Examples of Methods and Tools for Coastal Resilience Assessments

Introduction: Approaches for assessing coastal resilience have been termed as either "Bottom-Up" or "Top-Down" (Link et al. 2015).

- **Bottom-Up** assessments are typically based on direct input from local communities and utilize anecdotal information, experience, and expert judgment in addition to available data. Results from Bottom-Up assessments are intended for use by the community to identify vulnerabilities and build capacity to respond and recover. These results are generally not transferable to other locations and often are not broadly shared with others because of the proprietary and subjective nature of results.
- **Top-Down** assessments typically have a larger spatial domain and are externally generated using regional, state and local data sets. Top-Down results can be utilized to intercompare regions, understand implications of policy, and engage stakeholders. Ideally Bottom-Up results would be utilized in Top-Down assessments; however, non-uniformity of applications, proprietary considerations and the subjectivity of Bottom-Up results have limited aggregation (Link et al. 2015).
- **Resources** are also discussed; these can provide data and general understanding for both types of assessments.

This summary provides examples of both Bottom-Up and Top-Down methods as well as Resources available for understanding and assessing coastal resilience. The intent is not to include all available tools and data sources, but rather provide examples to lend understanding and lead the reader to more exploration.

Bottom-up Community Evaluations

1. **Coastal Resilience Index** (CRI) (Sempier et al. 2010) - Mississippi – Alabama Sea Grant Consortium. http://masgc.org/coastal-storms-program/resilience-index
    a. Summary: The CRI assessment can be utilized by communities to examine how prepared they are for storms and storm recovery. To complete the CRI, community leaders apply the tool in a guided discussion about their community's resilience to coastal hazards.
    b. Purpose:
        i. Provides a simple, inexpensive method for community leaders to perform a self-assessment of their community's resilience to coastal hazards.
        ii. Identifies vulnerabilities a community may want to address prior to the next hazard event.
        iii. Guides discussion within a community, not intended for comparison between communities.
    c. CRI Details:

i. Uses information that is readily available as well as community input.

ii. Has eight pages and includes six sections (critical facilities and infrastructure, transportation issues, community plans and agreements, mitigation measures, business plans and social systems).

iii. Asks mainly "yes" or "no" questions; CRI rating is determined by number of "yes" responses.

iv. Can be completed in less than three hours.

d. Applications:

i. 49 Gulf of Mexico communities.

ii. Effectiveness of CRI applications have been reviewed by Mississippi-Alabama Sea Grant http://masgc.org/impacts/article/community-resilience-index-improves-preparedness-of-coastal-municipalities-

2. **Community Rating System** (CRS) – Federal Emergency Management Agency (FEMA), National Flood Insurance Program (NFIP) - http://www.fema.gov/media-library-data/1395661546460-d6859e8d080fba06b34a6f1a4d0abdba/NFIP_CRS_March%202014%20508.pdf

a. Summary: The CRS is a voluntary program for communities to receive a discount on flood insurance premiums if they meet the minimum NFIP standards.

b. Purpose: Reduce the potential for flooding damage to vulnerable properties, encourage comprehensive floodplain management within communities, and ultimately reduce flood insurance premiums.

c. Details: The CRS uses class ratings from 9 to 1, with communities entering the program at a CRS Class 9. Advancement into lower CRS Classes reduces flood insurance premiums by 5 percent for properties in Special Flood Hazards Areas (SFHA). A community can receive points to advance Classes by disseminating public information, providing mapping and regulations, reducing flood damage, and providing warnings and response. CRS specialists can help communities to apply the program.

d. Applications: 1,296 communities and 3.8 million policyholders (FEMA 2014) participated in the CRS as of 2014.

3. **Community Resilience System** (CRS) – Department of Homeland Security (DHS) - www.resilientus.org/recent-work/community-resilience-system

a. Summary: The CRS is a web-enabled process that helps communities evaluate their resilience to a range of environmental, physical and economic threats, and establish the necessary actions to improve overall resilience.

b. Purpose: Engages members providing community services and stakeholders in a systematic approach towards visioning and action planning for resilience. Community services provide essential functions for the community, and help

define the capacity to function and meet needs of residents. Eighteen community services are identified, including economic (financial resources, workforce); infrastructure (public safety, energy, water, natural environment); and social (public health, education, arts, entertainment, and recreation).

c. Details: Contact DHS to initiate CRS, info@resilientUS.org

d. Applications: Applied to 7 communities: Anaheim, CA; Anne Arundel County and Annapolis, MD; Charleston and Tri-County Area, SC; Gadsden, AL; Greenwich, CT; Mississippi Gulf Coast, MS; and Mount Juliet, TN.

