ASSESSING THE ECONOMIC IMPACTS OF CLIMATE CHANGE EVENTS TO MARINE INDUSTRIES IN LONG BEACH, CALIFORNIA

A Paper From:
California Department of Boating and Waterways

Prepared By:
Aaron R. McGregor

DISCLAIMER

The findings in this document were funded and initially prepared for the California Department of Boating and Waterways. This document does not represent the views of the Department of Boating and Waterways, their employees, or the State of California. The Department of Boating and Waterways, the State of California, and their employees make no express of implied warrant, and assume no legal charge for the information in this paper; nor does any party represent that the uses of this information will not infringe upon privately owned rights. This paper is being made available for information purposes only and has not been approved or disapproved by the Department of Boating and Waterways, nor has the Department of Boating and Waterways passed upon the accuracy or completeness of the information in this paper. Users of this paper agree to hold blameless the funding agency for any liability associated with its use. Further, this work shall not be used to assess actual coastal hazards, insurance requirements or property values.

Prepared for the Ralph and Goldy Lewis Center for Regional Policy Studies
Director: J.R. DeShazo

June 2010

Abstract

The scientific community predicts significant ecological and economic impacts from a warming climate. Warming-induced sea level rise and storm surges are two climatic variables that place California at risk in the coming century. Responding to the threats posed by a rapidly changing climate, Governor Arnold Schwarzenegger issued Executive Order S-13-08, mandating State agencies to plan for climate change impacts along the California coast. Many of California's waterways and boating venues lie on the Pacific coast. In accordance with Executive Order S-13-08, this study models the expected impacts to Long Beach's marinas from a rise in sea level with/without a 100-year storm. Baseline economic impacts from Long Beach's marinas were estimated for the 2008 calendar year. Sea level rise and 100-year storm analyses were modeled to estimate the potential for Long Beach's marinas to face temporary or permanent closure from rising sea levels and/or a 100-year storm. Temporary or permanent inundation of Long Beach's marinas will result in a loss of boating days and corresponding boater spending in the region.

Policy Question

What are the economic impacts of climate change events, specifically rising sea levels and low-probability storm events, to coastal marinas in Long Beach, California?

Results

A respective 1.0 m and 1.4 sea level rise in 2050 and 2100, absent peak tides and extreme storm surges, will not result in measurable impacts to Long Beach's marinas in 2050 or 2100. However, a 2.0 m rise in sea level by 2100 will result in year-round, inundation-related closure to Shoreline Marina and Rainbow Harbor Marina. A **one-year** closure to these marinas will result in lost sales totaling $35.8 million.[1] The annual direct and secondary effects from a closure to these marinas amounts to a loss of 420 jobs for the local economy, $12.4 million in lost labor

[1] All losses/damages are in 2008 dollars.

income and $20.7 million in lost value added. Inundation to Long Beach's Marine Bureau infrastructure will result in structure and content losses totaling $7 million.[2]

A respective 1.0, 1.4 and 2.0 m sea level rise accompanied by a **single** 100-year storm event in 2050 or 2100 will result in a loss of sales totaling approximately $2.6 to $4.4 million in 2050 and $3.4 to $7.2 million in 2100. Total direct and secondary effects amount to a loss of approximately 34 to 57 jobs in 2050 and 45 to 95 jobs in 2100, lost labor income of $0.95 to $1.6 million in 2050 and $1.3 to $2.7 million in 2100, and lost value added of $1.5 to $2.6 million in 2050 and $2.0 to $4.3 million in 2100. Inundation to Long Beach Marine Bureau infrastructure will result in structure and content losses of $9 to $11 million.

The capital cost of structural adaptation measures to increase resiliency of Long Beach's marinas is approximately $106.3 million, with additional annual maintenance costs totaling $2.7 million.

