

A tale of two surveys: What coastal communities need to meet the challenges posed by climate change

By

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Hampton Roads, Virginia

Hampton Roads ranks among the most threatened areas in the United States in terms of populations at risk of flooding from sea level rise and land loss (McGarry *et al.* 2014). That vulnerability stems from the area's sprawling development across relatively low, flat topography and its adjacency to the Atlantic Ocean, the Chesapeake Bay and Bay tributaries. Some neighborhoods already experience flooding from king tides and poor storm water drainage.

In the next 20 years, the Department of Homeland Security (DHS) expects that the predicted 6-inch sea level rise will result in flooding affecting up to 30,000 people in the region (DHS 2016).

Tidal flooding is only part of the problem; in 20 years, DHS predicts that a Category 3 hurricane would put 787,000 people in the area at risk of storm surge flooding. This estimate does not appear to account for any shifts in population.

Northeastern U.S. Coast

The northeastern United States has experienced dramatic changes in its coastal and ocean ecosystems — the result of centuries of population growth, dense development, and overfishing.

Sea level rise along the Northeast coast is occurring at higher rates than the global average. Land subsidence, changes in offshore winds, ocean circulation patterns, and increased average wave heights (Bertin *et al.* 2013) all will affect local erosion rates, increasing risks to developed and natural shorelines. Devastating severe weather events, such as Superstorm Sandy, illustrated the vulnerability of the region's coastal cities and prized beach communities.

Across the eastern United States seaboard, densely populated and economically productive low-lying coastal areas are experiencing the effects of erosion and flooding caused by sea level rise and more severe storms. The Environmental Defense Fund (EDF) surveyed experts on coastal climate change issues in the northeastern U.S. in summer 2015 and the mid-Atlantic's Hampton Roads area of Virginia in summer 2016. For each, EDF aimed to understand perceptions about the effects of climate change on local environmental priorities. The Hampton Roads survey also sought to identify priority governance, policy, and technical challenges associated with improving the region's ability to cope with sea level rise and improve its resilience to severe weather events.

The combined two surveys captured input from 139 respondents, primarily composed of academics and representatives of governmental agencies and non-governmental organizations. All self-identified as having interest or expertise in aspects of environmental and natural resource protection or management, community planning, coastal geology or engineering, or emergency response.¹ These surveys provide interesting insights about what they believe communities need to protect their shores using natural infrastructure as well as traditionally engineered solutions.

Two different approaches were used to refine the input gathered from the surveys. After the northeastern survey, EDF organized a workshop involving a subset of those surveyed. They discussed their reactions to survey findings, shared information, discussed opinions, and

developed a consensus regarding future environmental priorities based on specific regional assets: marine fisheries, estuaries and wetlands, and cities and towns. For the Hampton Roads survey, one-on-one dialogues underscored the results. Both surveys and the workshop's results illustrate that restoring natural infrastructure should be a component of coastal resilience plans.

An obvious difference between the two studies is that of geographic scale (Figure 1). The Northeast survey focused on the coastal regions from Long Island north to the Gulf of Maine. The region's shorelines include extensive reaches of high energy rocky and sandy coastlines, punctuated by more sheltered bays. Common features along the coast are estuaries and their systems of lagoons, coves, tidally influenced rivers, and streams. Iconic beaches and beach communities, like those along Long Island, New York, Cape Cod, Massachusetts, and Old Orchard Beach, Maine, attract large summer populations. The geographic scope of Hampton Roads is far more localized. The Hampton Roads area is dominated by its location near the mouth of the Chesapeake Bay, and several rivers. It includes the high energy sandy shore of Virginia Beach. Its coastal areas experience an influx of summer tourists. For both surveys, results regarding priorities may not apply to a specific watershed, municipality, or neighborhood.

SHIFTING COASTAL ZONE ENVIRONMENTAL PRIORITIES

Responses to the two surveys showed considerable consistency regarding future environmental issues given the expected effects of climate change (Table 1).²

The Hampton Roads survey results revealed a high degree of consensus that shoreline erosion, stormwater quantity, habitat loss, stormwater quality and nutrient management, management of coastal developments, and shoreline hardening would become more problematic in

1) Additional details about the Hampton Roads, Virginia survey can be found at <http://www.edf.org/sites/default/files/hampton-roads-survey-report.pdf>; a summary of the Northeast survey was presented at Social Coast 2016 (<https://coast.noaa.gov/socialcoast/ppt/Smith.pdf>) and a formal paper is in preparation.

