Managing U.S. Coastal Hazards

Position Statement. Storms, tsunamis, and rising sea levels threaten U.S. coastal communities and their economies. Much of the nation's existing coastal infrastructure must be adapted to expected future conditions or relocated. New coastal development and post-storm reconstruction should be planned, sited, and maintained with coastal geologic hazards clearly in mind.

Purpose. This position statement summarizes the main geologic hazards along the marine coats of the United States—Atlantic, Gulf, Pacific, and Arctic—and urges scientists and policy makers to collaborate toward integrating geoscience information into policy and management actions in order to reduce the nation's future vulnerability to these hazards.

Rationale

The United States is vulnerable to coastal hazards. In 2010, more than half of the U.S. population resided in coastal watershed counties (NOAA, 2013a). The U.S. coastal zone supports 66 million jobs and contributes US$8.3 trillion to the U.S. economy, or 58% of the nation's economic output (NOAA, 2013a). The high population density in coastal regions and continued pressure for residential, commercial, and industrial growth persist despite a range of natural hazards and an increasing number of disasters. Hurricanes and coastal storms, such as Katrina (2005), Ike (2008), and Sandy (2012), underscore the nation's vulnerability to coastal hazards and the risks and costs of rebuilding in disaster-prone areas.

The type and severity of coastal geologic hazards—and the potential harm they can inflict on existing or future development—vary because of differences in geology, tectonic setting, topography, climate, and oceanographic conditions. Although the Great Lakes shorelines experience many of the same hazards as do marine coasts, the latter are the exclusive focus of this position statement. The scientific community has made considerable progress in improving our understanding of these hazards and the risks they pose. Resource managers and decision-makers in all sectors (government, business, and non-profit) must be willing and able to access and apply geoscience information to inform their decisions in order to avoid catastrophic losses from the following hazards.

Coastal Storms

Some of the costliest natural disasters in U.S. history have resulted from tropical and extra-tropical storms that brought high storm surges, large waves, heavy precipitation, and coastal erosion. The nature of these storms varies, but development along all U.S. coastlines is exposed to significant risks.

Low-lying areas along the Gulf and Atlantic coasts are routinely battered by hurricanes and other tropical systems. Barrier islands are particularly vulnerable due to their low elevations. The combination of storm surge and large waves can wash over islands, undermining structures built on the shoreline or dunes, and destroying roads and bridges connecting the islands to the mainland.

- Nor'easters produce high winds, storm surges, and very large waves, which have flooded low-lying areas, and overwashed and eroded beaches and dunes of the Atlantic barrier islands (Hyndman and Hyndman, 2010). Man-made alterations or constrictions to natural drainage systems can trap salt water from storm surges, which can contaminate shallow aquifers that provide drinking water to many coastal communities.
- El Niño events on the Pacific Coast have elevated sea levels as much as 30 cm for weeks at a time. High tides and storm waves during these periods have flooded low-lying communities and extensively damaged coastal development and infrastructure on cliffs, bluffs, dunes, and beaches (NRC, 2012; Russell and Griggs, 2012).

The number of hurricane-related deaths has decreased over the past century due in large part to our improved ability to both predict landfall location and evacuate at-risk populations. Unfortunately, the cost of damages has dramatically increased, reflecting rapidly growing coastal populations, more construction in hazardous locations, more expensive buildings, and the high costs of post-storm solid waste disposal from damaged infrastructure. Nine of the twelve most costly hurricanes in U.S. history occurred between 2004 and 2012 (NOAA, 2012), including Katrina at approx. US$125 billion. Estimates for economic losses from Hurricane Sandy in 2012 are US$65 billion (NOAA, 2012).

Tsunamis

The 2004 Indian Ocean disaster spurred worldwide progress toward reducing loss of life from future tsunamis. Major advances include official early warnings for tsunamis generated by earthquakes in distant locations (Bernard et al., 2006). Such warning systems, formerly limited to the Pacific Ocean, now have the potential to help reduce loss of life on Atlantic and Caribbean shores as well. There remains, however, the greater hazard posed by tsunamis from nearby earthquakes. Near-field waves may arrive before official warnings are delivered (Yulianto et al., 2010). Nearly all the loss of life from the 2011 Japanese tsunami occurred in the near-field. The flooding began as soon as 25 minutes after the start of the earthquake. The enormity of the disaster was difficult to anticipate from the geologic records of a comparable tsunami in A.D. 869 (Sawal et al., 2012; Sugawara et al., 2012).