Conclusion and Recommendations

This study illustrates the potential climate change impacts to municipal marinas in Long Beach, California. In the coming century, a large number of marinas on the California coast will also be presented with similar reductions in economic output due to rising sea levels and extreme storm events. It is imperative that additional analyses be conducted at high-profile marinas along the California coast. Such studies will provide policymakers with the necessary information to make decisions that will bolster California's boating industry, which currently plays a key role in the State economy. If policymakers plan accordingly for projected climatic changes, boating and supporting industries will continue to play a significant role in the California economy. If adaptation strategies are not incorporated in a timely manner, the recreational boating industry, as well as the California economy, could experience significant impacts.

[2] Sales refer to the sales of firms within the region resulting from boater spending. Direct effects are the changes in sales, income and jobs in those business or agencies that directly receive the boater spending. Secondary effects are the changes in the economic activity in the region that result from the re-circulation of the money spent by boaters. Labor income refers to wages and salaries, payroll benefits and incomes of sole proprietor's. Value added accounts for income accruing to households in the region plus rents and profits of businesses and indirect business tax.

Geophysical Modeling with Geographical Information Systems (GIS)

The study area for this report spans a majority of the Long Beach coastline, bordered by the Los Angeles River Mouth to the north and the Alamitos Bay to the south. This area incorporates onshore marinas and adjacent municipally governed marine industries. The study area does not incorporate the Port of Long Beach or additional onshore infrastructure and industries that are susceptible to climate change events, but are not classified as municipally governed marine industries.

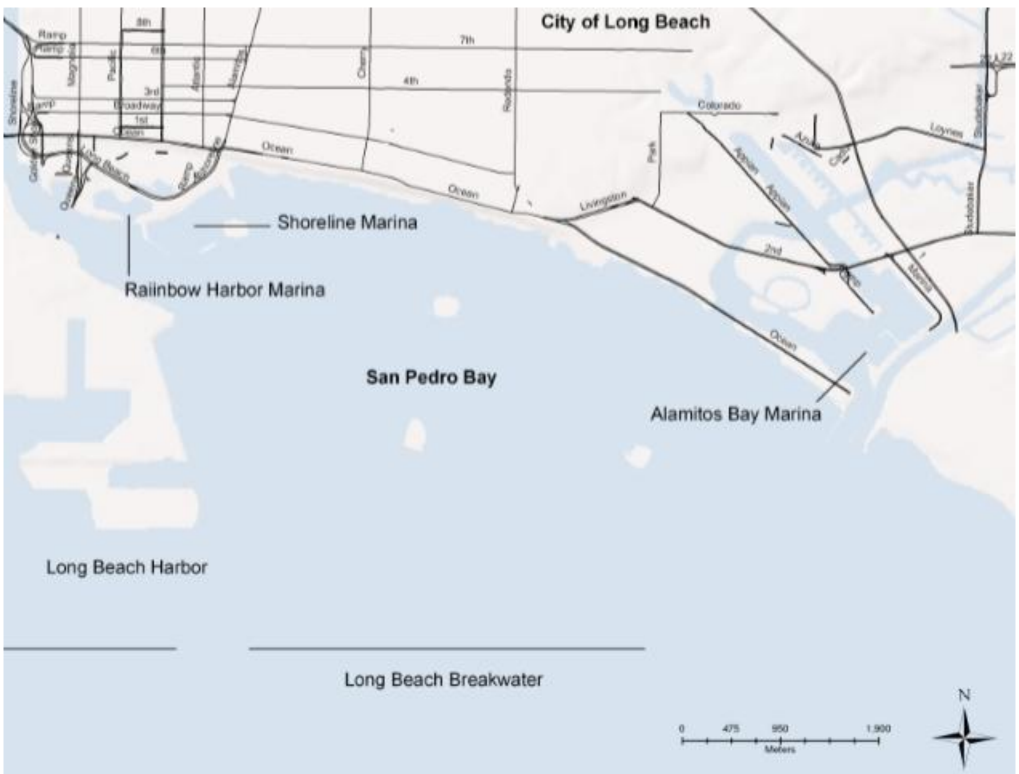

Figure 1. Study Area in Long Beach, California

Modeling Sea Level Rise Scenarios

Sea level rise scenarios used in the analysis include: Cayan B1 & A2, and Pfeffer 2.0 m (2100). The 2000-2100 twenty-five-year approximations for each of these sea level rise scenarios are found in Figure 2.