Table 1.

Top environmental concerns after considering impacts from climate change. These findings stem from two surveys of experts and an expert dialogue that included work groups focused on issues especially relevant to coastal cities and towns and a work group on wetlands and estuaries. For the Hampton Roads Survey, sea level rise and storm surge were not offered as choices as they were presented as the given effects of climate change (n = number of respondents).

Northeast Survey (n=80)	Northeast Cities & towns work group	Northeast Wetlands & estuaries work group	Hampton Roads Survey (n=59)
Sea surface temperature	Storm surge levels, intensity and frequency	Sea level rise	Shoreline erosion
Habitat degradation/loss — coastal	Sea level rise	Development	Storm water quantity and timing
Sea level rise	Shoreline erosion	Storm surge level, intensity, and frequency	Habitat alteration
Storm surge levels/frequency	Rainfall/heavy precipitation	Freshwater flows/timing	Storm water quality
Shoreline erosion	Air/sea surface temperature (increases)	Ocean acidification	Management of development
Increasing storm intensity/frequency	Coastal habitat degradation and loss	Sea surface temperature	Shoreline hardening
Rainfall/heavy precipitation	Organic pollution	Air temperature	Trash, urban runoff, marine debris
Air temperature	Impacts of hardening and other structures to protect infrastructure and property	Rainfall/heavy precipitation	Water demand & supply
Freshwater flows/timing			“Other”
Organic pollution			Trophic shifts

a future influenced by climate change (Cunniff and Davis 2016).

Of the work groups asked to refine and expand on the results of the Northeast survey, the two addressing areas akin to conditions in Hampton Roads (i.e. the cities and towns and wetlands and estuaries work groups) are summarized here. The work groups’ discussions both resulted in raising the effects of development and shoreline hardening as a key future environmental stressor. Both work groups were given the same survey

2) Although both surveys provided similar sets of environmental issues to evaluate, the surveys approached the questions differently. Respondents to the Hampton Roads survey were asked to select up to five of 19 environmental issues (including “other”) that they believed would be most exacerbated by sea level rise and more severe storm events. The list of 19 issues is found at <http://www.edf.org/sites/default/files/hampton-roads-survey-report.pdf>. The Northeast survey asked respondents to rank for many of the same issues the level of impact of existing and future conditions. The Northeast survey also provided a specific year (2050) and a modified IPCC A2 scenario (4°F air temperature increase, 5°F sea surface temperature increase, 10% precipitation increase, and 3-ft sea level rise) for experts to consider in making their assessments.

results with which to work and were allowed to lump, split, or otherwise define categories. For example, development was defined by the wetlands and estuaries work group as a new broader stressor category that incorporated a number of environmental stressors: hydrologic barriers, direct impact/fill, watershed inputs, hardened shorelines, impervious areas, and aquaculture.

Even though the terms they employed were not identical, each of the Northeast work group’s discussions yielded a fairly consistent list of top future environmental stressors. Priorities are listed in order (highest on top) but the exact order of top priorities should not be given too much weight given the small size of each of these work groups (about 10 people) implies factors such as their composition and the nature of that day’s conversations could easily have altered the final order.

Looking across the Northeast survey (as supplemented by the work groups) and the Hampton Roads survey, the results are similar but not identical. The chief common future concerns were habi-

tat loss, shoreline erosion, stormwater runoff (timing, quantity, and quality), and impacts of development. Hardening the coast and other infrastructure and housing protection measures, such as barriers and dams, become bigger environmental concerns.