4. **Communities Advancing Resilience Toolkit** (CART) © - University of Missouri, Terrorism and Disaster Center, National Child Traumatic Stress Network - http://tdc.missouri.edu/cart.shtml ; http://www.oumedicine.com/psychiatry/research/terrorism-and-disaster-center/interventions/community-resilience-(cr)

   a. Summary: Engages community and stakeholders in a process of surveys, meetings, and strategy development and implementation to evaluate resilience to a range of adverse conditions.

   b. Purpose: Builds upon communication, learning and collaboration of community stakeholders to solve problems with local assets. Specific activities within CART foster communication (discussions to combine skills and knowledge to achieve better outcomes); learning through interactions; and consensus and implementation of common goals.

   c. CART Details: Addresses four interrelated sectors of a community that affect resiliency: Connection and Caring (shared values, support systems, diversity, etc.); Resources (natural, physical, financial, human, social); Transformative Potential (data collection, analysis, skill building); and Adversity (e.g., disaster management, terrorism, violence, recession, etc.).

   d. Applications: not known; see http://www.ncbi.nlm.nih.gov/pubmed/24180095 .

5. **Resilience Matrix (RM)** – US Army Corps of Engineers (USACE) - Fox-Lent et al. (2015), http://link.springer.com/article/10.1007/s10669-015-9555-4

   a. Summary: The RM is a facilitated, screening-level assessment that uses community expertise to characterize the community's capacity to address the four stages of resilience (prepare, absorb (or resist), recover, and adapt) across four system domains: physical (infrastructure and features), informational (data collection and dissemination), cognitive (decision-making and governance), and social (citizens, social networks) (Figure 1).

Figure 1. Performance scores for housing (dark=greater capacity; light=lower capacity) (Fox-Lent et al. 2015)

b. Purpose: The 16-cell RM collectively describes functionality of a complex system that is exposed to various types threats. Through application, community members may realize gaps in capabilities and identify opportunities to partner with other agencies and organizations. Applications can be repeated at later times to assess progress and changing conditions.

c. Details: Community leaders, together with representatives from federal, state, and local agencies and organizations, collectively assess a community's capacity to perform in each cell of the RM.

d. Applications: In past studies, the RM has been completed via facilitated discussions, including Rockaway Peninsula, NY (Fox-Lent et al. 2015), and Mobile Bay, AL (in preparation).

Top-Down Community Evaluations

1. **Baseline Resilience Indicators for Communities** (BRIC) - Hazards & Vulnerability Research Institute at the University of South Carolina

   a. Summary: A framework for assessing the inherent resilience of an area of community that does not considering the vulnerability of an area to a particular hazard. BRIC examines available data for an assessment of 6 broad categories: ecological, social, economic, institutional, infrastructure, and community competence (Figure 2; http://webra.cas.sc.edu/hvri).

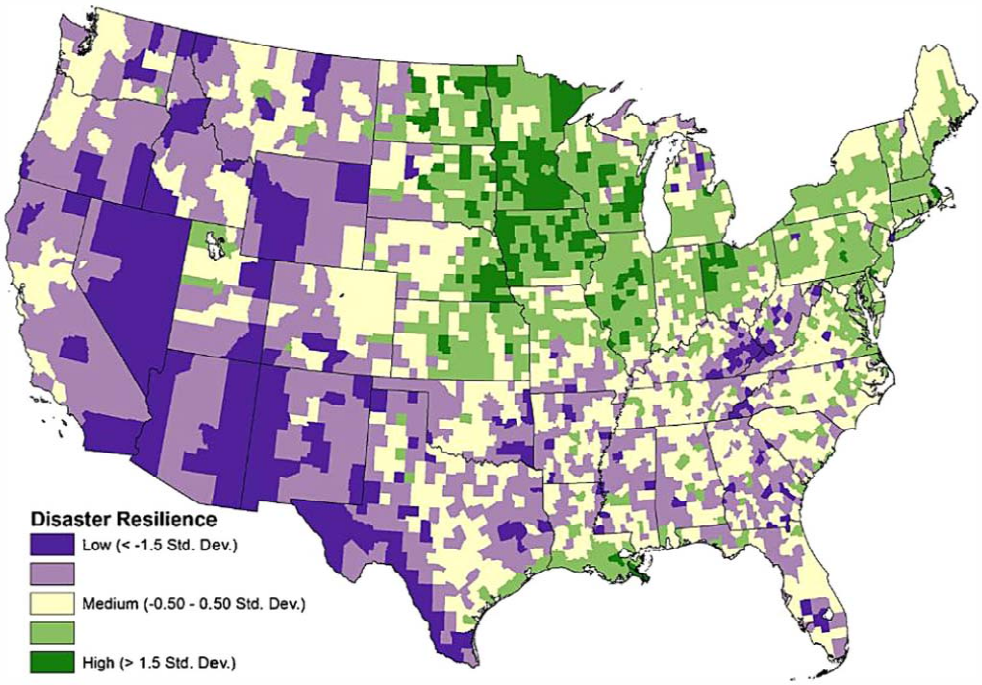

Fig. 1. Disaster resilience index for the contiguous United States, 2010.