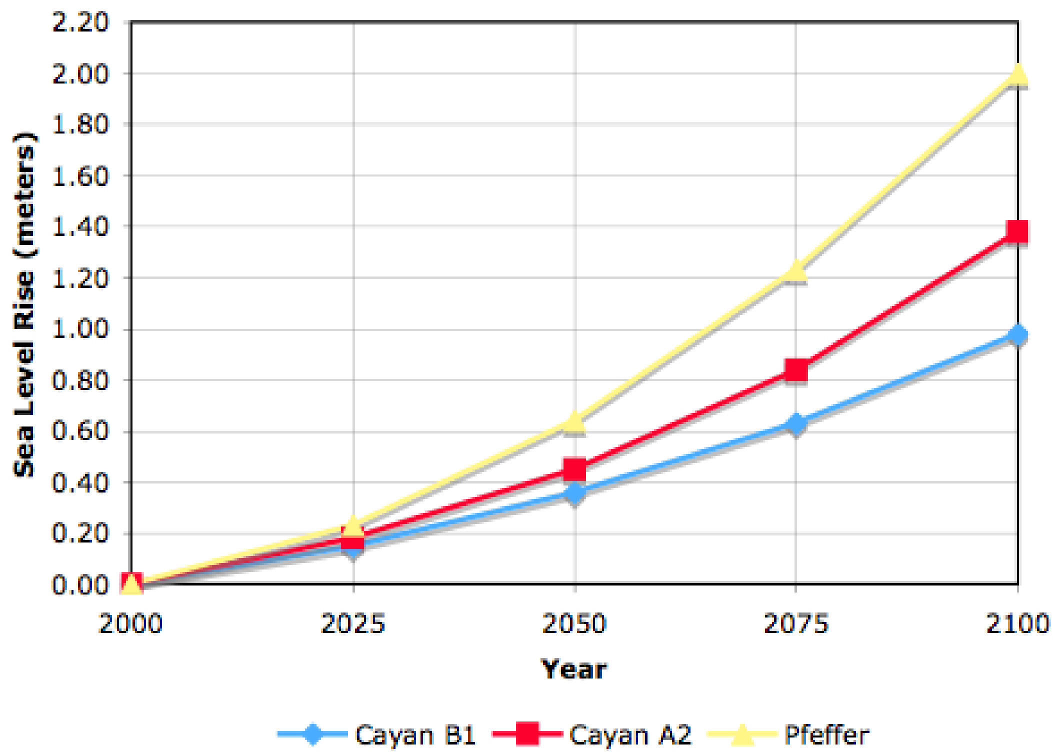

Figure 2. Adopted California Sea Level Rise Scenarios for 25-year Intervals (2000-2100)

Geographical Information Systems (GIS) mapping methods were used to identify areas inundated by a future rise in sea levels. To delineate areas vulnerable to sea level rise, digital elevation models (DEMs) representing the elevation of the Earth's surface were used. The DEMs used in this study were compiled from the Pacific Institute and Phillip Williams and Associates. This was the most accurate terrain data available at the time of analysis.[3] Multiple GIS spatial analyst tools were used to identify the elevation of land surfaces at-risk to sea level rise.