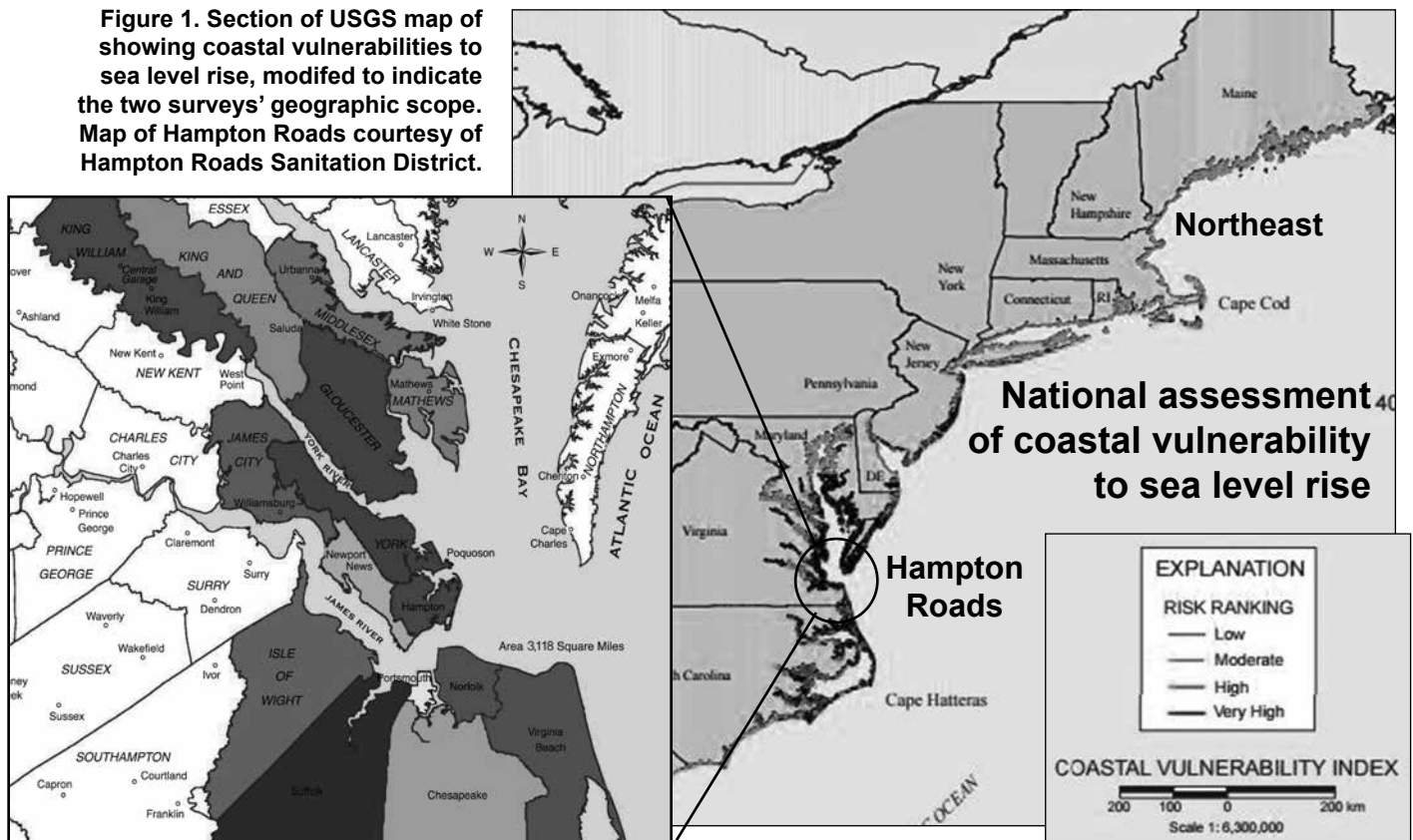
Most of these challenges already exist.³ It is worth noting that those surveyed did not represent the full spectrum of issues that affect a community’s resilience (e.g. transportation, energy, etc.).

SURVEY IMPLICATIONS FOR NATURAL INFRASTRUCTURE AS A KEY PART OF COASTAL RESILIENCY PLANS

These results underscore that the human responses to sea level rise, more frequent storms, flooding, and erosion events will increasingly define the character of our shores. How we choose to adapt our coasts to climate change will have significant bearing on the environmental quality of the coastal environment, our

3) The shifts in environmental priorities due to climate change that were revealed by the Northeast survey is discussed by Smith *et al.* (in prep.)

Figure 1. Section of USGS map of showing coastal vulnerabilities to sea level rise, modified to indicate the two surveys' geographic scope. Map of Hampton Roads courtesy of Hampton Roads Sanitation District.



personal connection to the coast, and the socio-economic contributions of our coastal communities.

