Resilient coastal systems and community planning

ASBPA Science & Technology Committee

March 2014

In the aftermath of recent storms such as Hurricanes Katrina in 2005 and Sandy in 2012, many communities and organizations have discussed the importance of developing resilient coastal systems to reduce risk to coastal populations from future hurricanes, severe storms or other natural disasters (e.g. tsunamis). This interest has been heightened by concerns over the potential future effects of climate change and sea level rise on the coastal zone.

The American Shore and Beach Preservation Association (ASBPA) recognizes the need for resilient coastal systems--the ecosystems and landscapes that comprise our coastal barriers, barrier islands, and strands — to increase the sustainability of our coastal communities. Herein, we discuss the definition of resilience, describe various components of a resilient coast, and present ASBPA's recommended community actions to plan, manage, and maintain a resilient coastal system.

DEFINING RESILIENCE

The term "resilience" can have different meanings depending on the context of usage. The National Academies of Science (2012) defines resilience as "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events." A healthy coastal system has the capacity to naturally achieve all of those parameters over a sufficient duration. However, human intervention might sometimes be necessary to hasten the recovery of the system (e.g. beach nourishment, dune restoration, etc.) after severe storm events or other large disturbances. Breaking down the definition by its elements -- absorption/resistance, recovery, and adaptation – may help communicate the concept of resilient coastal systems; consider these elements:

Resistance — the property of a system to remain essentially unchanged when subject to disturbance (Levin 2009),

Recovery — the return of a system to a previous state (based on Schultz et al. 2012), and

Adaptation — initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects (IPCC 2012).

Simplistically, a beach that naturally erodes via transport of sand offshore during a storm, then recovers to its previous functional performance as the sand returns to the beach in the days and months following the storm, can be thought of as a resilient coastal system. However, a beach that loses sand during a storm — due to the effects of inlets or adjacent structures or a localized storm event — may take years to naturally recover to pre-storm levels, if at all. From a human perspective, the shoreline system might not be considered resilient, because the recovery might not be quick enough to protect development due to a net loss of sand to the system. Humans could intervene to speed recovery or restore lost services, and not surprisingly the extent of appropriate intervention relates to the severity of disturbance and extent of damages. Since resilience applies to a wide spectrum of conditions and is a function of the ability of a system to recover from a given disturbance, a coastal system may be considered resilient to a certain set of disturbances but less resilient to more severe conditions. Thus, the concept of coastal resilience must consider factors such as the magnitude of disturbance, acceptable time scales of recovery, location of development, the required protection provided by the system, and whether recovery is achieved through natural processes or human intervention.

Schultz et al. (2012) offers definitions of engineering, ecological, and community resilience based upon three U.S. Army Corps of Engineers (USACE) mission areas (Navigation, Storm Damage Reduction [including beach nourishment], and Environmental Restoration) and identifies a strategy for calculating resilience in each of the three concept categories. The following section provides descriptions of each category and discusses how resilience differs in emphasis and how each might be demonstrated or measured.

Engineering resilience

"Engineering Resilience" is the ability of an engineered project to resist and recover from a given disturbance. The emphasis is on functional performance, which may be calculated as the rate at which pre-disturbance performance levels are recovered as compared to the design goals.

For instance, an engineered shore protection project commonly includes beach nourishment as a key component. Beach nourishment projects are designed, constructed, and maintained to replicate natural systems that 1) protect against economic losses from storms, 2) provide recreational space, and 3) restore and preserve the beach-dune ecosystem. Establishing the design parameters for protection involves complex analyses that consider the system's response to historical and likely future storm events to yield a beach designed to provide an optimal level of storm protection during its design life.

An engineered beach project is designed to at least partially recover from anticipated storms that occur within the renourishment interval with renourishment to provide for full recovery. Recovery from an extreme storm that exceeds the design may even require reconstruction of the project. Such human intervention for recovery is considered part of the overall project life-cycle costs.

Adaptation may result if the beach system responds in an unanticipated manner to a point that requires reconsideration of the design. An unforeseen response would likely indicate that either the design assumptions were incorrect (such as actual fill grain size differs from the design) or conditions have changed (such as changes in natural sediment supply or sea level rise).

