SEA LEVEL RISE ADAPTATION:
EMERGING LESSONS FOR LOCAL POLICY DEVELOPMENT

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The mission of the Marine Policy Institute (MPI) at Mote Marine Laboratory is to strengthen the scientific basis of public policy and societal decision making for economic development and sustainability of our oceans and coastal ecosystems. Working closely with Mote scientists and other programs, the Institute conducts multi-disciplinary research to translate science on marine and coastal issues for policy-makers, community leaders, and the public at large. Since its creation in 2006, MPI has published technical reports on offshore drilling, red tide, and sea level rise.

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Executive Summary

Many coastal communities across the United States are beginning to plan for climate-related sea level rise. While impacts and solutions will vary with local conditions, jurisdictions which have begun this process seem to pass through three common stages when developing policy for local sea level rise adaptation: l) building awareness about local sea level rise threats, 2) undertaking analyses of local vulnerabilities, and 3) developing plans and policies to deal with these vulnerabilities.

Becoming aware of sea level rise as a local threat. Two key factors, in combination or separately, seem to help to stimulate community awareness about sea level rise as a potential threat. One factor is the availability of credible and easy-to-understand scientific information about local sea level rise, ideally coming from or being reinforced by local scientific institutions. The other factor is whether the community has experienced a natural coastal disaster, such as storm surge or a hurricane, which raises awareness about future shoreline vulnerabilities and the exacerbating effects of sea level rise. A variety of ad hoc or planned activities (such as workshops, discussion groups, speakers' events, and expert panels) provide opportunities to build community awareness about local sea level rise threats. These activities are typically sponsored by local organizations and community groups and helped by an interested media, as well as local experts and research institutions that provide credible technical information.

Assessing local vulnerabilities and risks. This second stage involves collecting information and undertaking a scientific assessment of local vulnerabilities and risks from projected sea level rise over the medium and long-term. The aim is to use the best available scientific information to identify areas and activities most threatened by future sea level rise. This stage is generally more structured; it is often led by technical experts and endorsed formally or informally by policy makers and community leaders. Most communities use already available baseline information and analytical tools, including digitized elevation maps, sea level rise viewers, and regionally adjusted global projections for different scenarios of rise. This second stage generally results in a technical 'vulnerability assessment' report that identifies the most vulnerable areas, likely risks, and adaptation options.

Developing an adaptation plan and supportive policies. The third stage involves using the vulnerability assessment to develop an adaptation plan and policies to address priority risks. Policy makers and community planners now become formally involved. A community's natural systems (the natural environment and ecosystem functions and services) and human systems (the built environment and associated economic and social assets) must both receive attention for sustaining a community's livelihoods and value systems. Following extensive public and expert review, a final plan typically emerges with policy and program actions that are scientifically-based and politically and economically feasible. Policymakers then formally adopt the plan with resolutions, ordinances, and other decision tools to support implementation.

Scientists emphasize that communities can address many sea level rise impacts through early planning and well-designed adaptive measures. As more low-lying coastal communities plan for sea level rise, insights from existing adaptation experiences will continue to inform and inspire ongoing and new efforts. Adapting to sea level rise will be essential for Florida's vulnerable communities to safeguard local livelihoods and qualities of life. Local leadership and community-wide involvement will play key roles.

Introduction

Context

Many low-lying coastal communities around the United States are becoming concerned about how current and future sea level rise could affect their livelihoods and qualities of life. Florida's coastal communities are among the most vulnerable to threats from sea level rise. A 2008 study identified the Miami and the Tampa-St. Petersburg regions as two of the ten most vulnerable cities in the world, along with greater New York, New Orleans, Amsterdam, Rotterdam, Osaka-Kobe, Tokyo, Nagoya, and Virginia Beach (Nicholls et al., 2008).

For most low-lying coastal communities, their economies depend on the ecological and other services provided by coastal and marine environments for such core activities as tourism, fisheries, commerce, ports, recreation, water management, wildlife protection, and storm buffers. Coastal regions already vulnerable to the effects of tropical storms, storm surge, flooding, and hurricanes, will see greater impacts as sea levels rise.

For Florida's coastal communities, sea level rise will become one of the most tangible and recognized impacts from climate change; one can simply observe progressively rising water levels each year particularly during high tide periods and increasing wave action inland during storms. Scientists explain that sea level change will vary regionally and locally depending on natural features such as coastline geography, land motion (whether the coast may be experiencing subsidence or uplift), ocean currents, and winds. For Florida, scientists project sea level rise generally will track global trends and projections because of the area's geophysical characteristics (FOCC, 2010). Economic and social vulnerabilities to sea level rise will vary regionally and locally depending on which resources will be most likely impacted; vulnerabilities also vary based on the extent to which local economies and livelihoods are tied to their coastal and marine environments.

Many coastal communities, counties, and states across the United States passed through three main stages or phases to build resilience to sea level rise. The stages included: l) becoming aware that sea level rise may be a local threat; 2) assessing main vulnerabilities using risk-based analysis; and 3) developing adaptation plans and policies to address priority vulnerabilities and reduce or avoid major risks over the near-, medium-, and long-terms. These initiatives are taking place in a variety of geographic, demographic, economic, political, and social settings. They reflect a growing awareness and concern about climate change and the need for local action. Recent surveys on climate change from such national institutions as the Brookings Institution, Yale University and its Project on Climate Communication, and George Mason University's Climate Communication Center confirm that the public's climate change awareness and concern have gradually grown in recent years across the country (Leiserowitz et al., 2013a; 2013b; Borick and Rabe, 2012).

Throughout the adaptation process, local leadership and local action are decisive. Leadership may come from a variety of sources acting collectively or alone, depending on the community, from government agencies, scientific research groups, environmental organizations, or university departments to concerned community groups, neighborhoods or individual citizens. Local media can play an important catalytic role in raising awareness and promoting dialogue. Leadership

from elected officials, policy advisors, and community decision-makers ultimately turns awareness about sea level rise into action for adaptation.

Local public sector leaders can take many actions to move the process of awareness building and adaptation planning forward. These include assigning specific tasks to public sector staff and creating new or designating existing working groups or task forces involving experts and the concerned public with the responsibility to assess and advise on risks and adaptation options. Key supportive measures, as decisions are taken to proceed with adaptation, include incorporating sea level rise data into long-range planning so that community development paths take into account risks and adaptation options, building partnerships with business and other nongovernmental groups to help design and implement strategies, strengthen policy frameworks, and monitor implementation and change in order to accommodate new scientific information.

Purpose

The purpose of this paper is to help advance community dialogue and further inform local decision-makers about key elements and steps for addressing climate-related sea level rise. It summarizes the results of a project the Marine Policy Institute (MPI) undertook during 2011-12 to review experiences from fourteen U.S. coastal jurisdictions representing a variety of city, county, and state efforts with sea level adaptation (Box 1). There are many more initiatives underway than those reflected in this sample, but the "focus jurisdictions" were selected because of the extensive information publically available on their experiences and lessons being learned that could provide insights for coastal communities, especially in Southwest Florida.

The paper is intended for a broad audience, including community leaders, local environmental and community organizations, technical advisors to local governments, planners, concerned businesses, students, and the general public. It is divided into three sections corresponding to the three broad stages of policy building for sea level rise adaptation that the studied jurisdictions seem to share, as noted above: l) building awareness, 2) assessing vulnerabilities, 3) planning adaptation. It elaborates these stages and some of the key techniques used in different jurisdictions to help build local awareness and support for plans and policy actions for sea level rise adaptation as threats and vulnerabilities unfold with time.

Scope of research

Research for this project drew from descriptive and analytical publications broadly and publically available, particularly through government websites and peer-reviewed academic journals. Main sources for this literature and information included publications, reports, and analyses from the focus jurisdictions and national government agencies such as the U.S. Environmental Protection Agency (EPA), its National Estuary Programs (NEPs), the National Oceanic and Atmospheric Administration (NOAA), and the National Aeronautics and Space Agency (NASA). Foundation-supported studies and academic and scientific research institution reports provided additional information.

The reference section at the end of the paper lists useful reference websites and the specific literature reviewed. To be as reader-friendly as possible, references within the text are limited to key points where a particular source seemed useful for readers wanting more information.

Box 1: Jurisdictions Reviewed for this Project

Charlotte Harbor National Estuary Program Area, FL
City of Olympia, WA
City of Punta Gorda, FL
City of Satellite Beach, FL
Delaware Coasts
Hawaiian Islands Coasts
Lee County, FL
Miami-Dade County, FL
New Jersey Coasts
Rhode Island Coasts
San Diego Bay Area, CA
San Francisco Bay Area, CA
Somerset County, MD
Worchester County, MD

Stage 1: Becoming Aware of Sea Level Rise as a Local Threat

In the local adaptation process, the first step is building a community's awareness of sea level rise as a potential threat to its economy and environment. Experience suggests that awareness-building strategies should reinforce or build upon community values (Leiserowitz, 2006) and involve existing local institutions and processes as much as possible (Rasker, 2012). Community interest in learning about sea level rise is influenced by many different factors. This project found two key factors are: l) whether a community has easy-to-understand scientific and technical information on sea level rise trends and projections that is readily available and locally relevant; and 2) whether the community or region has experienced a recent natural coastal disaster such as a hurricane or storm surge that resulted in economic and environmental damage. In addition to these two factors, a study conducted by a non-profit research firm, Headwaters Economics, found that decision-makers in adapting communities offered some practical tips for building awareness about climate risks, including sea level rise (Rasker, 2012). Box 2 lists the elements identified by the Headwaters Economics study, and the following sections discuss the two key factors identified by the MPI project.