It doesn't take a coastal engineer to figure out that the more intense storms and higher wave heights expected along the Atlantic coast from climate change will increase demand for shoreline protection measures. With more intense precipitation expected, coastal riparian flooding can be reasonably expected to both more frequent and more problematic. Solutions to reduce risks from riparian and surface water flooding will also be in high demand as more intense precipitation events challenge our ability to manage stormwater runoff. The links between development, shoreline erosion, and habitat loss are well established (Dugan *et al.* 2011; O'Meara *et al.* 2015). Gittman *et al.* (2015) has already documented positive correlations between both storm frequency and wave height and coastal hardening (i.e. more frequent storms or higher waves result in more coastal hardening).

Unfortunately seawalls, revetments, and bulkheads prevent inland migration of wetlands and beaches in response to sea level rise and eventually result in the loss of these shoreline environments (Pilkey *et al.* 2012; NRC 2007; Sutton-

Grier *et al.* 2015). Therefore expanding the use of hardened shorelines in response to sea level rise and erosion due to climate change can be problematic from environmental, aesthetic, and tourism perspectives. The survey results as supplemented with the work groups and one-on-one interviews reflect that local and regional resource managers and planners are aware of these issues and the implications that the response to climate change may further aggravate already degraded conditions.

Fortunately, measures exist that can address aspects of these challenges. Natural infrastructure solutions, such as living shorelines, offer new options and are especially well-suited for sheltered shorelines — estuaries, lagoons, and tidally influenced rivers — where much shoreline armoring along the U.S. Atlantic coast has occurred (Gittman *et al.* 2015). In many places, replacing revetments and bulkheads with natural infrastructure can stabilize shores, improve water quality, and enhance fisheries. On open coasts, restoring beaches and vegetated dunes offer ways to rebuild protective shores that blunt wave energies.

Many communities along the eastern seaboard are carefully assessing their risks and developing multi-faceted strategies

that reduce vulnerabilities, lower risks, and provide other benefits. Seabrook, New Hampshire, Stamford, Connecticut, and Norfolk, Virginia, are among those whose strategies include restoring natural infrastructure. An additional benefit from restoring natural infrastructure can be improved recreation space that includes access to water and/or space for bike paths, to improve the quality of life of residents and tourists. Other benefits include improved water quality and/or groundwater recharge, which can help address other community needs. The most sophisticated local entities complement these strategies by moving vulnerable developments out of flood-prone areas and implementing new development and building codes that improve stormwater retention, improve water quality, reduce flood peaks, and increase building flood resiliency.

KEY CHALLENGES FOR BUILDING COASTAL RESILIENCE IN HAMPTON ROADS

When asked to choose five from among 28 challenges they encounter in building resilience, respondents to the Hampton Roads survey demonstrated considerable agreement about the top three issues (Figure 2). Respondents' choices and supplementary comments reflect that they feel the public and political leaders do not

understand flood risks and perceive that addressing climate change is something to do at some point in the future.

Building resilience requires individual actions, takes time, and needs sustained public support for government activities. If the public isn't clamoring for changes to create resilience, then public officials will continue struggling to secure buy-in for measures like changes in zoning and building codes as well as buyout programs that create paths to resilience. If the public perceives that sea level rise as too far in the future and not a present-day priority, then it is that much more challenging to secure their involvement in planning and support for funding.

Given the long timeframe associated with planning and constructing public works projects, officials believe that improved awareness of existing and future risks would spur greater stakeholder support. Another way to prompt positive engagement by stakeholders will be to include solutions in resilience plans — such as natural infrastructure — that are perceived as providing immediate benefits to the community.

Build capacity to reduce risks

The Hampton Roads survey solicited information about desired skills, tools, information, and research and development priorities. Common themes emerge when looking across the responses. There exists a strong desire to improve public awareness of present-day and future flooding risks — particularly to build better understanding of the implications of flooding to especially vulnerable populations and neighborhoods, businesses, and the region's economic security.

To improve risk perception and build support for actions, survey responses reflect strong support for three complementary strategies:

- Improved tools to aid assessment of risks;
- Enhanced awareness of opportunities to reduce risk; and
- Heightened ability to make well-informed selections from among the options to reduce risk.