Figure 2. BRIC values for the US in 2010 (Cutter et al. 2014). *The average value of the BRIC was 3.18, with a standard deviation of 0.37, a minimum value of 1.67 (least resilient) and a maximum value of 4.39 (most resilient). In this figure, the BRIC scores were classified using standard deviations into five categories for visualization purposes.*

b. Purpose: Utilizes existing data as proxies for resilience that are summed with equal or different weighting to create an aggregated resilience index.

c. Details: Data include ecological (greenspace, 100-year flood-plain, wetlands, and soil erosion); social (race, education, doctors, elderly, crime); economic (housing, homeowners, employment, household income, businesses); institutional (hazard mitigation plan, National Flood Insurance Policies per housing units, expenditures for emergency management); infrastructure (mobile homes, medical capacity, new building permits, evacuation potential, age of housing); and community competence (political fragmentation, disaster experience, social capital, debt/revenue).

d. Applications: US-wide.

2. **Resilience Capacity Index** (RCI) – http://brr.berkeley.edu/rci/data/map

a. Summary: The RCI is a single value aggregated from 12 equally-weighted factors related to a metropolitan area's capability to recover from an unknown future disturbance. The equally-weighted factors are publically-available from federal and local sources.

b. Purpose: To provide a measure of a metropolitan area's relative capacity to recover from a future disaster.

c. Details: The equally-weighted factors are grouped into three categories: Regional Economic Capacity, Socio-Demographic, and Community Connectivity. The RCI is based on the standard deviation of a given area from all other metropolitan areas. Higher or lower RCI values result from greater or lesser standard deviation values, respectively. Capacities incorporated include income equality, economic diversification, regional affordability, business environment, educational attainment, without disability, out of poverty, health-insured, civic infrastructure, metropolitan stability, home ownership , and voter participation.

d. Applications: US metropolitan areas (Figure 3).