Box 2: Tips for Building Local Awareness about Sea Level Rise

Interviews with local decision makers from 10 jurisdictions across the United States which were taking climate change adaptation actions found that the following elements were key components of effective strategies to build awareness and initiate adaptation actions.

- Focus on an immediate recognizable threat
- Use economic and fiscal arguments
- Find an entry point to use local values
- Reach out to the community
- Start with an existing process
- Make use of regional compacts
- Do not get trapped by the political debate over climate change
- Do not get too complicated with scientific or planning concepts too soon
- Involve elected officials early in the awareness building process

Source: adapted from Rasker, 2012, pp. 2-4.

Having credible information on sea level rise

An important factor that seems to help motivate or stimulate community interest in learning about potential sea level rise risks seems to be the ready-availability of scientific information relevant for understanding local trends and projections of sea level rise. This information is particularly effective when provided or promoted by institutions or organizations that are locally respected and recognized as credible and objective in their scientific and technical work.

Dissemination of such information has a multiplier effect when picked up by local media, in addition to being provided or promoted by scientific entities. Experiences from the jurisdictions studied for this project suggest that key players in the information dissemination process range from local, regional, and national government agencies to respected environmental organizations and scientific research and academic institutions. In several coastal regions of the country with major estuaries, local NEP initiatives play a catalytic and ongoing technical leadership role in providing local sea level rise information. The efforts of these organizations is most effective when they have capacity to produce sea level rise-related information that is in a format understandable to non-experts while still providing technical links for coastal managers and planners to do additional research for more background information and guidance on possible tools and approaches. Table 1 presents examples of organizations and information formats that communities have or are using to build awareness and understanding of sea level rise risks.

Table 1: Examples of Initiatives to Build Sea Level Rise Awareness

Type of Org.	Organization	Information Initiative
Local/State Government	City of Satellite Beach, FL (funded by EPA Climate Ready Estuary Program)	-Op-ed pieces for local news sources -Press releases, slideshows, posters -Public service announcements on the radio -Public forums -City news letters -FIT online Digital Library -Close communication with the Comprehensive Planning Advisory Board
	Department of Natural Resources (MD)	-Public-friendly sea level rise pamphlets -Public engagement via a working group -Public summits -Online visualization tools, including inundation map viewer
	Miami-Dade County Office of Sustainability (FL) and NOAA	-"Media Packets" that included newspaper clippings, photos, statistics, and charts about how sea level rise could impact departments' activities -Inundation and salinity maps -Maps of "Social Vulnerability Index" -Workshop with county department representatives
NEP	Charlotte Harbor NEP (FL)	-Articles in "Harbor Happenings" newsletter -Public workshops -Publication of updates for the public -Online WaterAtlas, a directory for water-related information

(Table 1 continued)		
NEP	San Francisco Bay Estuary Program (CA)	-Workshops for area authorities on planning for climate change (modeled on a pilot program in Washington State)
Science Research	South FL Regional Planning Council and Miami-Dade Climate Change Advisory Task Force (FL)	-Climate Change Community Toolbox -One-page factsheets on sea level rise -Public-oriented inundation maps
	University of Florida, Southeast Climate Consortium, Florida Climate Institute	-Conference on Climate Information for Managing Risks: Local to Regional Adaptation and Mitigation Strategies -Online publications for non-experts that overview recent sea level rise research and policy

Online sources of non-technical scientific information about climate-related sea level rise are growing in impressive numbers. Important national sites tracking the latest scientific data and trends are maintained by such technical agencies as the National Aeronautics and Space Administration (NASA), National Oceanographic and Atmospheric Administration (NOAA), and the Environmental Protection Agency (EPA). Regional organizations such as the Gulf of Mexico Alliance (GOMA) and many non-governmental organizations, university climate change centers, and climate change internet networks have emerged, distilling and maintaining updated information about adaptation efforts in a readily accessible and easy to understand format.

Examples of online information networks include the Climate Adaptation Knowledge Exchange (CAKE), the *StormSmartCoasts* network (a Gulf of Mexico Alliance initiative), the Georgetown Climate Center's Adaptation Clearinghouse, and NOAA's climate change pages of links to the latest relevant articles and publications. Community leaders and concerned residents can especially benefit from these resources both for their summary information, case studies, and for links to more technical information. For example, CAKE provides an extensive database of short but thorough explanations of existing research, analyses, policy initiatives, and other information related to climate adaptation in local and state jurisdictions around the country (see www.cakex.org). *StormSmartCoasts* provides many networking tools for coastal planners and researchers, including specialized online information networks, document directories, and state-by-state compendiums of existing storm preparation and climate adaptation tools for coastal communities bordering the Gulf of Mexico (see www.stormsmartconnect.org). The Georgetown Climate Center's Adaptation Clearinghouse is an online, user-friendly search engine for scholarly research on climate change and adaptation (see http://www.georgetownclimate.org).

There are other regionally- and locally-oriented online portals and directories hosted by government bodies that direct information on sea level rise to specific coastal communities (for example, for information about initiatives taking place in Florida, see www.flseagrant.org/coastalplanning/policy-tools-and-resources). Figure 1 illustrates logos of several popular online sources with credible, user-friendly climate change and sea level rise information. The 'Useful Websites' listed at the end of this report provides additional online resources.

Figure 1: Important User-friendly Climate Science Sources and Websites

Experiencing a natural coastal disaster

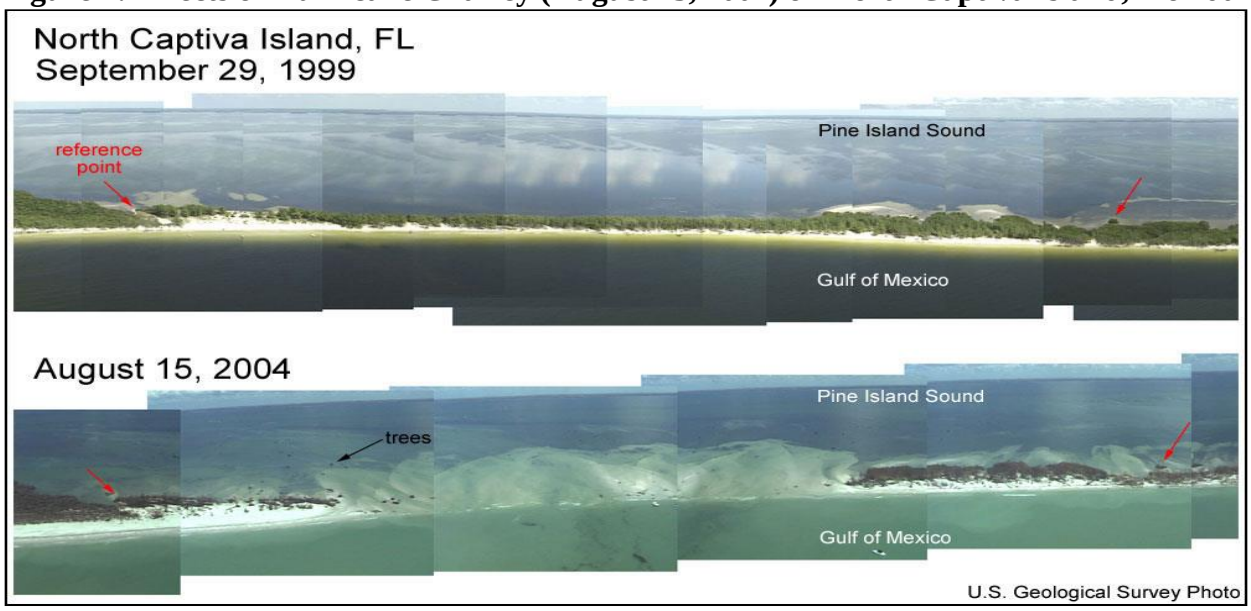
A second key factor that seems to motivate coastal communities to better understand local sea level rise threats relates to whether they have recently experienced a natural coastal disaster (for example, a hurricane, tropical storm, storm surge, or coastal flooding). Such communities may be more open to discussions about future vulnerabilities and adaptation options because the disasters make future sea level rise risks more tangible, particularly where serious economic and environmental damage may have resulted. The experience is likely to increase community concern and attention to a fuller consideration of future risks (Weber, 2010), including coastal risks exacerbated by rising sea levels that will intensify the impacts from coastal flooding, storm surge, and coastal erosion. Post-disaster planning tends to provide a venue for stimulating sea level rise discussions once the emergency nature of the disaster has eased and the focus has shifted to addressing coastal redevelopment and preventing or minimizing future coastal risks.

