PACIFIC INSTITUTE

Research for People and the Planet

Testimony of Dr. Peter H. Gleick[1] Before the California Assembly Select Committee on Sea Level Rise and the California Economy

May 15, 2013

Chair and members of the Assembly Select Committee: thank you for inviting me to offer testimony today on the economic risks facing the State of California from accelerating sea-level rise. The reality of climate change will affect California in many ways, from rising temperatures to changes in fire frequency, drought and flood risks, threats to agricultural production and our water resources, and especially, growing damage and destruction along our extensive coastline from rising sea levels.

Over the past century, sea level has risen nearly eight inches along the California coast, and climate science research suggests very substantial additional increases in sea level over the coming century. The Pacific Institute, with support from the State of California, completed a detailed analysis of the current population, infrastructure, and property at risk from projected sea-level rise if no actions are taken to protect the coast.[2] Our study uses projections developed by the State of California from current best estimates, but does not reflect the worst-case sea-level rise that could occur. Indeed, new science suggests these estimates may be conservative.

The report also evaluates the cost of building structural measures to protect high-valued locations, but if development continues in threatened areas, all of these estimates will rise substantially. And we conclude that no matter what policies are implemented in the future, sea-level rise will inevitably change the character of the California coast and impose massive costs on the State.

What is at Risk?

California's coastline includes more than 2,000 miles of open coast and enclosed bays and is vulnerable to a range of natural hazards, including storms, extreme high tides, and

[1] Dr. Gleick is President of the Pacific Institute, Oakland, California. He is an elected member of the U.S. National Academy of Science and a MacArthur Fellow. His comments reflect his own opinion.

[2] Several detailed papers are available with our results, including: Heberger, M., H. Cooley, P. Herrera, P. H. Gleick, E. Moore. 2011. Potential impacts of increased coastal flooding in California due to sea-level rise. Climatic Change. Doi:10.1007/s10584-011-0308-1. Also, Heberger, M., H. Cooley, P. Herrera, P.H. Gleick, and E. Moore. 2009. The Impacts of Sea-Level Rise on the California Coast. California Energy Commission, CEC-500-2009-024-F. Sacramento, California.

654 13th Street, Preservation Park, Oakland, California 94612, U.S.A.
510-251-1600 | fax: 510-251-2203 | email: pistaff@pacinst.org | www.pacinst.org

rising sea levels resulting from global climate change. Development along California's coast is extensive. Approximately 31 million people live in California's coastal counties (U.S. Census Bureau 2000; NOAA 2004). Indeed, six of the ten fastest growing coastal counties in the United States between 1980 and 2003 are in California (NOAA 2004).

Major transportation corridors and other critical infrastructure are found along the California coast, including oil, natural gas, and nuclear energy facilities, as well as major ports, harbors, and water and wastewater plants. The California coast is also an extraordinary cultural and ecological resource and offers extensive tourism and recreational opportunities.

Even without climate change flooding and erosion already pose a threat to communities along the California coast. And there is compelling evidence that these risks will increase in the future. Rising seas put new areas at risk of flooding and increase the likelihood and intensity of floods in areas that are already at risk. In areas where the coast erodes easily, sea-level rise will likely accelerate shoreline recession due to erosion.

Key Findings

Over the past century, sea level has risen nearly eight inches along the California coast, and general circulation model scenarios all suggest very substantial increases in sea level as climate changes accelerate over the coming century. The Pacific Institute study includes a detailed analysis of the current population, infrastructure, and property at risk from projected sea-level rise if no actions are taken to protect the coast, as well as some of the costs of building structural measures to reduce that risk. We find the following:

- Under medium to medium-high greenhouse-gas emissions scenarios, mean sea levels along the California coast are projected to rise from 1.0 to 1.4 meters (m) by the year 2100.[3]
- These sea-level increases will put 480,000 people at risk of a 100-year flood event, given today's population. Populations in San Mateo, Alameda, and Orange Counties are especially vulnerable.
- Sections of the California coast not vulnerable to flooding are often highly susceptible to erosion. We estimate that a 1.4 m sea-level rise will accelerate erosion, resulting in a loss of 41 square miles of California's coast by 2100.
- Among those affected are large numbers of low-income people and communities of color.

[3] Maps for the entire coast of California demonstrating the extent of the areas at risk are posted at www.pacinst.org/reports/sea_level_rise

- A wide range of critical infrastructure, such as roads, hospitals, schools, emergency facilities, wastewater treatment plants, power plants, and more will also be at increased risk of inundation in a 100-year flood event.
- Significant flooding is possible at California's major ports in Oakland, Los Angeles, and Long Beach. These ports are central to the economy of California, the nation, and the world. The Port of Los Angeles-Long Beach, for example, handles 45%–50% of the containers shipped into the United States.
- Other infrastructure at risk includes:
    - nearly 140 schools;
    - 34 police and fire stations;
    - 55 healthcare facilities;
    - more than 330 U.S. Environmental Protection Agency (U.S. EPA)-regulated hazardous waste facilities or sites, with large numbers in Alameda, Santa Clara, San Mateo, and Los Angeles counties;
    - an estimated 3,500 miles of roads and highways and 280 miles of railways;
    - 30 coastal power plants, with a combined capacity of more than 10,000 megawatts;
    - 28 wastewater treatment plants, 21 on the San Francisco Bay and 7 on the Pacific coast, with a combined capacity of 530 million gallons per day;
    - the San Francisco and Oakland airports;
    - vast areas of wetlands and other natural ecosystems, including an estimated 550 square miles, or 350,000 acres, of wetlands exist along the California coast.
- Adapting to sea-level rise will require tremendous financial investment. Given the high cost, we think that individuals, the State, and local agencies will not be able, financially, to protect everything, leading to additional costs from damages and extreme events.