Ecological resilience

"Ecological Resilience" describes the ability of a natural, self-organizing system to absorb change and disturbance such that it provides the same functionality. In Ecological Resilience, relationships among populations are maintained so that the system retains the same functions, structure, and responses to future events.

On the coast, a pertinent example involves a natural dune system populated with sea oats and other native dune species that are partially eroded during a storm. The vegetation's root system helps improve the dune system's overall resistance to storm waves and elevated water levels. Recovery occurs as sea oats and other species naturally repopulate, and the dune gradually rebuilds through wind-blown transport where there exists a sufficient supply of sand, dry beach and wind speeds exceeding the threshold for sand movement. Depending on the severity of the storm and the pre-disturbance condition of the natural system, recovery could vary from days to decades. Successful adaptation can occur in a variety of forms including reformation of the dune system at a landward location depending on the proximity of the water line to the vegetation line.

Community resilience

"Community Resilience" is the ability of organizations and human communities to learn and adapt in ways that (a) preempt and avoid major mishaps that would otherwise disrupt their desired functions, or (b) recognize the risk of damage and provide the resources for restoration after damage occurs. The emphasis is on the community's ability to adapt, reorganize, or develop new functions and/or actions that are specifically conditioned on the disturbance (e.g. storm, tsunami).

In general, communities strive to maintain their same functionality following a disturbance. Resilient communities are better able to withstand and recover from disasters when they learn from past disasters, develop storm redundancies, strengthen preparedness, and utilize available resources to respond and recover from adverse situations. Because resilience is both complex and dynamic, sustaining resiliency will require coastal communities to improve their capacity to learn and adapt.

Examples of community preemptive resilience might involve preplanned coastal evacuation strategies with multiple exit routes, coastal zoning plans in place prior to storms that require adaptation following disasters, and actions to limit storm surge and wave damage to homes and businesses. Alternately, resilience can be realized through recognition of likely damage with planning and funding restoration and consistent community-level support for infrastructure and natural resource recovery and maintenance.

Recovery of an engineered beach on the community level can be greatly improved through careful project planning including for sediment source identification, debris removal following the disturbance, and consistent periodic and episodic monitoring. An understanding of coastal risks may also help identify significant vulnerable areas that are and are not viable for recovery; pre-storm planning can greatly facilitate community recovery in the immediate post-storm period.

COMPONENTS CONTRIBUTING TO A RESILIENT COASTAL SYSTEM

Some coastal protection strategies by federal, state, and local entities have been under way for decades and have contributed to the resiliency of our coastal systems.

Regional Sediment Management

"Regional Sediment Management" (RSM) is a USACE initiative, working collaboratively with stakeholders and partners, focusing on a systems approach to optimize the use of sediments while increasing benefits, reducing costs, and improving the environment. The classic RSM example involves a harbor navigation project requiring maintenance dredging to re-establish project depth. Previously, the USACE would dredge such projects and dispose the material in an offshore site as the least-cost alternative. RSM looks at the overall system and, for example, may identify an eroding downdrift shoreline adjacent to the navigation project as a potential site for beneficial use of the dredged sediment. Assuming that the material meets requirements for upland beach placement, RSM concepts encourage dredged material placement on the eroding beach. If the dredged sediment has significant fines, sometimes it can be placed in the nearshore to provide a wave break and feed the downdrift beach. RSM frequently results in cost savings through combination of the two projects for navigation and shore protection. Many states and USACE districts have cooperative workgroups that identify needs and provide guidance on upcoming projects, and are prepared with the required permits. This type of cooperation helps ensure that sediments beneficially stay within the coastal system.

For example, the city of South Padre, TX, has been working on RSM strategies with USACE and the Texas General Land Office for 25 years to beneficially use sand dredged from the entrance of Brazos Santiago Pass to nourish downdrift beaches through direct beach nourishment and nearshore placement. The city and USACE are now adaptively working on adjusting the nearshore placement area so that the dredged sand is placed within areas of greatest need. An adaptive combination of direct beach placement and nearshore placement strategies provides for flexibility to maintain a healthy beach and dune system that provides storm protection for the local community.