The correlation between a community's natural coastal disasters and the vigor of their sea level rise adaptation planning suggests that such disasters may be significant factors in helping trigger efforts to incorporate climate-related sea level rise risks and adaptation measures into long-term planning and policy making. For example, Rhode Island began investigating sea level rise adaptation when it experienced unusually frequent and severe flooding in waterfront parks (Goss, 2009). The intensifying flooding provoked authorities to conduct a study of shoreline changes, which found that sea level rise was a large factor in the observed shoreline destruction (Goss, 2009). Rhode Island's Coastal Management Program, following its research on causes of waterfront flooding, adopted some of the earliest sea level rise planning benchmarks of any coastal community in the nation (Rubinoff, el al., 2008).

In Southwest Florida, in 2004, Hurricane Charley's high storm surge and severe shoreline damage (like that experienced on North Captive Island, as seen in Figure 2) helped move coastal authorities in Charlotte Harbor and the City of Punta Gorda, FL, to include longer-range threats to its coastal resilience, including climate change and sea level rise (NOAA, 2010). The research and analysis efforts of the Charlotte Harbor NEP eventually determined that current and projected sea level rise, exacerbated by storm surge, posed a substantial threat to the region's economic success and cultural heritage (CHNEP and SWFRPC, 2009). The resulting vulnerability assessments for the Charlotte Harbor Estuary and City of Punta Gorda following Hurricane Charley produced detailed and comprehensive analysis, including sea level rise risks (CHNEP and SWFPRC, 2010).

In Maryland, the damaging impacts from Hurricane Isabel significantly contributed to building the initial public support necessary for decision makers to take action on sea level rise risks (Johnson, 2010). The hurricane heightened public awareness of storm surge and flooding. This focus, coupled with a conference that the Maryland Department of Natural Resources convened to examine environmental factors that exacerbated Isabel's coastal impact, helped get sea level rise adaptation off the ground on the state-level (Johnson, 2010). Maryland also sponsored initiatives at the county level to apply its robust state adaptation framework and funding commitments (Rubinoff, et al., 2008).

Figure 2: Effects of Hurricane Charley (August 13, 2004) on North Captiva Island, Florida



Source: USGS. Available at: http://coastal.er.usgs.gov/hurricanes/charley/.

Stage 2: Assessing Local Vulnerabilities and Risks

Assessing climate-related sea level rise risks involves evaluating the likelihood that certain actions (including inactions) could lead to losses that the community considers significant and wants to minimize or avoid. Planners, scientists, and community decision-makers often discuss community resilience using the inter-related concepts of threats, vulnerabilities, and risks, which might be distinguished as follows:

- *Threat*: a possible danger or harm;
- *Vulnerability:* a specific weaknesses that makes the threat possible, or in other words the extent to which a community is unable to cope with the damage or harm at a certain point in time; and
- *Risk:* the likelihood a chosen action (including inaction) will lead to some kind of loss.

How a community responds to potential sea level rise risks depends on its analyses of what threats it faces and how vulnerable it is to those threats (NRC, 2011, p. 169). As noted above, the particular economic, environmental, social, and cultural features of a coastal community influence its vulnerabilities and thus are the crucial considerations of this analysis. If the community determines it faces no serious threats or major vulnerabilities, then there may be little or no risk associated with continuing business as usual for the time being, and it may not be necessary to immediately consider adaptive measures.

Taking a risk-based approach to analyzing vulnerabilities requires the use of science. In particular, two specific aspects of future sea level rise require scientific analysis:

- *Projected amount:* the level of sea rise that a coastal community will experience over a planning horizon (e.g., sea levels at 2100), and
- *Projected rate:* the rate at which sea levels will rise, or in other words, the timeframe during which progressively higher levels of rise can be reasonably expected to occur.

The best scientific projections about these two aspects of climate-related sea level rise provide a baseline for identifying local threats, how these threats may change in the future, and key features of the community and its natural environment that may be most vulnerable with time. In economic terms, this risk-based approach uses a form of cost-benefit analysis; the costs of implementing various adaptation options are weighed against their benefits to reducing future risk or damage. Experiences from the case studies reviewed suggest several key operational principles assist vulnerability assessment: l) making best use of existing scientific projections to define threats and risks; 2) using existing tools (e.g., visualization generators, maps, and other planning aids) to build scenarios concerning risks and vulnerabilities over time, as well as response options and their associated economic, social and ecological outcomes; and 3) building in flexibility for changing circumstances and new scientific understandings. The following sections discuss these three operational principles.

Use existing scientific information

Communities and local and state organizations assessing sea level rise vulnerabilities generally start with the latest global or national projections available in official, peer-reviewed assessments from credible scientific institutions. Projections are based on data analyses and climate modeling of two core determinants of global sea level: ocean water temperature (because sea water expands as it warms) and runoff from melting land ice (e.g., glaciers and ice sheets such as those in Greenland and the Antarctic). The two main sources of these projections are: l) periodic assessments of the United Nations Intergovernmental Panel on Climate Change (IPCC), an international, nonpartisan body created in 1988 to monitor scientific knowledge about climate change and its potential environmental and socio-economic impacts; and 2) periodic reports of the U.S. Global Change Research Program (USGCRP), a coalition of thirteen federal departments and agencies working with leading scientific universities and businesses pursuant to

the Global Change Research Act of 1990, which requires national assessments of climate change every several years (for information on USGCRP, see http://www.globalchange.gov).

At the international level, the fourth IPCC Assessment Report (AR4) was published in 2007 and served as the baseline reference for most regional and local scientific research and policy making from mid-2000s to present. Thousands of scientists and officials from over one hundred countries collaborate in IPCC reports. Lead authors of AR4 were awarded the Nobel Peace Prize "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change" (Norwegian Nobel Committee, 2007). Due to insufficient scientific agreement and data on land-ice melt, the 2007 AR4 only used global ocean temperature increases to project sea levels. The Fifth Assessment Report (AR5) began to be released in segments in September 2013. In contrast to AR4, AR5 incorporates data on both ocean warming and melting of glaciers and ice sheets.

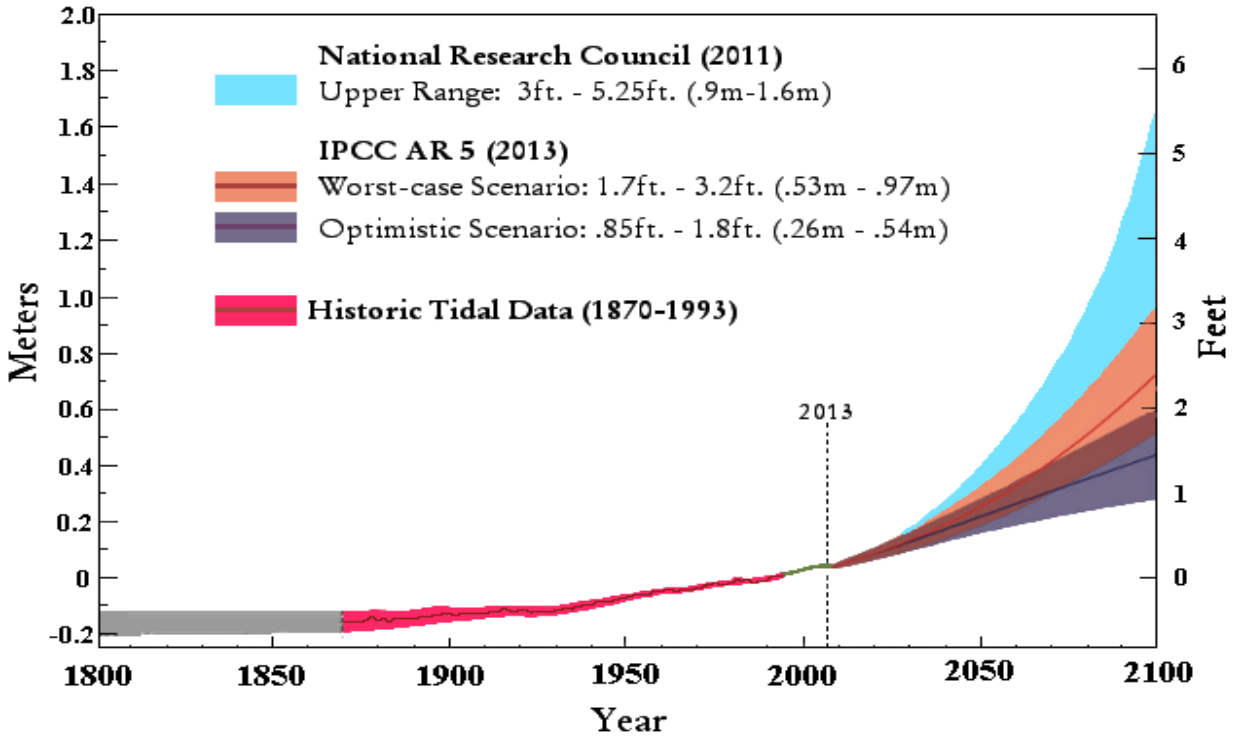
IPCC AR5's sea level rise projections expand the upper range for 2100 from about 2 ft. (the AR4) to almost 3 ft. (AR5). As with prior reports, AR5 outlines several sea level rise scenarios for 2100 based on emissions reductions and other assumptions; it concludes as the ocean warms and glaciers and ice sheets melt, global mean sea level will continue to rise under all scenarios at a faster rate than we have experienced over the past 40 years. It notes with "high confidence" that since the mid-19th century, the rate of sea level rise has been larger than the mean rate during the previous 2,000 years. The most optimistic emissions reduction scenario projects only an additional 10 in. rise, with levels possibly rising a bit more than 3 ft. in the worst case scenario.