The coasts of the United States are subject to far-field and near-field tsunami hazards (Barth and Titus, 1984). The greatest near-field hazards are associated with subduction zones in Alaska, Cascadia, and the Caribbean. The subsidence that would accompany a repeat of the giant 1700 Cascadia earthquake would cause a relative sea-level rise of as much as one meter along parts of coastal Washington, Oregon, and northern California (Atwater et al., 2005). The National Tsunami Hazard Mitigation Program has taken steps to address these hazards with measures that include inundation modeling, evacuation signage, and public education, although the program continues to face challenges.

Climate Change–Sea Level Changes

Global sea-level rise is perhaps the most obvious manifestation of climate change in the oceans. The rate of sea-level rise has increased globally from about 1.7 mm per year over most of the last century to about 3.1 mm per year over the past two decades (Merrifield et al., 2009, NRC, 2012), and this rate is projected to increase in the future. A 2012 National Research Council report projects an average global sea-level rise in the range of 50 to 140 cm by 2100. Sea-level rise varies along U.S. coasts, due in large part to regional differences in land uplift or subsidence and to changes in ocean currents (Sallenger et al., 2012). The wide range in future sea-level rise trajectories presents challenges to sustainable coastal zone management.

The long-term impacts of an increasing rate of sea-level rise along the U.S. coast are becoming increasingly clear (NOAA, 2013b). Sea-level rise will affect coastal communities and infrastructure through more frequent flooding and gradual inundation, as well as increased cliff, bluff, dune, and beach erosion. Coastal aquifers that provide water for drinking, industry, and irrigation will be affected, as well as the ecosystems supporting coastal fisheries. Coastal transportation corridors, coastal power and wastewater treatment plants, transfer and discharge systems, ports and harbors, other municipal infrastructure and private development, including homes and businesses, will be affected (Russell and Griggs, 2012; Burkett and Davidson, 2012). Adaptation to sea-level rise must take place in the context of regional and local, as well as global, sea-level changes.

Other Considerations

Implications for Coastal Management

Losses from long-term, chronic events, such as progressive sea-level rise and large storms, as well as larger-scale natural disasters, such as tsunamis, continue to increase over time, due to increasing development in coastal communities (Hyndman and Hyndman, 2010). Recognizing, delineating and mapping, and identifying and publicizing the risks that they pose can enable coastal management or land-use decisions that will reduce future losses for public infrastructure and private development, as well as government funds spent on repetitive losses (Burkett and Davidson, 2012). Political, institutional, and public recognition of the risks posed by coastal hazards is necessary for advancing a sustainable approach to coastal management. Storms such as Katrina, Ike, and Sandy emphasize the severity and reality of such hazards and present an opportunity to reassess and reduce the exposure of coastal communities to storm surges and inundation. The densely populated shorelines of New York and New Jersey and the low lying areas of the southeastern Atlantic and Gulf coastal plains are among the most vulnerable to sea-level rise and storm surge and will only become more vulnerable with time (NOAA, 2013a).

RECOMMENDATIONS

- Geoscientists should communicate information and concerns about coastal hazards and the risks they pose to government agencies and the public, thereby encouraging and supporting responsible and sustainable policies, actions, and decisions. This could be accomplished through a state and federal partnership to systematically map areas vulnerable to coastal hazards over the next century, especially by incorporating high-resolution LiDAR.
- Coastal property damaged in past events or that are at risk from future events should be delineated and the risks determined and documented. Local governments should develop relocation or adaptation plans for existing at-risk development and infrastructure, whether public or private. Future sea-level rise and the exposure to coastal hazards, as well as the cost and lifetime of any proposed facility, should be factored into decisions about construction or reconstruction.
- Government agencies should accept their responsibility for using the best information and recommendations that the geosciences community can provide in land-use decisions, including regulation of coastal construction and reconstruction, in order to develop resilient coastal communities and infrastructure in high-risk coastal areas and to reduce losses from recurring natural events.
- The U.S. must develop a vision for the future that accepts the natural processes of a high-energy, rapidly evolving coastal system, and that seeks to live with the dynamics of change. This is essential in order to maintain sustainable coastal economies and preserve the natural resources upon which these economies are critically dependent.

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