Emerging as a high priority for respondents was improved risk modeling, flood mapping, and other tools. These would help improve stakeholder aware-

Table 2. Top R&D priorities identified in the Hampton Roads survey (Cunniff and Davis 2016).

Theme	Top research & development priority	Response percent (n=59)
Risk perception	Comparison of flood modeling results to actual community member understanding of and personal estimates of flood impact to property.	65.2%
Risk	Development of tools to compare changes in flood damages from various mitigation options.	58.7%
Relocation	Identifying primary concerns about and test possible solutions for relocation to guide creation of relocation policies and programs.	51.1%
MLOD strategies	Development of local engineering and ecological criteria for coastal wetland restoration.	77.3%
Stakeholder and political support	Development and testing of messages regarding value and benefits of MLOD strategies that include natural infrastructure; — and — In-depth assessment of regional industries and businesses that will directly benefit from a climate change adaptation economy.	44.4% (tied)
Policy, financing, & legal issues	Explore and develop new financing mechanisms for coastal resiliency.	66.7%

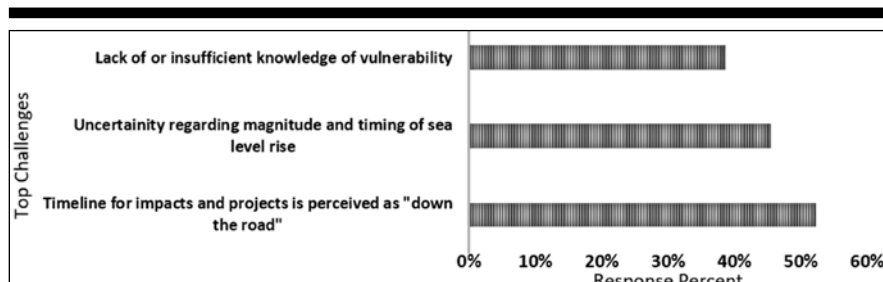


Figure 2. The top challenges to reducing Hampton Roads' risks from sea level rise and storm damages. For additional information see Cunniff and Davis 2016.

ness of the impacts of flooding and the options for mitigating storm hazards. They also can help build community consensus around the appropriate solution sets. Comments reflected an interest in having a “regional planning template” that showed heights and duration of flooding — ideally bringing together information on riparian floods as well as storm surge coupled with sea level rise — to demonstrate to stakeholders the affects to their communities. Such high-resolution models and refined risk assessment technologies are necessary to assess and compare the performance of risk management solutions including fresh options for reducing risk, such as natural infrastructure.

Data alone will be insufficient, however. Those surveyed emphasized the need for user-friendly tools to trigger important conversations. User-friendly interfaces would increase the utility of new information to stakeholders and government officials. They allow exploration of questions like: What risks are acceptable and what combination of solutions reduce risk and improve revenue generation in my community? Comments recognized the necessity of translating flood probabilities and flood heights into detailed descriptions and visualization tools to reflect both the short- and long-term consequences of flooding in a manner meaningful to homeowners and businesses. Consistent with these find-

ings, a majority of respondents identified as their top research and development priority for enhancing risk perception the creation of a “model to compare flood modeling results to actual community member understanding of and personal estimates of flood impact to property” – in short, a way to make the personal costs of floods real. These crucial high-resolution models and friendly interfaces need to be complemented with significantly improved community outreach and engagement tactics — a point raised by some of those surveyed.

Expand attractive options to reduce risks

Comments reflected a desire for improved tools to more fully characterize and compare the costs and benefits of risk-reduction solutions, including ecosystem services. Respondents (which were a cross-section of experts from academia, environmental nongovernmental organizations, engineering and construction businesses, and local and federal governments) noted that if stakeholders had knowledge about flood reduction measures, they were primarily familiar only with traditional structural approaches (e.g. seawalls, bulkheads, and levees) and they were not aware of the environmental, cost, and quality of life tradeoffs associated with these structures.