The AR5 report's *Summary for Policy Makers* states: "Confidence in projections of global mean sea level rise has increased since the 2007 report because of the improved physical understanding of the components of sea level, the improved agreement of process-based models with observations, and the inclusion of ice-sheet dynamical changes." AR5 concludes it is "virtually certain" global mean sea levels will continue to rise beyond 2100. (Numerous other reports also conclude sea levels will continue to rise long after 2100; see Glecker et al., 2012; Canadell et al., 2007; Mikolajewicz et al., 2007, p. 614-615; Eby et al., 2009.) These findings highlight how coastal adaptation planning is crucial over the long-term (IPCC, 2013).

The latest assessments from the U.S. government generally reinforce these AR5 international findings. In 2011, the National Research Council (NRC) of the National Academy of Sciences released a report entitled "Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia" (NRC, 2011). It incorporates the latest data on ocean expansion due to seawater warming *and* land ice melt, and it reflects the collective scientific understandings of the agencies in the USGCRP. Like AR5, the NRC report follows a scenario approach. Depending on the level of emissions and climate assumptions used, the NRC concludes that global mean sea level rise could be 2 ft. 2 in. - 5 ft. 3 in. by 2100. The NRC's mid-range scenario (2 ft. 11 in. - 3 ft. 3 in.) compares closely to the IPCC AR5 upper-range. The projections from the latest reports of the U.S. government and IPCC are compared in Figure 3.

In addition to these high-profile, comprehensive assessments, individual scientists continue to publish peer-reviewed articles reflecting their latest research on data and climate models of future sea level rise. NOAA, as a lead government agency in the U.S. Global Change Research Program, monitors these publications through its Coastal Services Center for trends and areas of possible convergence that may be useful to communities and practitioners for planning.

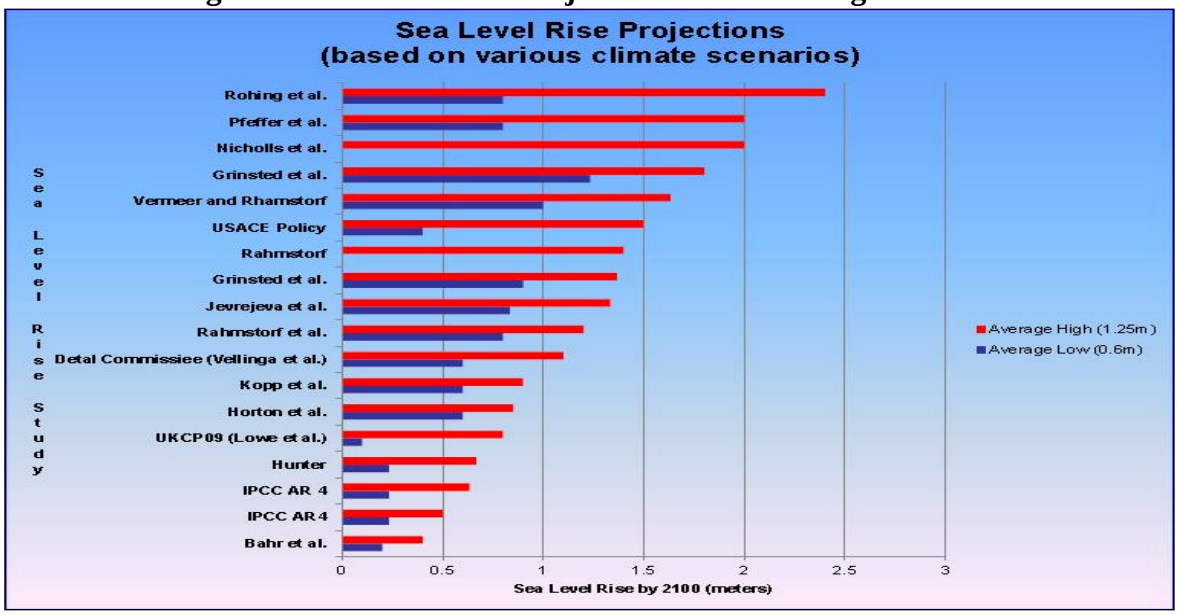
Figure 3: Sea Level Rise Projections of the 2013 IPCC and 2011 NRC Reports



Source: Adapted from the sea level rise projections of the IPCC (2013), NRC (2011), and Masters' (2009) depiction of EPA's historic tidal data.

In recent years, projections being made in such scientific publications seem to be converging around a range of from .6 m for a low-range global sea level rise to roughly a little more than one meter for a high-range of rise by 2100. (Figure 4 shows NOAA's array of projections compiled from recent major peer-reviewed scientific studies (vertical axis).

Figure 4: Sea Level Rise Projections from Leading Scientists



Source: Maucy, 2012 .

Build on available analytical tools to assess local vulnerabilities

NOAA has developed a 'Roadmap' for communities working to adapt to coastal risks and assess their climate vulnerability. Among its guidance, this Roadmap emphasizes the importance of using existing information resources and engaging stakeholders across the community as part of its strategy to assess vulnerabilities (Box 3). Today, most coastal communities, including all coastal communities of Florida, have digitized land elevation data and sea level rise web-based tools developed by NOAA and others to help develop scenarios of different levels of sea rise and areas and services most vulnerable to inundation.

Box 3: NOAA's Climate Vulnerability Assessment Strategy

In their Roadmap for Adapting to Coastal Risk, the NOAA Coastal Services Center recommends that adapting communities use these strategies to conduct vulnerability assessments:

- Engage key staffers and stakeholders in a comprehensive, rapid, local vulnerability assessment
- Use existing information resources to evaluate potential hazards and climate impacts
- Collaborate across disciplines to better understand and plan for impacts
- Identify opportunities for improving resilience to current and future risks
- Engage key staff members and stakeholders in a comprehensive, yet rapid, assessment of local vulnerabilities.

Source: NOAA, 2011.

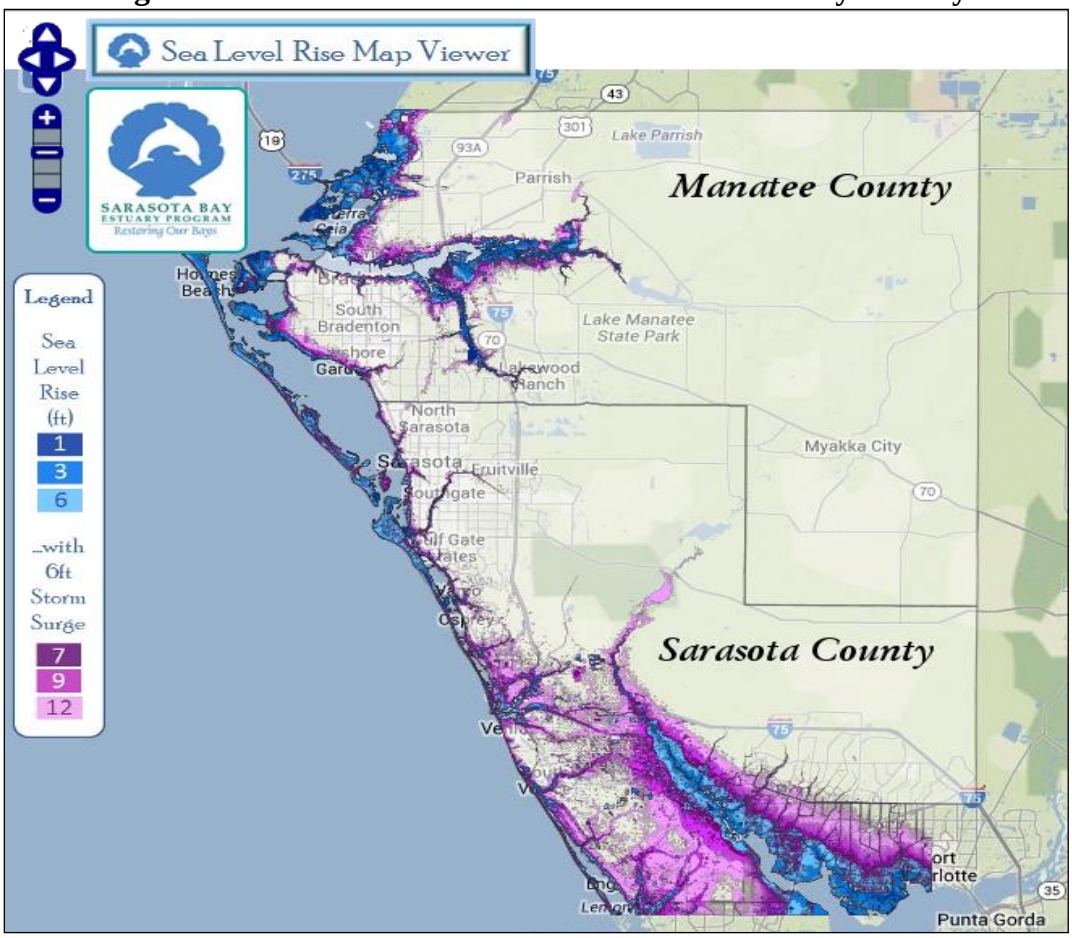
Of the communities reviewed for this project, a common initial approach is to make use of available analytical tools to help stimulate community discussions about key vulnerabilities, priority areas or services for attention, and different adaptation options. Such tools also help communities focus on the importance of using different benchmarks of sea level rise over the near, medium, and long term (called 'planning benchmarks') in order to be able to assess how to best adapt and change with time. Once communities are able to visualize different inundation scenarios, they are usually interested in gathering more information to understand the most critical economic, ecological, and social/cultural impacts as a basis for setting priorities and defining feasible and essential adaptation actions. These operational considerations are discussed below.

