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REPORT IN BRIEF

WATER SCIENCE AND TECHNOLOGY BOARD and OCEAN STUDIES BOARD
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Reducing Coastal Risk on the East and Gulf Coasts

AN INCREASE IN THE AMOUNT OF PEOPLE AND PROPERTY along the coast**,** together with climate change and a misalignment of economic incentives, pose daunting challenges for managing U.S. coastal risk. Currently, the majority of coastal-storm-related federal investments are provided only after disasters occur. Given the enormous and rising costs of coastal disasters, a strategic national vision for reducing risk is needed, guided by a national coastal risk assessment that identifies areas most at risk and helps to prioritize future investment. Stronger incentives should be developed to improve pre-disaster planning and mitigation efforts at the local level.

Coastal-storm-related economic losses have increased substantially over the past century, largely due to increases in population and development in hazardous coastal areas. Eight U.S. cities (Miami, the New York-Newark region, New Orleans, Tampa-St. Petersburg, Boston, Philadelphia, Virginia Beach, and Baltimore) rank among the world's top 20 in terms of potential average annual losses from coastal flooding. In addition, population is growing rapidly along the U.S. southeastern and Gulf coasts, where major hurricanes are most frequent (see Figure 1).

The widespread flooding and loss of life due to Hurricane Katrina in 2005 and the extensive damage throughout New York and New Jersey from Hurricane Sandy in 2012 demonstrate the impacts on metropolitan areas that are not adequately protected against storm surge and wave attack. Climate change poses additional threats to coastal communities from sea-level rise and possible increase in the strength of the most intense hurricanes.

This report is the third in a series advising the U.S. Army Corps of Engineers (USACE) on a range of water resources issues. USACE plays a large role in coastal risk management, working in collaboration with other federal agencies and state and local governments. The report assesses the performance of coastal risk-reduction strategies to date, how modern risk principles might be better incorporated, and other general principles to guide future investments.

Miami ranks 2nd on a list of the world's cities with the most to lose (potential for average annual losses) to coastal flooding. Photo courtesy NOAA.

INSTITUTIONAL LANDSCAPE FOR COASTAL RISK MANAGEMENT

Responsibilities for coastal risk reduction are spread across numerous agencies and all levels of government, each driven by different objectives and authorities, with no central leadership or unified vision. Planning, zoning, and building ordinances—key elements of disaster preparedness—are primarily the responsibility of local governments. Mitigation measures, such as raising homes and coastal risk reduction strategies, can involve federal, state, and local agencies in varying capacities. Federal agencies assist state and local governments with response and recovery following major events, and also provide data and tools to support planning efforts.

To date, the nation's efforts have been more reactive than proactive, with the vast majority of funding being provided only after disasters occur. For example, between 2008 and 2012, $493 million was appropriated for USACE coastal storm risk management efforts through the annual budgeting process,

while at least $12.8 billion was allocated for coastal risk projects via emergency supplemental appropriations. Pre-disaster funding for mitigation, preparedness, and planning is limited, and few regional evaluations of coastal risk have been performed to inform risk reduction expenditures.

A major impediment to U.S. coastal hazard management is the misalignment of risks, rewards, responsibilities, and resources associated with coastal development and post-disaster recovery. Developers, builders, and state and local governments reap the rewards of coastal development but do not bear equivalent risk, because the federal government has borne an increasing share of the costs of coastal disasters (see Figure 2). The resulting "moral hazard" leads to continued development and redevelopment in high-hazard areas.