Natural Features, Nature-Based Projects, and Living Shorelines

"Natural Features, Nature-Based Projects, and Living Shorelines" are efforts by governments or individuals to replicate natural systems to support coastal resilience by stabilizing the shoreline, attenuating wave energy, or slowing inland water transfer. Bridges and Wagner (2013) define "Natural Features" as those that "are created or evolve over time through the actions of physical, biological, geologic, and chemical processes operating in nature." Coastal wetlands, natural reefs, dunes, vegetation, beaches, and rocky shores, among others are examples. USACE (2013) defines "Nature-Based Projects" as "those that may mimic characteristics of natural features but are created by human design, engineering, and construction to provide specific services such as coastal risk reduction." Beach and dune restoration projects are examples of Nature-Based Projects.

"Living Shorelines" are defined by the National Oceanic and Atmospheric Administration (NOAA 2014) as "a shoreline management practice that provides erosion control benefits; protects, restores, or enhances natural shoreline habitat; and maintains coastal processes through the strategic placement of plants, stone, sand fill, and other structural organic materials (e.g. biologs, oyster reefs, etc.)." Living shoreline projects tend to focus on the integration of the biological and physical processes.

These risk reduction strategies can be alternatives to structural solutions or used in a hybrid approach, and are additional tools for coastal communities to adapt to changing conditions brought on by storms, sea level rise, or human influences.

NON-STRUCTURAL PLANNING

Considering the changes in climate, sea level, and resulting changes to areas exposed to inundation and storm damage by waves or flooding, many communities are beginning to plan for rebuilding after storm events. Immediately after a significant disturbance, there is an emotional push to rebuild to pre-storm conditions. However, considering the ongoing changes to our environment, rebuilding in the same location may not always be a long-term solution. Planners are beginning to consider the vulnerability of areas within communities and the level of damage that warrants a decision to not rebuild and repurpose those areas. Agreements must be in place prior to storms so that communities recognize the inherent realities of living within a dynamic coastal environment, and accept these risks.

ASBPA provides technical and policy support for its member communities' efforts to utilize beach restoration as a primary tool to combat long-term erosion, alone or in combination with other erosion management tools such as erosion control structures or public facility relocation, in order to develop a long-term and sustainable coastal management plan.

The Nature Conservancy (TNC) recently released a report of innovative hazard mitigation strategies called "Reducing Climate Risks with Natural Infrastructure," focusing on projects in California (TNC 2012). The Surfers Point Project in Ventura combined nourishment, dune restoration, and managed retreat to relocate public facilities across the street.

FEMA & NFIP standards

These provide communities some tools for mitigating the impacts of storms and minimizing damages from future storms. The Federal Emergency Management Agency (FEMA) administers the National Flood Insurance Program (NFIP) on behalf of the federal government. FEMA commonly provides federal funding for partial recovery after storms. On a national basis, FEMA has established base flood elevations (BFEs) for construction of homes and businesses in flood prone areas across the country. In coastal areas, BFEs account for storm surge and wave action. Local and State building codes frequently reference FEMA BFEs (often with some additional freeboard) as the minimum elevation for horizontal structural members in the coastal zone. After major storms, structures that are rebuilt must meet these BFE standards, which help improve the resiliency of coastal buildings and reduce flood risks.

USGS shore assessments

The United State Geological Survey (USGS) has identified coastal erosion trends for much of the U.S. coast under their National Assessment of Shoreline Change Project and related programs (http://coastal.er.usgs.gov/shoreline-change). These reports identify historic erosion rates and provide an indication of the potential future erosion. While changing conditions such as sea level rise, sediment supply and interventions can result in shore movements that differ from historic changes, these reports can help interpret existing challenges and enhance our understanding of the risks of living close to the shore.

RECOMMENDED ACTIONS

ASPBA recognizes the need for more resilient coastal communities on a national basis. As such, we present below a series of recommendations intended to enhance the engineering, ecological, and community resilience of U.S. coastal areas. While not totally comprehensive, these recommendations provide a good framework for discussions in support of planning for improved resiliency throughout our coastal regions.