Modeling 100-year Storm Events

To estimate the risk of flooding from a storm event, one can apply basic probability theory. Storms are viewed as a random event; the probability of a flood occurring in any given year is independent of prior conditions. For the purpose of this analysis, a 100-year storm event, which

[3] Interferometric Synthetic Aperture Radar (IFSAR) data was produced by the National Oceanic and Atmospheric Administration (NOAA). IFSAR vertical accuracy is ± 2.2 m.

has a 1% probability of occurring in any given year, was modeled in combination with adopted sea level rise scenarios.

Similar GIS processes used to identify at-risk areas from sea level rise were also used to isolate areas inundated by a 100-year storm. Base flood elevation (BFE) data, which represents the existing 100-year flood plain, compiled by the Pacific Institute was used to delineate areas vulnerable to flooding. Flood analyses were conducted with a combination of BFE datasets from Federal Emergency Management Agency (FEMA) Flood Insurance Studies and additional BFEs produced by Phillip Williams and Associates. To account for sea level rise impacts to existing BFEs, flood plains were shifted up according to respective sea level rise scenarios (Figure 3). After isolating areas vulnerable to flooding, inundation grids were analyzed to remove small ponds and additional areas that did not accurately represent the dynamics of flooding.

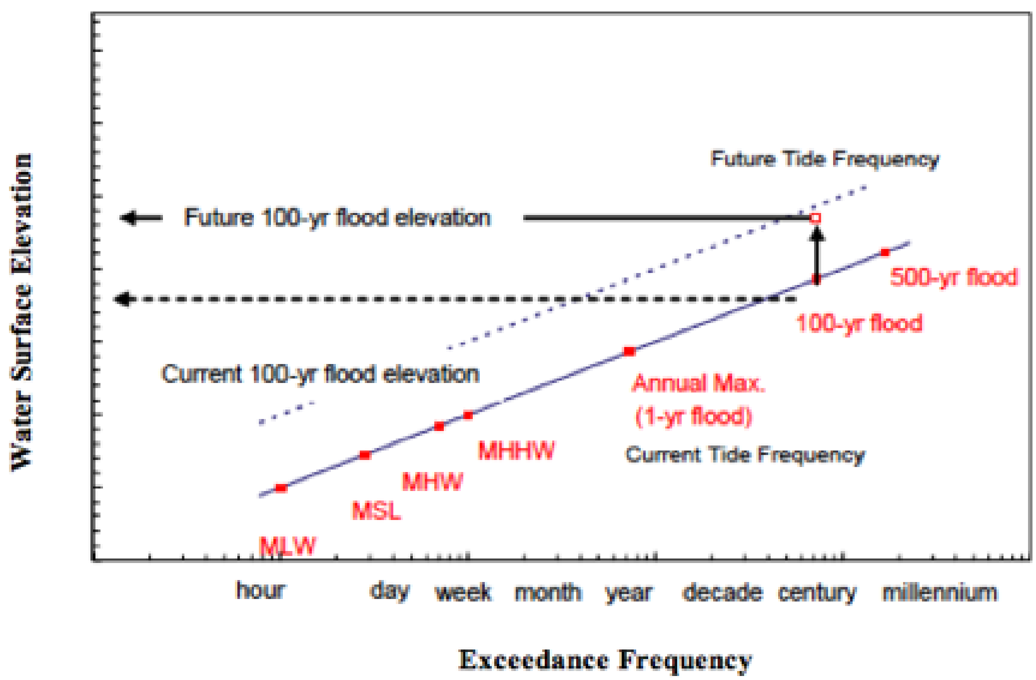

Figure 3. Overview of Future Coastal Flooding Frequencies[4]

[4] Heberger, M., H. Cooley, P. Herrera, P. H. Gleik, and E. Moore. 2009. The Impacts of Sea Level Rise on the California Coast. The Pacific Institute. California Climate Change Center. CEC-500-2009-024-F.