Digitized elevation data and inundation scenarios. As of the late 2000s, coastal areas of Florida and most of the Gulf of Mexico have updated digitized land elevation data based on the use of satellite-based Light Detection and Ranging (LiDAR) technology, which is roughly accurate within 6 in. of vertical height. Often managed by county GIS offices, these databases are an essential part of a 'toolkit' for building scenarios for what areas will be most affected by different levels of sea level rise. The LiDAR elevation data provide a valuable tool for communities to explore and discuss impacts of different inundation levels for low, medium, and high sea level rise. Based on this database, visualization tools are increasingly available to help coastal communities and decision-makers see images on a screen showing where flooding and sea level rise are likely to present the most serious risks, particularly in low-lying areas with critical infrastructure (for example, roads, storm water drains) and public services (for example, hospitals, fire stations).

The NOAA Coastal Services Center has developed the main web-tool (called "Sea Level Rise and Coastal Flooding Impacts Viewer"), which is accessible to Florida coastal communities and

the wider Gulf of Mexico. It overlays the latest LiDAR elevation data on coastal landscapes and allows the viewer to manipulate the maps on a sliding scale from 1 to 6 ft. of sea level rise. This online viewer is user-friendly, and readily accessible to the public and technical agencies (available at: csc.noaa.gov/slr/viewer/). Drawing on that approach, in 2011, the Sarasota Bay Estuary Program developed a local, simplified sea level rise web viewer that covers Sarasota and Manatee Counties. This local tool, called the Sarasota Bay Estuary Region, illustrates scenarios of 1, 3, and 6 ft. sea level rise inundation alone as well as the flooding resulting from this inundation combined with 6 ft. of storm surge. (See Figure 5 for a map this tool generated using those scenarios.) This online tool was developed through a project with the EPA Climate Ready Estuary Program and implemented in collaboration with the Marine Policy Institute at the Mote Marine Laboratory. It can be accessed on the Sarasota Bay Estuary Program website (available at: http://sarasotabay.org/slr-web-map/).

Figure 5: Sea Level Rise Web Viewer for Sarasota Bay Estuary



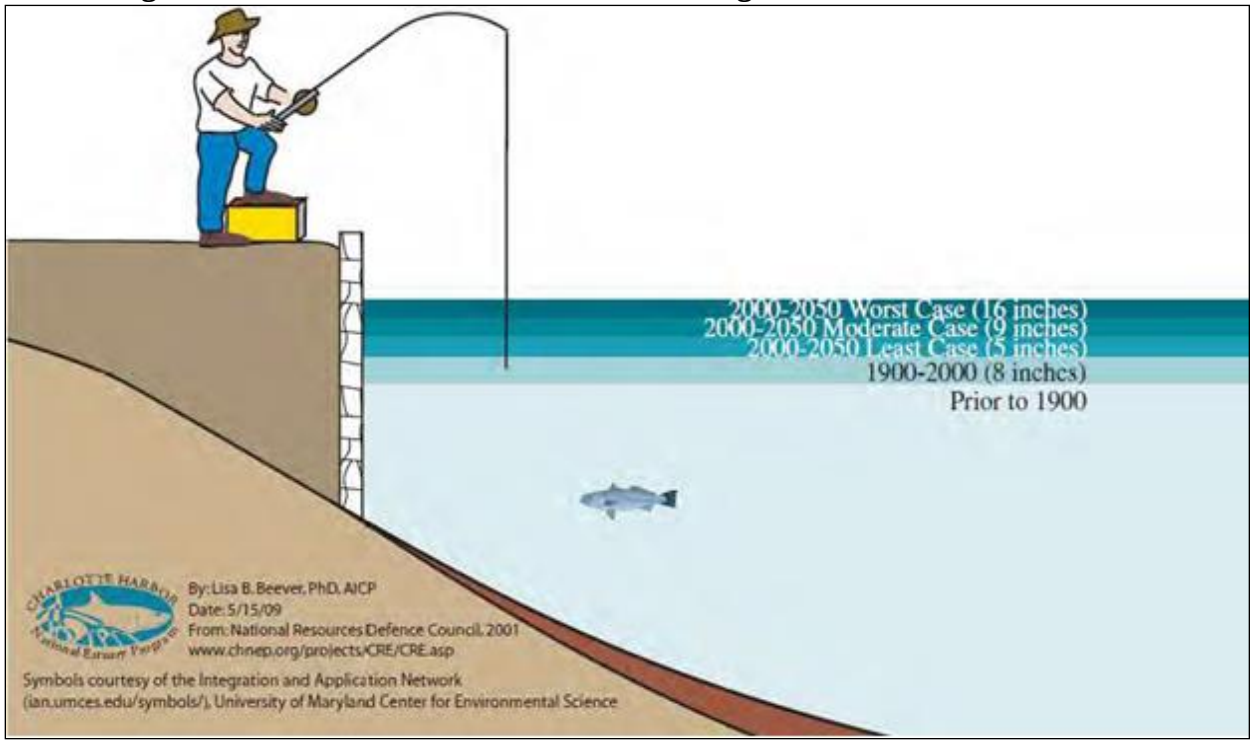
Source: Sarasota Bay Estuary Program Sea Level Rise Viewer, Accessed 20 Sept. 2013.

Sea level rise planning benchmarks. Another aid that communities are increasingly using for adaptation planning is planning benchmarks. This aid reflects interim timeframes for sea level rise projections in planning processes, rather than simply relying only on the projections for 2100 from most climate models. These different timeframes for specific projections are called planning benchmarks. Of the jurisdictions reviewed, many use three planning benchmarks: near-term (for example, 2025-2030), medium-term (for example, 2050-2060), and long-term (for example, 2090-2100). Analysts may use inundation models to establish ranges of rise for

different planning benchmarks. This is particularly important for community planning because public investments may need very differing planning horizons; for example, a major public infrastructure may have a project life of 50 to 75 years, and thus the project developers need a planning benchmark that is more long-term. In much public decision-making, the most relevant immediate benchmark will be relatively near-term (project life of 20-30 years) because that may require the most immediate adaptation and change with respect to local planning and investment.

Vulnerability assessments can provide useful guidance for planning and decision making when they include at least a range (best estimated minimum and maximum) for sea level rise within each benchmark. Like any scientific calculations, the sea level rise projection models rely on assumptions (for example, about changes in global carbon emissions) and have statistically unavoidable uncertainties. As a result, analysts often report sea level rise scenarios as having a certain 'probability'. For example, Charlotte Harbor NEP analysis reported there is a 50% chance the region will experience at least 9.4 inches of sea level rise by 2050; whereas, there is a 90% chance that they will experience at least 5 inches using that same benchmark (CHNEP and SWFRPC, 2009). Such projections would normally be updated as new scientific information becomes available. (See Figure 6 below for their illustration of these scenarios).

Figure 6: Charlotte Harbor NEP -- Illustrating Sea Level Rise Benchmarks



"Worst case" is 5% likely, "Moderate case" is 50% likely, and "Least case" is 90% likely. Source: CHNEP and SWFRPC, 2009.