Engineering

• Develop and implement a regional sediment management plan: Identify and link sediment source opportunities with nearby eroding and potential receiver beaches or beneficial use areas to help offset coastal sediment deficits and beach erosion; develop and incorporate inlet management plans that provide for offsetting of adverse inlet effects upon coastal system;

• Design and adapt to provide multiple levels of protection: Develop protection-redundancy through foredunes, dunes, buried sea walls, bulkheads, revetments;

• Recognize risks: Anticipate storms and the potential for damage to the protection system; utilize storm surge and morphology modeling to evaluate performance of design alternatives and assess storm impacts to existing system; consider potential for sea level rise, local subsidence, bayside breaching, and overwash in design;

• Evaluate potential future conditions with a range of scenarios affected by climate, sediment supply and interventions / adaptation;

• Develop and maintain a storm recovery plan: Obtain flexible federal and state permits with multiple sediment sources in order to be continuously prepared for emergency construction, address the potential need to close breaches;

• Replicate nature: Incorporate nature-based projects such as reefs, living shorelines, beach and dune sand-fill, dune vegetation, and wetlands within the coastal system to optimally form a comprehensive resilient coastal system; and

• Provide for maintenance: Anticipate and account for gradual and storm-induced degradation; identify quality sources of sand for rebuilding the beach.

Ecological

• Think holistically: Embrace and promote ecosystem-based management that focuses on the whole ecosystem and community and their diverse benefits or needs including sustainable fisheries, biodiversity conservation, and need for coastal protection;

• Act regionally: Manage sediment within the watershed on a regional scale to maintain sand delivery to coastline and effectively utilize sediment dredged from navigation channels using natural processes such as river flow and flushing of bays and estuaries;

• Replicate nature: Develop a beach and dune management plan; Restore the coastal system with sand of similar grain size to the native sand; Protect, enhance, and restore native vegetation on dunes and back beaches;

• Conserve resources: Establish ecosystem conservation areas and setbacks where beaches and wetlands will be protected and allowed to migrate and retreat; and

• Monitor: Develop network of sentinel monitoring stations – to provide a basis for responsible adaptive management based on measured physical conditions, performance, beach ecosystem functions, and recreational uses.

Community

• Recognize risks: Assess coastal storm and flooding risks to the community and identify public safety needs (including evacuation planning); periodically update risk assessment as science and technical skills improve; determine local storm surge and flood prone areas and assess the factors that increase risks in those areas;

• Adopt local codes: Use existing local regulatory tools to reduce flood risks to properties and infrastructure via siting, elevation, construction, and retrofitting criteria; monitor and improve upon those tools as needed;

• Plan: Periodically undertake shoreline assessments and formulate beach management strategies that reduce storm flooding and damage and protect, restore, or enhance natural resources/ecosystems that buffer flooding and reduce risks of damage; be proactive in disaster planning; and

• Educate: Inform decision makers and the public about local, state, and national efforts related to land use, construction practices, the value of dunes, and raising structures to reduce damages.

Funding

• Take a stand: Recognize public interests in resilient coastal ecosystems and communities; promote public funding from local, state and federal governments to support resilient coastal ecosystems and communities;

• Be preemptive: Prior to severe storms, identify any problem/vulnerable areas (i.e., hot spots with buildings that may suffer significant damage) and if possible, identify funds for potential buy out of problem properties if condemned after storms; and

• Be prepared: Maintain "engineered" design beach and desired level of storm protection; keep plans and monitoring reports on file to remain eligible for FEMA funding; maintain local emergency funding mechanisms for emergency projects; set aside sufficient funding to provide for damage to shorelines and infrastructure where risks cannot be reasonably avoided.

SUMMARY

ASBPA recognizes the need for adaptive and sustainable management practices that balance engineering, ecological and community resilience objectives tailored to local and regional conditions. In order for coastal systems to become more resilient, we need to consider the coastal system in a holistic manner, leveraging the environmental features of the region and engaging the community to manage our sediment resources, streamline policies, design viable projects, and adapt to future changes.

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