RECOMMENDED PROJECTION OF SEA LEVEL RISE IN THE TAMPA BAY REGION

Tampa Bay Climate Science Advisory Panel

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Introduction

The Tampa Bay region, with nearly 700 miles of coastline and 3.2 million residents - most 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 these 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, quality of life, and perhaps most importantly, 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[1]. In a report recently published by the World Bank, Tampa was identified as one of the ten most vulnerable coastal metropolitan areas (in terms of the overall cost of damage) throughout the world due to sea level rise and subsequent flooding. The report assumes that the cities do not to implement adaptation strategies in response to SLR[2]. 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. If adaptation strategies are not implemented, the cities such as those in the Tampa Bay region will likely experience the following conditions, all of which may incur substantial 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
- Shifts in wetlands and habitats, resulting not only in the loss of natural barriers against erosion (e.g., mangroves) but the ecosystem services and sense of place they provide for the region

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, quality of life; providing such a projection is the fundamental 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 group's goal is to collaboratively develop recommendations for local governments and regional agencies as they make decisions about

[1] https://tbeptech.org/TBEP_TECH_PUBS/2014/TBEP_04_14_%20FinalReport_Economic_Valuation_of_Tampa_Bay_Estuary.pdf
[2] http://www.worldbank.org/en/news/feature/2013/08/19/coastal-cities-at-highest-risk-floods

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.

Technical Methods and Recommendations

Estimates of future SLR are typically expressed by plotting or tabulating a quadratic function. This function is chosen 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 the 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[3].

Both the datum[4] and the rate of change[5] are defined using present day observations from a tide gauge proximate to the region of interest. Local sea level change rates reflect a variety of local factors, including vertical land motion (subsidence or uplift) and 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[6] has the longest reliable period of record in the region and is consistent with other nearby tide stations, including one located in the Gulf of Mexico at Clearwater[7]. Data measured at the St. Petersburg tide station shows that water levels in Tampa Bay have increased approximately 6.6 inches (~1 inch/decade) since 1946 when water levels were first recorded at this tide gauge (see Figure 1).

[3] 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.
[4] http://tidesandcurrents.noaa.gov/datums.html?id=8726520
[5] http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8726520
[6] http://tidesandcurrents.noaa.gov/stationhome.html?id=8726520
[7] http://tidesandcurrents.noaa.gov/stationhome.html?id=8726724&name=Clearwater Beach&state=FL

