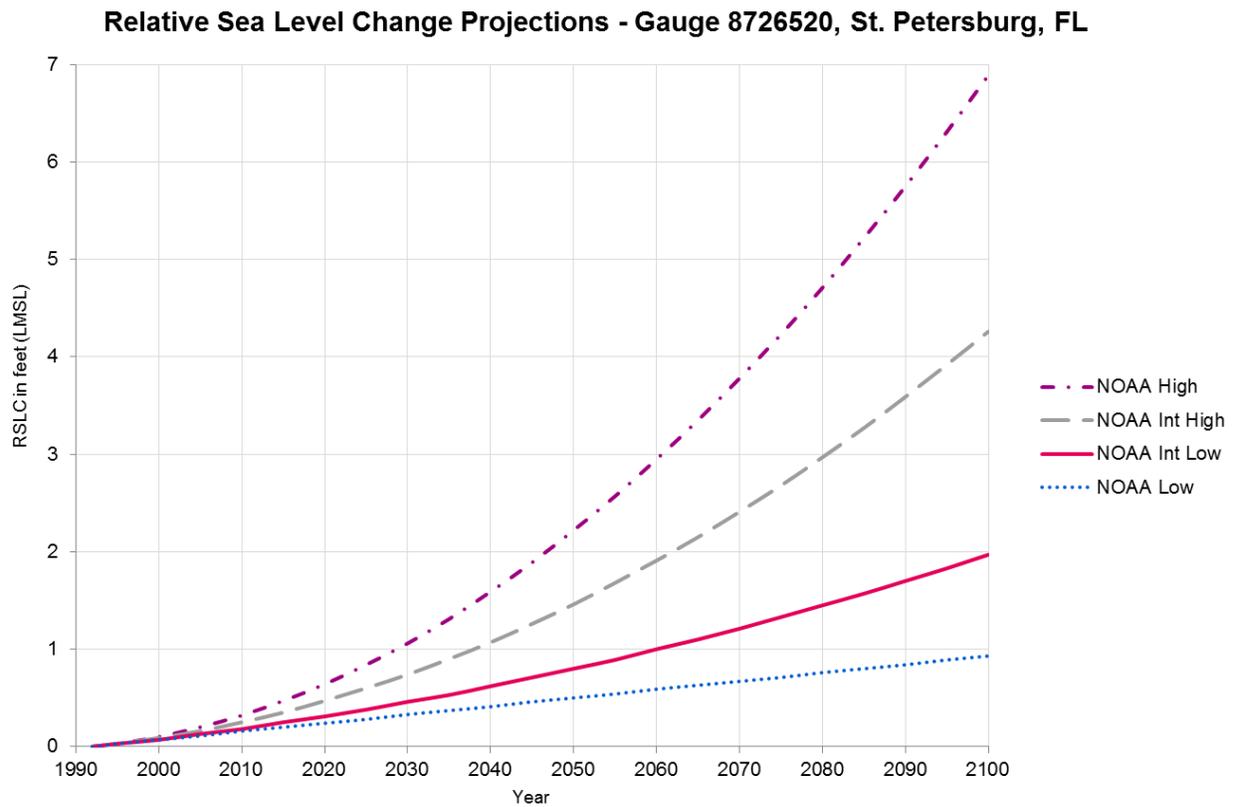

Figure 3. Graphic Relative Sea Level Change (RSLC) Scenarios for St. Petersburg, Florida, as calculated using the NOAA projections and regional corrections. (USACE, 2015)

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[9] NOAA led the multi-agency effort to inform the sea level portion of the NCA and produced the key technical report, so we will refer to these as the NOAA SLR projections.

[10] Although the CSAP recommends using the USACE Sea Level Change Curve Calculator Tool, this should not be confused with a recommendation of the USACE SLR projections. The USACE SLR projections are similar to the results produced by the IPCC and NCA, but are based on the National Research Council (NRC) report, *Responding to Changes in Sea Level; Engineering Implications,* published in 1987.

[11] When using the USACE Sea Level Change Curve Calculator Tool, first select the "St. Petersburg, FL" gauge, then choose "NOAA" as the output agency and factor the projected SLC rate as "Regionally Corrected."

The regionally adjusted NOAA SLR projections through 2100 (Table 1 and Figure 3) can be summarized as follows:

- *NOAA Low (0.93 feet)*: This is a linear continuation of the historically measured rate of sea level rise and is generally considered appropriate for use as a baseline comparison or in circumstances where there is a great tolerance for risk.
- *NOAA Intermediate Low (1.97 feet)*: This is based on global mean SLR projections from the IPCC 4th Assessment Report and primarily characterizes risks attributed to ocean warming.
- *NOAA Intermediate High (4.26 feet)*: This is an average of the high end of ranges of global mean SLR reported by several studies[12] using semi-empirical approaches that attempt to characterize the complex relationships between observed sea level change, air temperature, and actual ice sheet loss.
- *NOAA High (6.89 feet)*: This is derived from a combination of estimated ocean warming from the IPCC 4th Assessment Report global SLR projections and a calculation of the maximum possible glacier and ice sheet loss by the end of the century.

Table 1. Relative Sea Level Change Scenarios for St. Petersburg, Florida in Feet above Local Mean Sea Level (LMSL).