Planning benchmarks are becoming a common tool for communities to incorporate as part of their adaptation plans and policies for sea level rise. Table 2 below lists examples of planning benchmarks being used by several coastal areas around the country.

Table 2: Examples of Planning Benchmarks in Coastal Areas

Entity	Near-term	Medium-term	Long-term
Southeast Florida Regional Compact on Climate Change Action Plan (SFRCCCAP)	3-7 in. by 2030	9-24 in. by 2060	19.5-57 in. by 2100
Florida Ocean and Coastal Council (FOCC)	-	-	20-40 inches
Charlotte Harbor NEP and Lee County Resilience Strategy	5.1 in. by 2025 (50% likely) 2.8 in. by 2025 (90% likely)	9.4 in. by 2050 (50% likely) 5.0 in. by 2050 (90% likely)	10.4 in. by 2100 (90% likely) 19.8 in. by 2100 (50% likely)
City of Satellite Beach, FL	-	24 in. by 2050 (associated with losing 5% of city's land area)	-
Miami-Dade Climate Change Advisory Task Force	-	18 in. by 2050	36-60 in. by 2100
Broward County Climate Change Action Plan	3-9 in. by 2030	10-20 in. by 2060	24-48 in. by 2100
San Francisco Bay, CA	-	≤16 in. 2050	max. of 55 in. by 2100
Somerset County, MD	2 in. by 2025 (associated with 17 ft. of horizontal coastal erosion)	6 in. by 2050 (associated with 42 ft. of horizontal coastal erosion)	12 in. by 2100 (associated with 92 ft. of horizontal coastal erosion)
New York City (Hudson Valley & Long Island)	2-5 in. by 2020s 5-10 in. (rapid ice melt)	7-12 in. by 2050s 19-29 in. (rapid ice melt)	12-23 by 2080s 41—55 in. (rapid ice melt)

Sources: From top to bottom: SFRCCCAP adopted projections from US Army Corps of Engineers, 2009; FOCC, 2010; CHNEP and SWFRPC, 2009 and Beever et. al, 2010; recommended by Parkinson and McCue, 2011; findings in MDCCATF, 2008; Broward County Action Plan, 2010; adopted in resolution of San Francisco BCDC, 2011; recommended by strategy from MDDNR, 2008; NYSSLRTF, 2010.

Some studies seek to identify the "tipping point," or time by which the negative impacts of sea level rise (or risks) become too costly to mitigate or become irreversible unless the community takes measures to adapt beforehand. Establishing a tipping point can help policymakers and planners determine how soon adaptation measures should be implemented based on when the damage from sea level rise exceeds the costs of preventative adaptation or physically prevents adaptation altogether. For example, the vulnerability assessment for the City of Satellite Beach, FL, estimated the first 2 ft. of rise (expected by 2050) will only submerge 5% of the city, whereas subsequent rise (4 ft. total rise expected by 2100) will submerge 20% of the city's area and significant elements of its critical infrastructure. Thus, starting after 2 ft. rise, land loss rapidly accelerates. The assessment concluded this "tipping" point will occur by 2050, and thus the city has 40 years to implement adaptation measures before land and infrastructure loss becomes impossible or very costly to mitigate (Parkinson, 2011).

Risk-based analyses of economic, environmental, and social/cultural impacts. A third important operational consideration for sea level rise vulnerability assessments is multi-faceted risk analysis. The scope should cover existing and projected risks to the main elements of a

community's livelihood and values, including its economic, environmental and social/cultural aspects. Inundation visualization tools and planning benchmarks are relevant tools for assessing vulnerabilities in these three crucial aspects. Using planning benchmarks, the analyses have a framework for identifying priority economic, social, and ecological vulnerabilities and ranking the associated risks posed with time according to different sea level rise scenarios. In this process, it is important to start with *existing* coastal risks and then overlay how sea level rise will exacerbate them. For example, many communities vulnerable to tropical storms would consider how future sea level rise could magnify storm surge over time.

It also is important to consider new coastal risks created by sea level rise. For instance, as seas rise and coastal areas are submerged or otherwise impacted (e.g., changing salinity in tidal streams, saltwater intrusion into groundwater), businesses, coastal ecology, public infrastructure, cultural heritage, and overall economic values may be threatened or changed. This means that vulnerability assessments may focus broadly on different types of risks, or more narrowly on specific priority areas of concern. For example, the Charlotte Harbor Vulnerability Assessment examined an array of climate-related risks beyond sea level change, including changes in precipitation and extreme weather events (CHNEP and SWFRPC, 2009). In contrast, one assessment of Virginian coasts concentrated on the vulnerability of shallow tidal habitats (Bilkovic et al., 2009). In Maryland, Anne Arundel County conducted a vulnerability assessment specifically on its cultural resources (Sperling et al., 2010).

Economic vulnerabilities seem especially persuasive in building support for adaptation action. For example, the San Francisco Bay vulnerability assessment estimated that if unaddressed, the impacts of sea level rise will total $62 billion by 2100; the assessment concluded that if the region's sea level rise went unaddressed, 330 square miles of land would be vulnerable to inundation damage and the coastal regions would have a 98% heightened vulnerability to periodic flooding (San Francisco BCDC, 2012). To the extent possible, a key component of any vulnerability assessments is using the best available estimates of economic costs associated with different levels of rise and their corresponding damage to natural and built infrastructure, recreation, development, and other business opportunities.

Build in flexibility to tailor approaches

The case studies also suggested approaches for assessing vulnerability and adaptation options will vary as they are tailored to what is feasible and preferred. Flexibility allows communities to respond to changing conditions, new scientific information, and new opportunities.

Many communities employed research organizations to develop their assessments at the technical stage. Communities have a range of options here, from NEPs, government units, private consultants, nonprofit marine research centers, or university-affiliated institutions. Local municipalities (for example, in some Maryland cases) often use environmental consulting firms, suggesting that consultants are useful where there is not an ongoing need for risk-assessment capacity. Government units tend to focus on identifying state- or multistate-level vulnerabilities. For example, the U.S. Geological Survey produced the assessment of the northern Gulf of Mexico. Assessments published by university affiliates seem to focus on specific types of vulnerabilities, such as cultural (for example, the College of William and Mary's assessment for Virginia coasts) or ecological vulnerabilities (for example, the assessments of New Jersey coasts

completed by researchers at Rutgers and Princeton). Table 3 below lists several jurisdictions whose various vulnerabilities were assessed.

Table 3: Examples of Vulnerability Assessments

Type of Org.	Name of Organization	Assessment title	Jurisdiction(s) Assessed
National Estuary Programs (NEP)	Charlotte Harbor NEP (working with SWFRPC)	Charlotte Harbor Regional Climate Change Vulnerability Assessment	Charlotte Harbor, FL
	San Francisco Estuary Partnership (an NEP)	Vulnerability Assessments in Support of the Climate Ready Estuaries Program	San Francisco Estuary
Government Departments/ Agencies	DE Coastal Management Program (Department of Natural Resources and Environmental Control)	Preparing for Tomorrow's High Tide: Sea Level Rise Vulnerability Assessment for the State of Delaware	Delaware Coasts
	U.S. Geological Survey	Coastal Vulnerability Assessment of the Northern Gulf of Mexico to Sea-Level Rise and Coastal Change	Coastline from Galveston, TX, to Panama City, FL
	Gulf of Mexico Alliance, NOAA, Gulf Landscape Conservation Cooperatives, and USGS	Gulf Coast Vulnerability Assessment	Gulf Coast Ecosystems
	San Francisco Bay Conservation and Development Commission	Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline	San Francisco Bay, CA
	Southwest Florida Regional Planning Council	Lee County Climate Change Vulnerability Assessment	Lee County, FL
Consulting Firms	RWParkinson Consulting, Inc. (funded by the Indian River Lagoon NEP)	Assessing Municipal Vulnerability to Predicted Sea Level Rise: City of Satellite Beach, Florida	City of Satellite Beach, FL
	CSA International, Inc.	Sea Level Rise Response Strategy for Worcester County, Maryland	Worcester County, MD
	URS & RCQuinn Consulting, Inc.	Rising Sea Level Guidance for Somerset County	Somerset County, MD
University Affiliates	Princeton University	Future Sea Level Rise & the New Jersey Coast	New Jersey Coasts
	Virginia Inst. of Marine Science of the College of William & Mary	Vulnerability of Shallow Tidal Water Habitats in Virginia to Climate Change	Virginia Shallow Tidal Water Habitats
	University of Washington	Uncertain Future: Climate Change and Its Effects on Puget Sound	Washington Puget Sound Region
	Rutgers University and the American Littoral Society	Vulnerability of New Jersey's Coastal Habitats to Sea Level Rise	New Jersey Coastal Habitats

As a variation on Stage 2, some communities choose to identify policy options for adaptation as part of the vulnerability assessment process rather than during Stage 3 discussed below. This alternative approach seems to be particularly attractive when the assessed area is small and the assessing organization has the capacity both to conduct scientific review and analyze policy options. For example, Lee County simultaneously published its Climate Change Vulnerability Assessment and a separate document (its Resilience Strategy) presenting specific language recommendations for the county comprehensive plan. Some National Estuary Programs have used a variation of this strategy, identifying vulnerabilities and specific 'response needs', though not identifying or recommending response options. By assessing vulnerability and response options in the same step in adaptation, communities may be able to expedite the adaptation process.