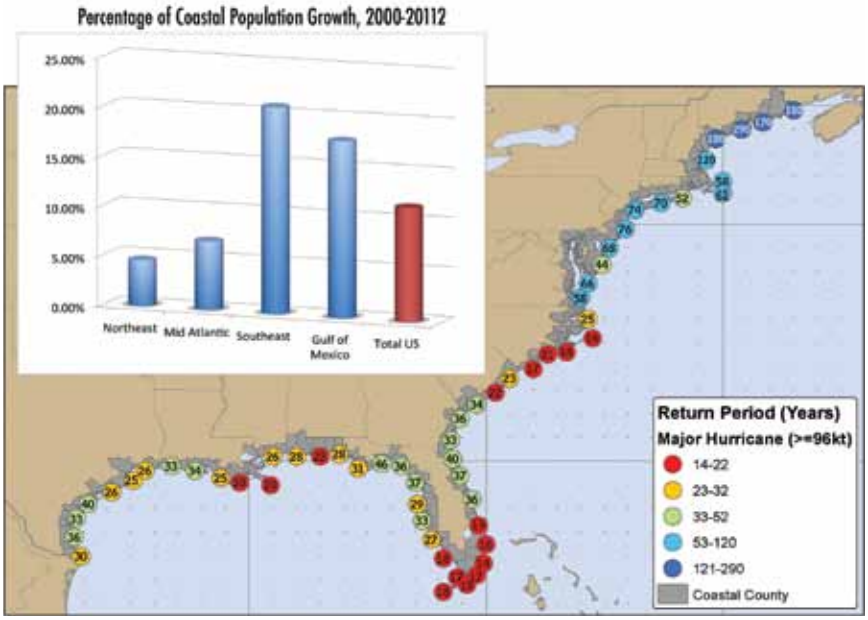

Figure 1. *Population growth along the Southeast coast and the Gulf of Mexico between 2000 and 2012 was faster than the national average growth of 11.5%. Those are the same areas where major hurricanes are most frequent. Red circles denote areas where major hurricanes return on average every 14-22 years. Population data from the National Ocean Economics Program, www.oceaneconomics.org; Return period graphics from NOAA.*

PERFORMANCE OF COASTAL RISK-REDUCTION STRATEGIES

Until the 1970s, seawalls, levees, storm surge barriers and other hardened structures were the preferred method for reducing the effects of waves, storm surge, and erosion. Within the past few decades, as adverse environmental impacts of hardened structures became clear, the USACE has emphasized beach nourishment and dune building. Other nature-based strategies include conserving, restoring, and/or expanding natural barriers such as salt marshes, oyster reefs, mangroves, and seagrasses. Ultimately, the optimal approaches for coastal risk reduction will be site-specific and may involve multiple strategies implemented together.

Beachfill projects and dunes provide some level of risk reduction for coastal infrastructure from erosion, flooding, and wave attack and may reduce the likelihood of forming new inlets. Short-term environmental impacts on biological communities are significant, but

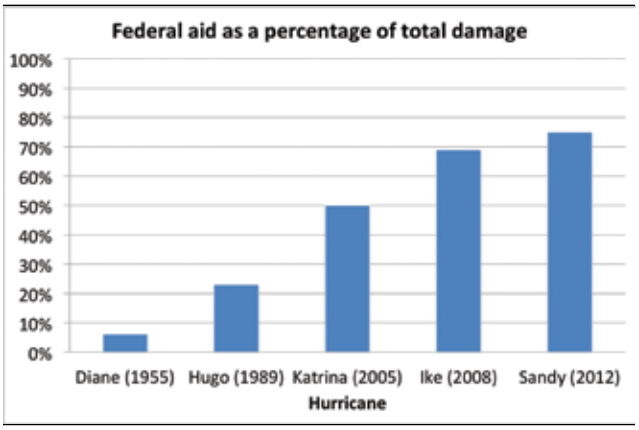

Figure 2. *Federal aid as a percentage of total damage has increased over the past 60 years, as exemplified by these five major tropical hurricanes. Source: Michel-Kerjan, 2013*

Beach nourishment projects repair erosion while increasing the distance between vulnerable coastal infrastructure and breaking waves, while dunes protect against wave energy and flooding. Source: http://marine.rutgers.edu/geomorph/oceancityfill.jpg

long-term cumulative ecological implications remain unknown because of the difficulty and cost of long-term monitoring. However, alternative designs could increase the ecological value of these risk-reduction features without greatly increasing construction costs.

Conservation or restoration of ecosystem features such as salt marshes, mangroves, coral reefs, and oyster reefs provides substantial ecological benefits such as carbon sequestration, improved water quality, and essential habitat for fish and other organisms. Natural features can reduce wave energy from low- to moderate-energy storms, but their capacity to substantially reduce storm surge remains poorly quantified. Saltmarshes and mangroves have been shown to reduce storm surge levels for fast-moving storms, but large expanses of habitat are needed to be most effective.

Many large coastal cities lack the space necessary to rely only on nature-based risk reduction approaches, and therefore, additional hard structures will be needed to substantially reduce coastal storm hazards. Adverse environmental impacts commonly accompany the construction of hard structures, although modified designs are possible to reduce these effects.

Strategies that reduce the consequences of coastal storms, such as hazard zoning, building elevation, land purchase, and setbacks, have high documented benefit-cost ratios, but they are given less attention by the federal government and are viewed as difficult to implement by states. Despite studies that show benefit-to-cost ratios between 5:1 and 8:1, federal funds for consequence-reduction strategies were only about 5 percent of disaster relief funds from 2004-2012. Nonstructural and design strategies that are commonly implemented, such as public information campaigns and elevation of buildings, tend to avoid property rights issues and impacts on economic interests.