Economic Costs Are High, and Incompletely Understood or Evaluated

National studies and studies focused on California have begun to evaluate the economic costs of sea-level rise, including the costs of both impacts and adaptation. While adapting to climate change will be expensive, so are the costs of doing nothing, as substantial investments are already at risk and vulnerable. Because the economic costs of flooding are highly site-specific, regional analyses are critical for guiding land-use decisions and evaluating adaptive strategies.

As a partial estimate of what is at risk, our study calculated the value of property (measured as the current replacement value of buildings and contents) at risk in the expanded flood zones. We estimate that value to be nearly $100 billion (in year 2000 dollars). An overwhelming two-thirds of that property is concentrated on San Francisco

Bay and the majority of this property is residential. This number substantially underestimates the total costs of sea-level rise for a number of reasons.

What has been left out?

Left out of these estimates are:

- The cost to the economy of damages to transportation infrastructure essential for moving people or goods, e.g., highways and ports, or the major interruptions (lost work, lost productivity, etc.) from these damages.
- The cost of repeated extreme events: even the cost of single extreme events can be very high, as seen recently with Superstorm Sandy and Hurricane Katrina.
- The cost of related deaths and injuries.
- The cost of impacts to the health and well-being of affected individuals from things like erosion, oils spills, and discharge of pollution from coastal industry.
- The value of lost wetlands and coastal habitats.
- The value of lost property or land, which is typically much higher than the buildings and contents. These values should be included if inundation is permanent or leads the abandonment of property.
- Additional costs of expected changes in population density or the level of development over the next century: these are largely unknown and will be determined by future policies on land use and coastal development.
- The costs from increased contamination of coastal freshwater aquifers.

What to do?

Our work also offers a comprehensive set of recommendations and strategies for, partly, adapting to sea-level rise. A number of structural and non-structural policies and actions could be implemented to reduce the risks facing the State.

Coastal armoring is one potential adaptation strategy. Approximately 1,100 miles of new or modified coastal protection structures are needed on the Pacific Coast and within San Francisco Bay to protect against coastal flooding. The total cost of building new or

upgrading existing structures just to protect high-valued infrastructure is estimated at about $14 billion (in year 2000 dollars).We estimate that operating and maintaining the protection structures would cost approximately 10% of the initial capital investment, or around another $1.4 billion per year (in year 2000 dollars).

If policies are put in place to reduce development in regions of future flooding, society could, over time, reduce the risks. While limiting coastal development or incrementally removing infrastructure at risk (an institutional adaptation) is likely the most effective way to reduce risk, this approach can also incur costs. Development permits designed to provide flexibility for future generations to address sea-level rise (e.g., development permits that allow development but stipulate that the area reverts to nature if seas rise a specified amount) may reduce today's cost. Conversely, if current development in coastal areas continues unchecked, a far larger population and far more infrastructure will be vulnerable than at present. We make no estimates of these changes.

Conclusions and Recommendations

Climate change must be integrated into the design of all coastal structures. The costs of modifying structures in the design phase are often far lower than the costs of later reconstruction or flood damage.

The federal and state governments, together with the insurance industry, should develop and implement a methodology for integrating climate change into insurance policies and strategies. Properly designed insurance policies are vital for helping landowners choose whether to protect or abandon risky property.

Federal flood insurance maps should include information on future flood risks due to sea-level rise. Because FEMA maps are the *defacto* planning documents used by most local governments, they should be updated to show future hazard areas and include the current science on climate change and sea-level rise.

Wetlands and the potential migratory paths should be protected. Development should be prohibited on natural lands that are immediately adjacent to wetlands at risk. These buffer areas may be the only areas suitable for future wetland restoration projects.

Future development should be limited in areas that are at risk from rising seas. In regions at risk that are not yet heavily developed, local communities and coastal planning agencies have the opportunity to limit development and reduce future threats to life and property.

Local planning processes need to involve communities most vulnerable to harm when developing appropriate preparation and adaptation strategies.

Protect vital societal resources, especially those that are "coastal-dependent." In many cases, the value of an area's infrastructure far exceeds the cost to raise structures or build protective barriers. For example, the San Francisco airport and the Port of Long Beach are extremely important to the state and national economy.

Consider phased abandonment of low- and medium-density areas at high risk. In some low- and medium-density areas, the monetary and environmental cost of holding back the sea may become unacceptably high and the lowest-cost option may be to allow natural processes to take place.

Cost-benefit analyses should explicitly evaluate the social and environmental costs of building coastal protection structures.

Coastal emergencies are inevitable. Coastal communities should improve disaster response and recovery. Improving community preparedness provides benefits for responding to any type of emergency.

Finally, the overall implications of sea-level rise diminish if we can reduce the rate and severity of change by reducing greenhouse gas emissions. The State of California is a leader in this area, but more can be done.

I congratulate you for considering this vital issue and for helping to raise attention to the grave challenges and risks facing the State from sea-level rises.

Dr. Peter H. Gleick
Pacific Institute, Oakland, California
Member, U.S. National Academy of Sciences
MacArthur Fellow
AAAS Fellow

For the full report, PDFs of inundation maps, and an interactive Google map of sea-level rise impacts, go to **www.pacinst.org.**