Also, the scope of assessments will vary among jurisdictions. While some limit their focus to sea level rise, others evaluate sea level rise impacts as part of a comprehensive analysis of overall climate-related risks, such as drought, extreme weather events, floods and other vulnerabilities. Climate vulnerability assessments require more resources than those that just focus on sea level rise, and they therefore generally study coastal regions that are large (such as the Puget Sound Region in Washington State) and overlap jurisdictions (such as the assessments of the Charlotte Harbor NEP and the forthcoming Gulf Coast Vulnerability Assessment).

Stage 3: Developing an Adaptation Plan

Once a coastal community or region has assessed its sea level rise vulnerabilities and risks, the next step involves deciding the responses needed and developing a plan to implement those responses so the community or region can adapt and build resilience. As with the other stages, local leadership often directs and guides this process. Several coastal communities across the United States are already taking concrete planning and policy actions for sea level rise adaptation. The discussion now turns to early lessons about the policy tools and common planning steps communities are applying at this stage.

Early lessons for adaptation planning

Consider the broad nature of adaptation needs. In scientific and policy literature, the concept of 'adaptation' for sea level rise and climate risks in general has evolved to emphasize two dimensions that need attention:

- **Natural systems resilience:** the ability of environmental relationships and elements to avoid and recover from damage from threats. For example, this could include—with respect to coastal tidal areas, wetlands, beaches and coastal vegetation—removing hard shoreline protections or other barriers in order to allow these natural systems to naturally migrate inland as sea rises. Facilitating natural systems resilience can also include protecting inland areas that eventually could provide future habitats ("retreat refuges") for endangered, threatened, or economically important species whose current coastal habitat areas will become submerged.
- **Human systems resilience:** protecting human systems (particularly the "built environment", such as roads, homes, business buildings) could include such measures as protecting important economic, social, and cultural areas and relationships; taking

measures to redesign and accommodate critical coastal facilities such as infrastructure which may need to continue in high-risk sites; and identifying inland areas away from vulnerable coastal sites from which public services, businesses, and residences can move or be built anew.

Use mix of policy tools. To thoroughly cover these broad dimensions of adaptation, experts stress that a mix of policy measures need to be available. In a nutshell, the three most commonly-cited adaptation options are *protect*, *accommodate*, and *planned retreat* (IPCC, 2007d; Deyle et al., 2007; Titus et al., 2009; Nichols et al., 1995). Even within a community, different areas will have different vulnerabilities conducive to different options. In other words, the policy mix will typically include some measures to fully protect essential services or high-value sites, other measures that make some accommodation by redesign to reduce risk for the service or structure in order to be able to remain at least over the near-term (for example, buildings on stilts), and other measures that involve retreat-relocation or removal of the structure completely because the cost of protecting against risk is not worth the benefits. All measures need to be grounded in science-based information and have community support and involvement, backed up by policies and programs that provide the needed authority and capacity for implementation.

A variety of practical policy tools commonly are available to help communities advance and sustain sea level rise adaptation. These include adding actionable measures to formal policies based on agreed-upon planning benchmarks; disseminating planning tips and guidelines; and launching educational initiatives, community and media outreach, and voluntary campaigns. In addition, public participation in this process is essential to developing plans that are economically and politically feasible as well as technically and scientifically sound.

Many publications explore and elaborate on these kinds of tools, sometimes as part of 'adaptation policy toolkits' published by university research centers, EPA's Sea Grant programs, NOAA, and others (see Useful Websites list). These publications can serve as useful guides for local use. For example, in 2009, the Marine Policy Institute undertook an assessment and published an analysis of sea level rise adaptation policy tools available for local governments of Florida, particularly to Sarasota County (Lausche, 2009). The report, entitled *Synopsis of an Assessment: Policy Tools for Local Adaptation to Sea Level Rise*, is available on MPI's website at: www.mote.org/mpi. As another example, the *Hawaii Coastal Hazard Mitigation Guidebook* has been used as a "reference manual" for sea level rise adaptation efforts in areas such as Kailua Beach (Hwuang, 2003).

Start with what is feasible and do transition planning. Plans and policies for sea level rise adaptation need to be promoted and developed giving attention to what is politically and economically feasible. This generally means taking small, achievable steps and including transitional planning and periodic review to accommodate changing circumstances and flexibility to incorporate new scientific information. An EPA review of experiences from its national estuary programs in the Climate Ready Estuary project found that linking adaptation planning to existing, well-established processes can increase credibility of the planning effort (Box 4).

Box 4: Lessons from Adaptation Planning in EPA's Climate Ready Estuary Projects

An 2010 EPA review of planning efforts for sea level rise adaptation in several national estuary programs found a number of common lessons that help start and sustain the adaptation process:

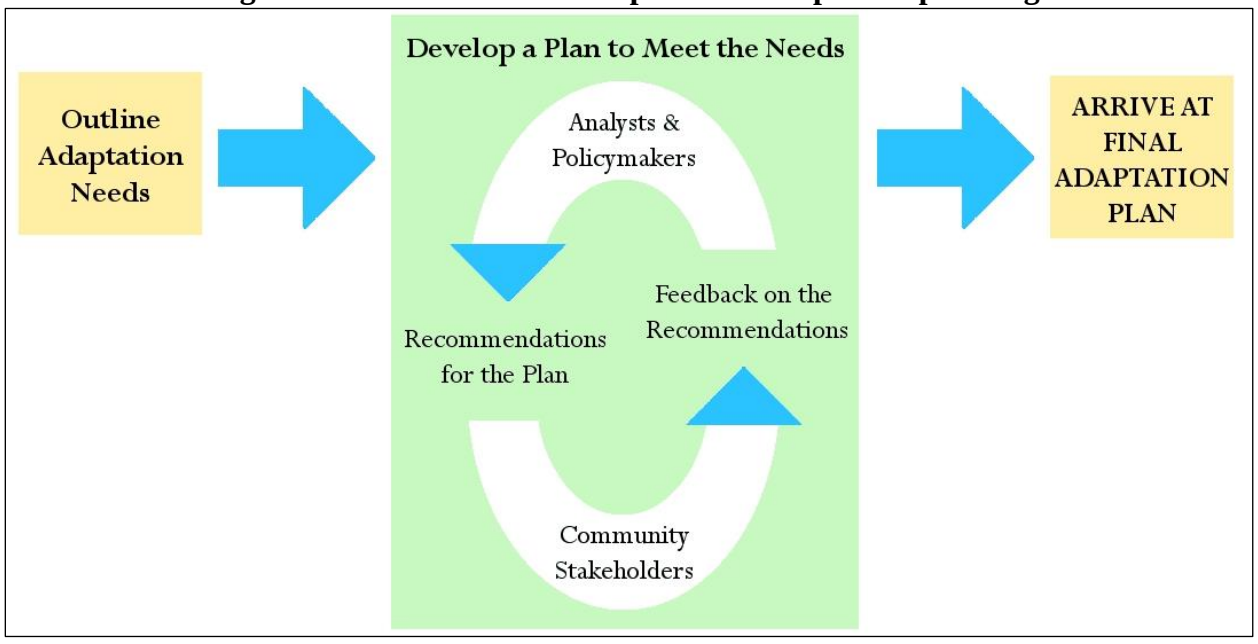
- *Start small.* Developing an adaptation plan for one community can garner interest in developing plans for larger regions.
- *Build adaptation planning into existing local, state, and/or federal planning efforts.*
- *Incorporate adaptation into restoration efforts already underway.*
- *Recognize that small steps do lead to future progress.*
- *Practice adaptive management.* Since adaptation planning is a fledgling process in many communities, planners will have to refine their work and re-evaluate their approach as new experiences are gained and partners join adaptation efforts.

Source: EPA, 2010, pg. 19.

Phases of decision making

Experiences from jurisdictions advanced in adaptation planning suggest that the decision-making process typically involves three interactive phases. As illustrated in Figure 7, these phases are: 1) the formal decision to develop a plan that addresses certain needs, as well as the set of decisions needed to authorize and provide resources for drafting the actual plan; 2) developing the plan through a participatory process for technical and public input and review; and 3) the decisions for adopting the final draft with all the associated policy, institutional, and resource support needed for its implementation.

Figure 7: Three main decision phases of adaptation planning



Defining adaptation needs and priorities. A preliminary step for developing an adaptation plan is to determine what the adaptation plan needs to accomplish. This often includes agreeing upon high-risk areas and priorities for adaptation and agreeing upon preliminary sea level rise planning benchmarks. Adaptation needs are drawn from the vulnerabilities identified in Stage 2

of the adaptation process. This step commonly involves leadership and key community and business interests agreeing to take the next step.