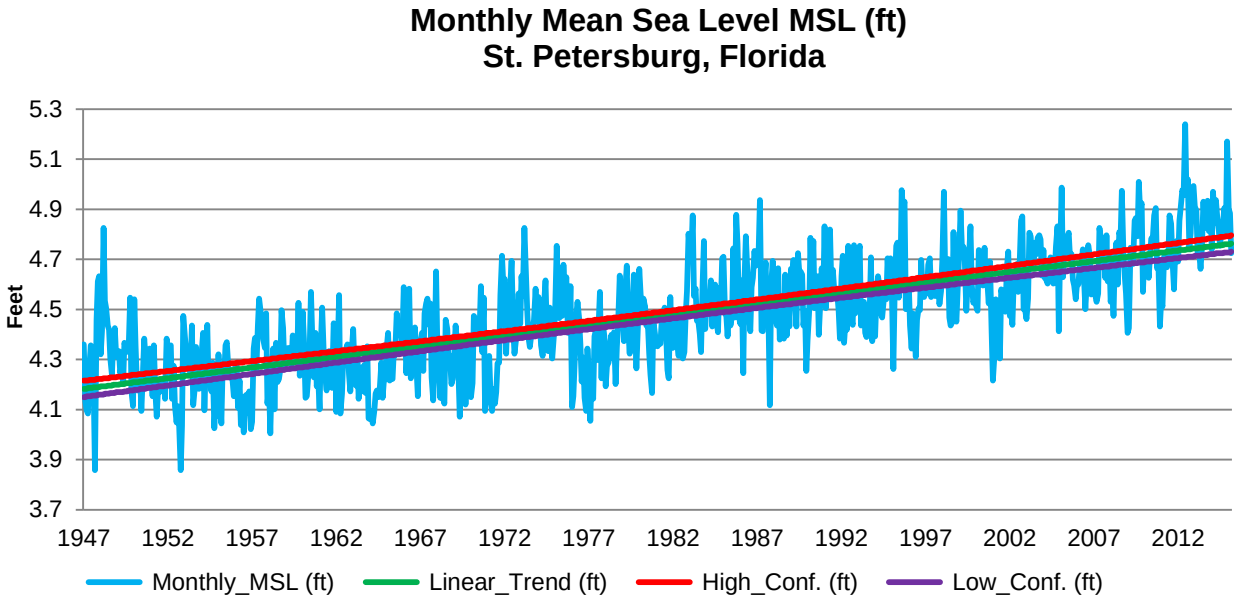

Figure 1. Mean Sea Level Trend in St. Petersburg, Florida, NOAA Tide Gauge #8726520

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. It 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 approximately every 5 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[8]), adjusted to local conditions, to inform adaptation and infrastructure planning efforts in the Tampa Bay region.

[8] 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.

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 US Army Corps of Engineers (USACE)[9]. 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 2 and Table 1[10].

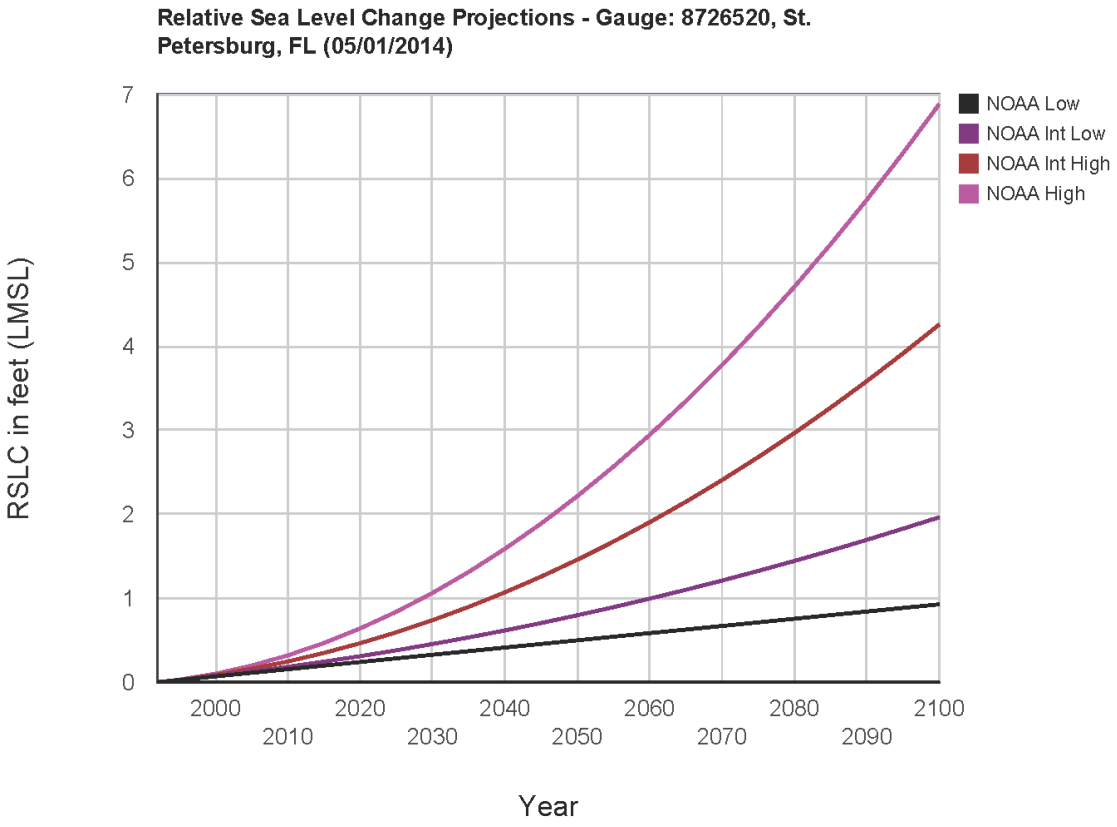

Figure 2. Graphic Relative Sea Level Change (RSLC) Scenarios for St. Petersburg, Florida, as calculated using the NOAA curves and regional corrections. (USACE, 2015)