Year	NOAA Low (Feet)	NOAA Int Low (Feet)	NOAA Int High (Feet)	NOAA High (Feet)
1992[13]	0.00	0.00	0.00	0.00
2025	0.28	0.38	0.60	0.84
2035	0.37	0.53	0.90	1.31
2050	0.50	0.80	1.46	2.22
2065	0.63	1.10	2.15	3.35
2075	0.71	1.33	2.68	4.23
2100	0.93	1.97	4.26	6.89

Summary

Based upon a thorough assessment of scientific data and literature on SLR, the CSAP concludes that the Tampa Bay region may experience SLR somewhere between 6 inches to 2.5 feet in 2050 and between 1 to 7 feet in 2100. Given this range of uncertainty in future SLR, the

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[12] Grinsted et al. 2009; Jevrejeva et al. 2010; Vermeer and Rahmstorf, 2009; Horton et al. 2008 from NOAA Tech Memo OAR CPO, p. 12.

CSAP encourages local governments and other agencies to use multiple scenarios in order to allow experts and decision makers the flexibility to consider a variety of contextual factors, including the expected lifespan of the project, project cost, and criticality of function, when developing adaptation strategies. Scenario planning offers opportunities to initiate actions now by balancing the costs of inaction against reasonable returns on investments made to infrastructure that may reduce future impacts and vulnerabilities. For example, decision makers may decide to plan for the NOAA Intermediate Low or Intermediate High scenarios when faced with projects with low to moderate risk tolerance such as temporary projects or infrastructure projects with a relatively short life cycle, while they may choose to plan for the NOAA High scenario in situations where there is little tolerance for risk (e.g. new infrastructure with a long anticipated life cycle such as a power plant, waste water treatment facility, or bridge) (NOAA, 2012). The level of adaptation planning necessary will be up to the planning entity and based on the acceptable level of risk and vulnerability.

The decision to use a common set of SLR scenarios throughout the Tampa Bay region will promote the efficient development of vulnerability assessment information, provide a platform for broad consensus that can facilitate political support at the local government level, enable increased inter-governmental sharing of policies, and serve as a resource for smaller local governments in the region that frequently look to their larger neighbors for planning and policy guidance. Furthermore, use of a regional set of scenarios for SLR will enable other entities, such as the CSAP, universities, regional agencies (e.g. Tampa Bay Estuary Program, Tampa Bay Regional Planning Council, Tampa Bay Water, Southwest Florida Water Management District) and others to develop decision support tools, best practices, and planning documents to inform policy, planning, and adaptation strategies for local governments and regional agencies managing transportation, infrastructure, water resources, and natural systems. The CSAP recommendations are intended to further these goals, but it is also important to acknowledge that scientific research is evolving. In order to keep up with the best available science, the CSAP advises that this recommendation be revisited, at minimum, every five years and sooner if significant scientific information on future SLR becomes available.

Local governments and other agencies planning for sea level rise in the Tampa Bay region should incorporate three key findings of the CSAP recommendation:

- Adaptation planning should employ a scenario-based approach that considers, at a minimum, location, time horizon, and risk tolerance.
- Projections of SLR should be consistent with present and future National Climate Assessment estimates and methods.
- Projections of SLR should be regionally corrected using the St. Petersburg tide gauge data.

A resilient Tampa Bay – one that acknowledges and responds to coastal vulnerabilities – is one that can support the economic, environmental, and cultural prosperity of this unique and highly valuable region.

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List of Acronyms

CSAP	Tampa Bay Climate Science Advisory Panel
IPCC	United Nations Intergovernmental Panel on Climate Change
LMSL	Local Mean Sea Level
MLLW	Mean Lower Low Water
MSL	Mean Sea Level
NCA	U.S. National Climate Assessment
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NTDE	National Tidal Datum Epoch
RSLC	Relative Sea Level Change
SLR	Sea Level Rise
USACE	United States Army Corps of Engineers

Definition of Terms

Datum: The base elevation used as a reference from which to calculate heights or depths; the point in time at which the sea level is defined to be zero.

Mean Lower Low Water: The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch.

Mean Sea Level: The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch. Shorter series are specified in the name; e.g. monthly mean sea level and yearly mean sea level. Local Mean Sea Level (LMSL) is the arithmetic mean of hourly heights at the specific tide station at which it was observed and should not be confused with any other vertical datum, including LMSL at other tide stations.

National Tidal Datum Epoch: The specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values for tidal datums. It is necessary for standardization because of periodic and apparent secular trends in sea level. The present NTDE spans 1983 through 2001 and is referred to as the mid-point or 1992. The NTDE is actively considered for revision every 20-25 years.

Projection: The numerical value of sea level change between time zero and some point in the future.

Rate of Change: How rapidly sea level is changing (increasing or decreasing) at time zero.

Relative Sea Level Change: The variance in the height of the water as measured in reference to a specific, stable vertical point on land (known as a benchmark) due to changes in local conditions (e.g. subsidence or vertical uplift).

Scenario: The quadratic function that shows possible sea levels at any point along the curve, between time zero and some point in the future.

Tool: An application that processes the datum, rate of change and projection to produce the plots or tables that describe how sea level will change in the future (e.g. USACE Sea Level Change Curve Calculator)

Tampa Bay Climate Science Advisory Panel

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