Basic guiding concepts may influence and focus the resulting strategy. For example, communities which have NEPs taking a technical lead in helping prioritize adaptation needs may particularly stress strategies to preserve natural features of the coastal areas (such as estuaries, dune systems, beaches, tidal streams, etc.). Communities with valuable cultural or historic sites along their coasts may give special attention to protection strategies and maintaining some specialized infrastructure to preserve those resources on their sites while ensuring public safety.

Goals and actions seem to be central elements of adaptation needs. FEMA describes goals as guidelines that explain what the planning entity wants to accomplish; actions are general clarifications of how measures will be implemented to achieve the goals (FEMA, 2002). It seems that a majority of outlines for adaptation needs do not include actions. However, some communities (such as Hawaii) use broad action needs to further guide this process. Together, goals and actions can focus a community's search for suitable adaptation strategies, policy, and planning tools. Table 4 lists examples of concepts that adapting communities are using to guide adaptation planning.

Table 4: Examples of Guiding Concepts for Developing Adaptation Plans

Coastal Community	Selected Guiding Concepts
Lee County, FL	Flexibility at an individual, organizational, and systemic level A multi-faceted skill set, including comprehensiveness, detail-orientation, quick decision-making, resourcefulness, innovation and diligence Redundancy of processes, capacities, and response pathways within a system Planning and foresight to prepare for identified impacts and risks. Diversity and decentralization of planning, response, and recovery activities. Plans for failure so that break-downs happen gracefully, not catastrophically
San Diego Bay, CA	Understanding of the need for adaptation policies that are effective and flexible enough for unpredictable circumstances. Assurance that climate change adaptation strategies are coordinated with local, state, national and international efforts to reduce GHG emissions. Priority for adaptation strategies that initiate, foster, and enhance existing efforts to improve economic and social well-being, public safety and security, public health, environmental justice, species and habitat protection, and ecological function.
Worchester County, MD	Political and economic feasibility, consistency with community vision Legal authority, institutional feasibility, demonstrated effectiveness, equity Estimated benefits outweigh estimated costs Minimizing of opportunity costs Positive or neutral environmental impact
Hawaiian Islands	Encourage balanced economic, social, community, and environmental priorities Promote a diversified and dynamic economy Encourage respect for the host culture Meet the present needs without comprising the needs of future generations Consider the principles of the ahupua'a system (a traditional Hawaiian land use division extending from the uplands to the ocean) Emphasize that all have the responsibility for achieving a sustainable Hawai'i

Sources: Beever et al., 2012; Hirschfeld and Holland, 2012; CSA International, Inc., 2008; Hawaii State Law, 2011.

Developing the draft plan and engaging stakeholders. This component involves identifying experts to analyze technical issues and develop preliminary recommendations on adaptation tools and strategies that address the most high-risk areas and adaptation priorities. Typically, the draft will propose or use already accepted planning benchmarks and involve expert and stakeholder input throughout. The experts charged with preparing the plan may be drawn from many different sources. The task may be delegated to in-house government analysts, as occurred in San Francisco; university affiliates, as is occurring in New York with Columbia University; outside consultants, as occurred in several Maryland counties; to a public process, as occurred in the City of Punta Gorda, FL; or to other organizations with the necessary capacities (EPA, 2010; 2012). An important prerequisite is that the experts chosen have an experienced working knowledge of the community or region's economic, political, environmental, and social features that require adaptation attention.

In this decision phase, some approaches involve the local community in identifying and testing the set of initial recommendations. For example, the Charlotte Harbor NEP used its website and newsletter to elicit from the public preliminary ideas for recommendations for Punta Gorda's adaptation plan; then, CHNEP worked with the University of Florida Levin College of Law to develop the initial wording of those recommendations (NOAA, 2010). Another approach is to develop the first draft in house with technical staff, as occurred in San Francisco. In either case, draft policy recommendations are the result of this part.

A helpful input to this process is an analysis of existing and needed adaptation capacities within the government and community. For example, Maryland's statewide adaptation initiative included an inventory of existing capacities and capacities that need to be expanded in order to ensure that the adaptation plan addresses gaps and avoids creating redundant capacities. Once the community's capacity and resources to carry out adaptation actions has been determined, planners and technical staff can focus on the set of existing or strengthened policies for sea level rise adaptation that best fits the governance structure.

Finalizing and adopting the plan. Engaging stakeholders in public hearings, public comment periods, and other venues helps policymakers and government staff further develop and refine the recommendations. It ensures that policymakers, analysts, and stakeholders from the community at large exchange comment on the recommendations and balance interests. Draft recommendations are revised to respond to public feedback and then returned to the community for further comments. This step may involve many cycles of review and comment on subsequent drafts to find a scientifically-based and politically and economically feasible strategy. For example, the San Francisco Bay Conservation and Development Commission (BCDC) held 36 stakeholder engagement sessions before it finalized and formally adopted a sea level rise adaptation resolution in October 2011. The BCDC staff began developing the text of the new regulations in November 2008. From then until September 2011, the BCDC staff continued to refine the language based on feedback from extensive dialogue with all stakeholders, including local governments, business interests, environmental organizations, and the public. The City of Chula Vista, CA, similarly held 11 outreach meetings through 2009 and 2010 to refine their sea level rise policy. The city sent e-mails and newsletter notices inviting community stakeholders to attend these meetings and give feedback on the draft plan. (See the MPI website (www.mote.org/mpi) for details on how these two communities developed and adopted their sea level rise policies.) In these and other communities moving toward this stage of the adaptation

process, community feedback came from coastal residents, environmental organizations, businesses, technical experts, and others who feel they have a stake.

This stage's goal is for stakeholders and policymakers to reach consensus on which policy tools should be used, how the adaptation plan's text should be worded, and how it should be formally implemented. Along the way, the consensus building process has presented some communities with challenges. In several communities, some coastal residents voiced strong economic and social concerns about action that could limit shoreline development permitting or change coastal zoning and management policy in ways that limit their freedom of property use. Building support and testing political, economic, and social feasibility of a proposed plan in terms of its mandatory or advisory functions may become an important part of the process of community involvement and building consensus.

The process of developing local sea level rise policy culminates when relevant elected officials formally adopt the finalized strategy, its recommendations, and resource commitments as official policy. This can involve adopting a resolution, ordinances, revisions or additions to existing policy, or other formal policy statements. Additional lessons about this process will likely emerge as more communities pursue adaptation initiatives and experience is gained. Throughout, understanding other communities' adaptation experiences can guide local leaders seeking to begin to take steps toward protecting their coastal communities from the rising seas.

Useful Websites

Government websites

EPA Climate Change Website, http://www.epa.gov/climatechange/.
Florida Climate Center and the Office of the State Climatologist, http://climatecenter.fsu.edu/.
Florida Sea Grant Climate Change and Sea Level Rise resources, https://www.flseagrant.org/climatechange/sea-level-rise/.
Gulf of Mexico Alliance Website, http://www.gulfofmexicoalliance.org/index.php.
IPCC main website, www.ipcc.ch.
NASA Global Climate Change Website, http://climate.nasa.gov/.
NOAA Coastal Services Center, http://www.csc.noaa.gov/.
NOAA State of the Coasts Website (presents information on national and state level coastal vulnerability), http://stateofthecoast.noaa.gov/vulnerability/.
Southeast Florida Climate Change Regional Compact Website, http://southeastfloridaclimatecompact.org.
U.S. Geological Survey's Climate and Land Use Change Website, http://www.usgs.gov/climate_landuse/.
U.S. Global Change Research Program, http://www.globalchange.gov/.

Scientific and scholarly organizations' websites

Georgetown Climate Center Website (which has policy toolkits and tracks climate change research and legislation), http://www.georgetownclimate.org/.
Marine Policy Institute at the Mote Marine Laboratory Website, www.mote.org/mpi.
National Academy of Sciences Climate Change Website, http://nas-sites.org/americasclimatechoices/.
Yale Project on Climate Change Communication Website (provides up to date information on public opinion of climate change and adaptation policy), http://environment.yale.edu/climate-communication/.

Websites for specific tools

Climate Change Adaptation Knowledge Exchange (library of case studies and hundreds of adaptation publications), www.cakex.org.
Georgetown Climate Center's Adaptation Clearinghouse (search engine for 1000+ adaptation documents), http://www.georgetownclimate.org/adaptation/clearinghouse.
IPCC assessments and data online library, http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml.
NOAA Online Sea Level Rise Viewer, http://www.csc.noaa.gov/digitalcoast/tools/slrviewer.
Sarasota Bay Online Sea Level Rise Viewer, http://sarasotabay.org/slrmap/slrmap_viewer.html.
South Florida Regional Planning Council Climate Change Community Toolbox, http://www.sfrpc.com/climatechange.htm.
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