PRINCIPLES TO GUIDE FUTURE INVESTMENTS

Strategies for coastal risk reduction will differ in terms of their benefits, costs, and ecosystem impacts. A key question facing society is determining when investments in coastal risk reduction are justified, and, if justified, what form they should take.

The report considers two approaches: (1) a *risk-standard approach* that recommends investments to achieve an acceptable level of risk reduction, such as reducing the threat of loss of life or the probability of severe flooding; and (2) a *benefit-cost approach* that recommends investments when the benefits of the investment exceed the costs. The report concludes that a benefit-cost approach, constrained by acceptable risk provides a reasonable framework

Hard structures like this Fox Point Hurricane Barrier in Providence, Rhode Island, are likely to become increasingly important to reduce coastal risk, particularly in urban areas where there is not enough space for nature-based strategies. Source: Neil Aquino

for evaluating coastal risk management investments. Unacceptable levels of risk may include a level of individual risk of fatality, the risk of a large number of deaths from a single event, or adverse impacts on social and environmental conditions that may be difficult to quantify in monetary terms. Setting such a standard requires value judgments, on which not all stakeholders will necessarily agree

Since the 1970s, many communities have adopted a de facto standard for risk reduction measures to withstand a 100-year flood (with a 1 percent annual chance of occurrence), because mandatory flood insurance purchase requirements are waived for properties located behind such structures. The report, however, states that there is no basis of evidence to justify this default level, which may be excessive in some areas and inadequate in dense coastal cities.

The White House Council on Environmental Quality's recently updated *2013 Principles and Requirements for Federal Investments in Water Resources,* provides an effective framework to account for a wider range of costs and benefits (including life-safety, social impacts, and environmental costs and benefits) than is currently feasible in the USACE planning process. Current project planning guidance gives primacy to national economic benefits, while other, less easily measurable benefits rarely influence project planning decisions. The document, which applies to water resources investment decisions across the federal government, not just within the USACE, represents a significant improvement. Until the updated guidelines to the *Principles and Requirements* are finalized and the new framework is put into action, the USACE could take steps to improve consideration

of multiple benefits and costs in the current decision process by more quantitatively considering information about life safety, social, and environmental effects.

NATIONAL VISION NEEDED TO COMPREHENSIVELY REDUCE COASTAL RISK

Given the enormous and rising cost of coastal disasters within the United States, improved system-wide coastal risk management is needed. Under the current planning framework, the USACE responds to requests at a local level on a project-by-project basis but has no authority to initiate a comprehensive national analysis of coastal risk and strategies to address them, unless specifically requested and funded by Congress. A national perspective is needed to achieve the most benefits from federal investments and provide regional solutions, rather than piecemeal, project-by-project approaches.

Coastal risk management requires a long-term vision, recognition of the wide array of potential benefits, and coordination of efforts that are currently spread across many agencies that sometimes operate under conflicting mandates. Developing and implementing a national vision for coastal risk management is not the responsibility of any single agency alone, but will require federal leadership and extensive collaboration among federal, state, and local agencies. Specific objectives and metrics should be developed so that state and local governments can identify necessary actions and assess progress.

The federal government should work with states to develop a national coastal risk assessment. The geographic patterns of disaster risk represented by human fatalities, economic losses, and social impacts can illustrate where the risks are greatest and in need of targeted risk reduction interventions. This analysis should not merely be based on the recent history of hazards but on a comprehensive assessment of risk, including multiple types of hazards under current and anticipated future conditions.

In light of behavioral and cognitive factors associated with low-probability, high-consequence events, stronger incentives (or disincentives for inaction) are needed to improve the quality of hazard and mitigation planning and the breadth of nonstructural mitigation strategies considered. For example, the federal government could adjust USACE cost sharing for coastal risk reduction projects according to the extent and quality of local hazard mitigation planning and the degree to which mitigation is incorporated into other local planning efforts (e.g., land use, transportation).

Although the USACE is limited in its capacity to independently initiate national coastal risk reduction strategies, it can use its existing planning framework to rigorously account for social and environmental costs and benefits, thereby supporting a more holistic view of coastal risk management. Additionally, the USACE should increase incentives for sound coastal planning and continue to develop and improve modeling tools to support state and local planning efforts.

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The National Academies appointed the above committee of experts to address the specific task requested by the U.S. Army Corps of Engineers. The members volunteered their time for this activity; their report is peer-reviewed and the final product signed off by both the committee members and the National Academies. This report brief was prepared by the National Research Council based on the committee's report.

For more information, contact the Water Science and Technology Board at (202) 334-3422 or visit http://dels.nas.edu/wstb. Copies of *Reducing Coastal Risk on the East and Gulf Coasts* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.