Modeling Long Beach Marine Bureau Infrastructure Losses

To identify at-risk infrastructure, marine industry parcel data acquired from the Los Angeles County Assessors Office was overlaid on the flood plain. Parcels that intersected with the flood plain for a provided scenario were inventoried. Satellite imagery was used to create additional parcel polygons when parcel data generalized the number of unique establishments. After inventorying at-risk municipal infrastructure, depth damage curves produced by the U.S. Army Corps of Engineers (USACE) were used to estimate losses (Figure 4). Depth damage curves are used to estimate the economic damages to inundated infrastructure by means of calculating the depth of flooding and relating this depth to the building value and its contents. The study estimates the dollar exposure of at-risk infrastructure while adjusting for depreciation factors that reflect the age of buildings and inflation in the construction industry. GIS raster methods, primarily a combination of zonal statistic techniques, were used to calculate the mean depth of flooding for at-risk parcels. Damages to buildings and their contents were calculated by applying depth damage curves respective to sea level rise and storm scenarios.

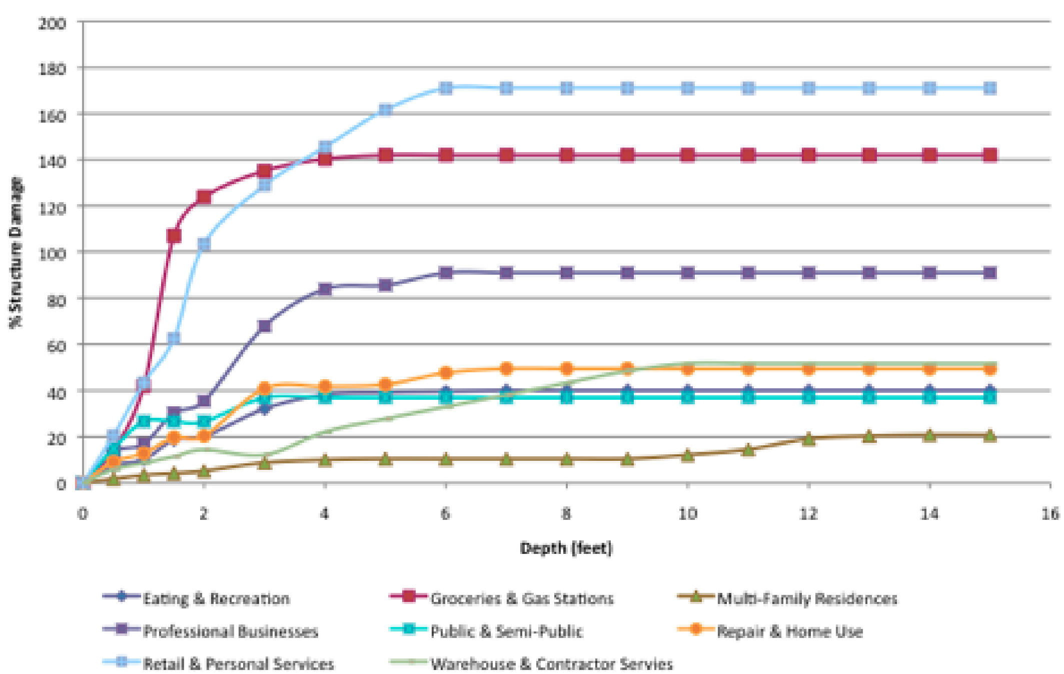

Figure 4. Depth Damage Curve for Infrastructure as a Percent of Structure Value

Modeling Economic Impacts to Long Beach's Marinas

To estimate the economic losses from a 100-year storm event following a rise in sea level, the economic impacts per one lost boating day were calculated. Similar to calculating infrastructure losses, the mean depth of flooding was calculated at each of Long Beach's marinas. The mean flood depth was used to construct marina closure scenarios. Natural disaster restoration timetables were analyzed to produce restoration parameters that account for the time needed to address structural damage, salt water intrusion, natural gas and electric damage, fuel and pump station damage, limited contractor availability in the event of large storm event on the coast and inspections and permitting. Restoration parameters were established for flooding between 0 to 4 ft, 4 to 8 ft, and 8 to 12 ft and evaluated by means of a sensitivity analysis. The period of closure at each of Long Beach's marinas was applied to per day economic output losses.