Respondents reflected interest in expanding public understanding of the consequences of shoreline hardening. Their comments provide supporting evidence: “The public tends to think structural features are the only way to solve flooding.” “Most people have no idea of the economic consequence of bulkheads, seawalls, etc., most think they are the only solutions.” And “They [the public] do not understand the cost, liability, and environmental impacts and often solely focus on the physical protection of their structures that would buy them more time/preserve value.” Respondents also indicated a belief that the public generally lacks understanding of how restoring and maintaining natural infrastructure can reduce risk and provide other co-benefits that enhance the region’s economy and its resilience. Respondents’ comments did not distinguish between nor define “stakeholders” and “public.”

Respondents demonstrated congruent opinions regarding the need for more information about all possible risk-re-

ducing solutions, including performance (e.g. what risks they reliably mitigate, how they work in concert with other options), life-cycle costs, and contribution to other community values and needs. Responses supported the need for tools to quantify risk reduction as well as evaluate environmental consequences to assess tradeoffs and aid selection of solutions that work best for community values and needs. Comments also reflected interest in improving understanding of design, construction, and maintenance requirements of restoring risk-reducing natural infrastructure features. All such improvements would help broaden consideration of natural infrastructure features.

When EDF asked about research and development priorities to advance adoption of multiple lines of defense (MLOD) strategies⁴ to enhance the region’s resiliency, the top priority was the development of local engineering and ecological criteria for coastal wetland restoration. To build stakeholder and political support, a top vote getter was development and testing of messages regarding the value and benefits of MLOD strategies (Table 2). Especially noteworthy to readers of *Shore & Beach* was the need for an in-depth assessment of regional industries and businesses that will directly benefit from a climate change adaptation economy.

CONCLUSIONS

Both surveys of experts reflected similar findings that some environmental concerns will be amplified by climate change. This is especially true if our response to sea level rise and storm threats continues to be dominated solely by traditional structural solutions as demonstrated by these surveys and supported by the findings of Gittman *et al.* (2015).

The results also demonstrate that agencies and public officials are struggling to choose where, when, and which measures to invest in. Communities are beginning to take measures that build paths to resilience. Respondents to the Hampton Roads survey expressed a desire to do more and faster to avoid the economic, social, and environmental disruptions associated with storm disasters.

A pervasive belief exists that the pub-

4) Multiple lines of defense strategies employ combinations of natural infrastructure, traditional engineered solutions together with buy outs, zoning, building codes to reduce impact of flooding and wind, and early warning systems for evacuation.

lic doesn’t sufficiently understand their risks and would act differently if they did understand them. Those surveyed also believe that more balanced and complete information about the advantages and disadvantages of actions to reduce risks would improve decision-making. The Hampton Roads survey findings indicate a compelling need for building regional citizens’ capacity to take measures that build their personal resiliency and to participate meaningfully in planning the region’s future. Sophisticated studies and public surveys would ascertain whether these perceptions are correct, and if so, methods to enhance community involvement, improve the penetration of information into these communities, and verify the effectiveness of education would be highly beneficial.

Once messages regarding the value and benefits of MLOD strategies are further developed and tested, it will be important for coastal planners and engineers to help disseminate these messages to their clients and local communities. New tools, complemented by more sophisticated messaging and community outreach, are desired. User-friendly tools are needed to build the public’s capacity to understand the complex array of factors needed to consider fully all reasonable risk-reduction options. Information is needed to describe the parameters of solutions: What risks they reduce, their reliability, how they complement one another, their life cycle costs, how to maintain functionality, their environmental costs and benefits, etc. Tools that help evaluate the cumulative impacts of solutions on the environmental, social, and economic wellbeing of the community are highly desired. We need to focus on digestible and actionable information for government officials and the general public.


Far more effective methods for involving communities and stakeholders. Such will be critical for building public understanding and support for actions to manage risks and build vibrant, resilient communities. Addressing these issues will facilitate public engagement and informed decision-making about which risks are acceptable, which solutions are suitable, and the advantages of taking action before crippling disaster strikes. Addressing each of these needs will be crucial for successfully building Hampton Roads into a more economically, socially,

and environmentally sustainable and resilient region.

Organizations as diverse as the Corps of Engineers (USACE 2015) and the Environmental Defense Fund believe that integrating natural infrastructure solutions to create multiple lines of defense strategies will reduce storm risks to properties and improve the resiliency of ecological systems. Such approaches are going to be essential to ensuring livable, vibrant coastal communities now and into the future.

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