The regionally adjusted NOAA SLR projections (Table 1 and Figure 2) can be summarized as follows:

- *NOAA Low (0.93 feet)*: This is a continuation of the historically measured rate of sea level rise as a baseline comparison. This is a low probability scenario.

[9] 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. Although the USACE SLR projections produce results that are similar to that of the IPCC and NCA, they are based on equations developed in 1987 for the National Research Council (NRC) report, *Responding to Changes in Sea Level; Engineering Implications* and do not represent the best available science.

[10] 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."

- *NOAA Intermediate Low (1.97 feet)*: This is based on global mean SLR projections from the IPCC 4th Assessment Report.
- *NOAA Intermediate High (4.26 feet)*: This is an average of the high end of ranges of global mean SLR reported by several studies[11] using semi-empirical approaches.
- *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. This is a low probability scenario.

Table 1. Relative Sea Level Change Scenarios for St. Petersburg, Florida in Feet above Lower Mean Sea Level (LMSL), base year 1992 control for national survey datum.

Year	NOAA Low (Feet)	NOAA Int Low (Feet)	NOAA Int High (Feet)	NOAA High (Feet)
1992[12]	0.00	0.00	0.00	0.00
2012	0.17	0.21	0.29	0.38
2032	0.34	0.49	0.80	1.16
2052	0.52	0.84	1.54	2.36
2072	0.69	1.26	2.52	3.96
2092	0.86	1.75	3.72	5.97
2100	0.93	1.97	4.26	6.89

Summary

Based upon a thorough assessment of scientific data and literature on SLR, the CSAP believes that the Tampa Bay region can expect to see 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 CSAP urges 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

[11] Grinsted et al. 2009; Jevrejeva et al. 2010; Vermeer and Rahmstorf, 2009; Horton et al. 2008 from NOAA Tech Memo OAR CPO, p. 12.
[12] The National Tidal Datum Epoch (NTDE) is calculated using tide gauge observations from 1983-2001. Therefore, the mid-point of 1992 is used as the starting point for the projected curves.

moderate risk tolerance (such as less expensive infrastructure, 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) (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.

Selecting and recommending use of a common set of SLR scenarios throughout the Tampa Bay region will allow for more 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, the Tampa Bay Regional Planning Council, universities 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 important to acknowledge that scientific research is a rapidly moving target. In order to keep up with the best available science, the CSAP advises that this recommendation be revisited in five (5) years at the minimum, or sooner if significant new 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

IPCC	United Nations Intergovernmental Panel on Climate Change
LMSL	Lower Mean Sea Level (average tidal measurement)
NCA	U.S. National Climate Assessment
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NTDE	National Tidal Datum Epoch
SLR	Sea Level Rise
CSAP	Tampa Bay Climate Science Advisory Panel
USACE	United States Army Corps of Engineers

Definition of Terms

Datum:	The base elevation used as a reference from which to reckon heights or depths; The point in time the sea level is defined to be zero.
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 is 1983 through 2001 (1992) and 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.
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:	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)

Group Composition

Organization	Representative	Designated Alternate
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US Geological Survey	Dr. Nathaniel Plant	Dr. Hilary Stockdon
The National Weather Service, Tampa Bay	Dr. Charlie Paxton	
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University of South Florida, College of Marine Science	Dr. Mark Luther	Dr. Steve Meyers
National Atmospheric and Oceanic Administration	Heidi Stiller	Kristen Larsen
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Manatee County	Rob Brown	
Pasco County	Melissa Charbonneau	Keith Wiley, Curtis Franklin
US Army Corps of Engineers	Glenn Landers (ex officio-Technical Advisor)	