Figure 5. Sea Level Rise and 100-year Storm Scenarios

Modeling Adaptation Responses

Structural measures can increase the resiliency of areas vulnerable to sea level rise and 100-year storms. Bulkheads and levees are the primary measures that protect landward structures at Long Beach's marinas. Levees and bulkheads currently provide full protective coverage for Long Beach's marinas and adjacent commercial establishments. In the event of sea level rise, existing levees will need to be reconstructed as bulkheads and raised to ensure protection of the marinas. A geospatial dataset of coastal armoring structures produced by the California Coastal Commission was used to identify existing protective structures in Long Beach. To ensure accuracy, site-visits were conducted to inventory the existing coverage and future protection needs at Long Beach's marinas. Protective structure needs were calculated to the nearest linear foot and adjusted for inflation.

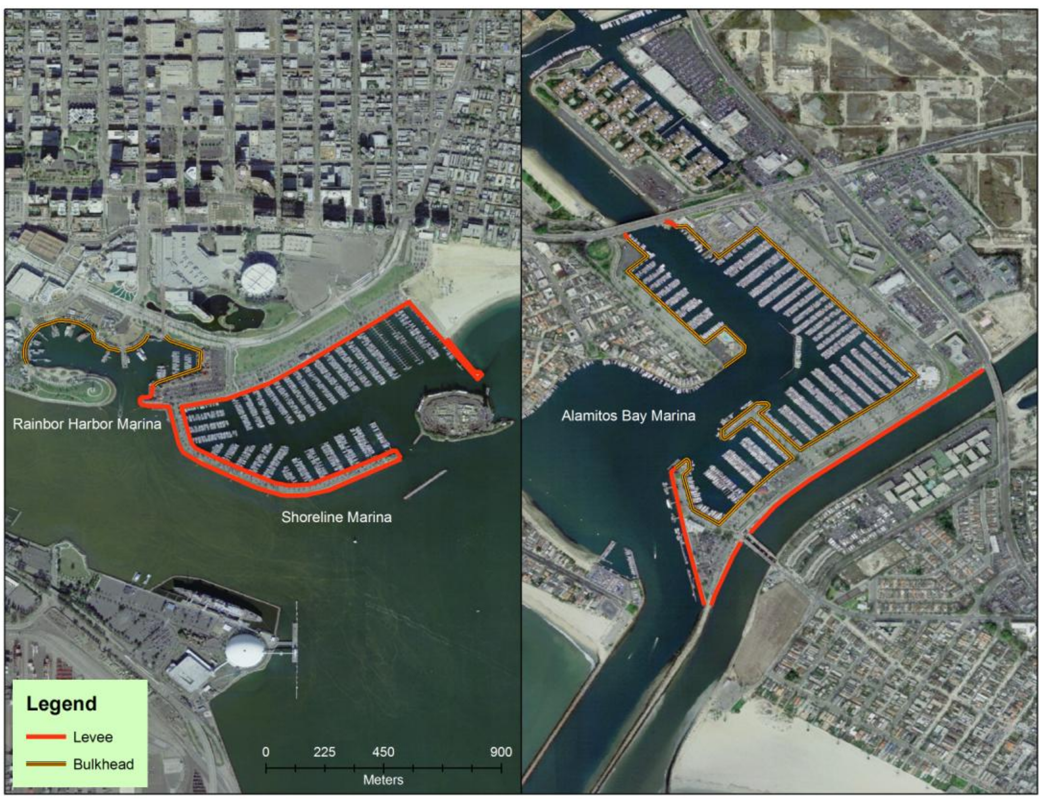

Figure 6. Existing Protective Coverage at Long Beach's Marinas