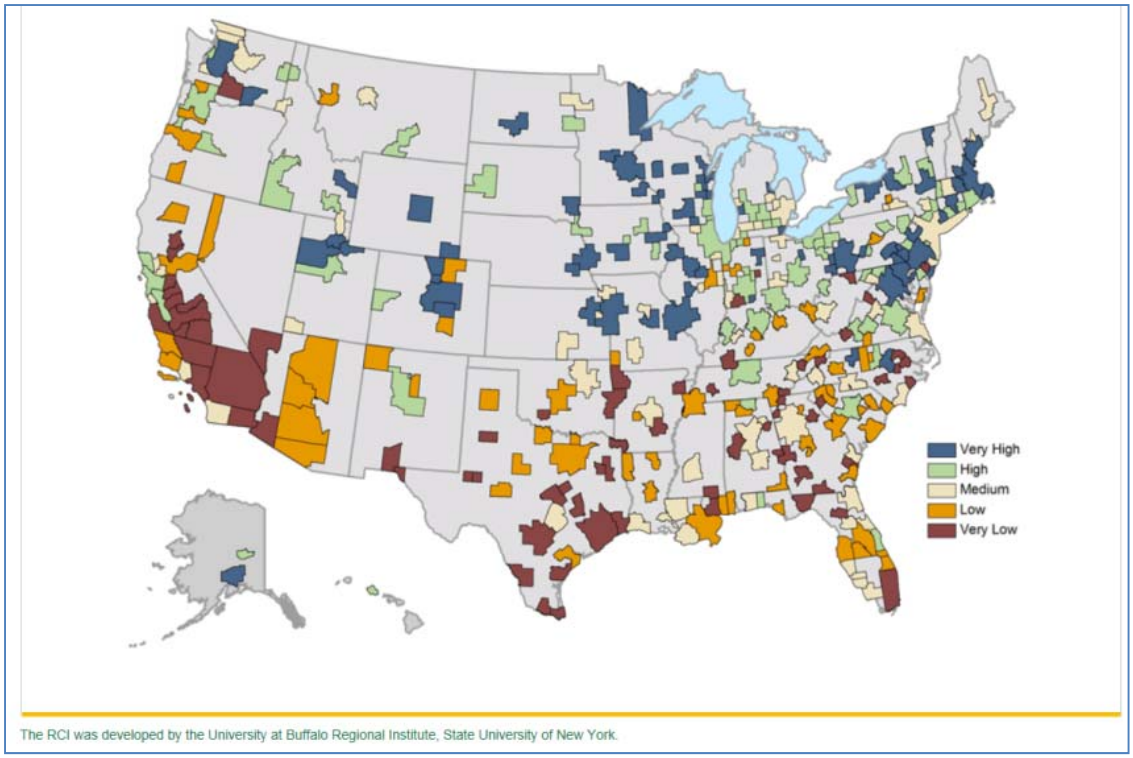

Figure 3. RCI values for metropolitan areas in the US (University at Buffalo Regional Institute, State University of New York).

3. **Infrastructure Report Card 2013** – American Society of Civil Engineers (ASCE) - http://www.infrastructurereportcard.org/a/#p/home (Figure 4)
    a. Summary: Every four years, ASCE releases a report card on America's Infrastructure by providing an A to F school report card grade by category and state, which can be aggregated to national summaries. An ASCE advisory council adjusts the grades using 8 criteria: capacity, condition, funding, future need, operation & maintenance, public safety, resilience, and innovation.
    b. Purpose: To inform the public about the condition of America's infrastructure in a concise and accessible manner.
    c. Details: Infrastructure is rated within 16 categories: aviation, bridges, dams, drinking water, energy, hazardous waste, inland waterways, levees, ports, public parks and recreation, rail, roads, schools, solid waste, transit, and wastewater. Grades are assigned as A=fit for the future, B=adequate for now, C=requires attention, D=at risk, and F=unfit for purpose. An ASCE advisory panel reviews information, interviews stakeholders and industry leaders, develops a summary report, and adjusts grading for uniformity. Grades are provided by state and category, which can then be rolled up nationally.
    d. Applications: Five report cards have been provided by State and Nation-wide since 1988.

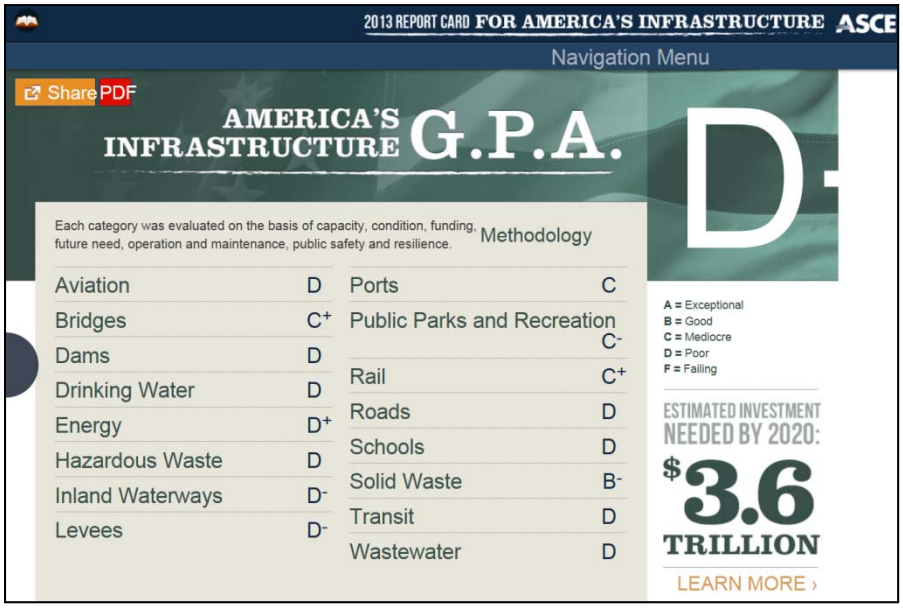

Figure 4. Most recent ASCE Infrastructure report card (2013) showing 16 categories and overall grade.

4. Others

a. America's River Initiative (ARI) report card, www.americaswater.org/reportcard/

b. Infrastructure Sustainability rating system, ENVISION, www.sustainableinfrastructure.org

c. United National Resilience Scorecard for Cities, http://www.unisdr.org/campaign/resilientcities/toolkit/essentials

Resources

1. **Coastal Resilience Tool** (CRT) – The Nature Conservancy (TNC) – http://coastalresilience.org/ (Figure 5)

   a. Summary: A coastal portal with georeferenced maps including oyster restoration, habitats, species, bathymetry, salinity, management, social, economic, and built infrastructure information. Part of the portal facilitates exploring community planning, flood and sea level rise, future habitat, restoration, and risks. Maps can be saved and exported for transmittal to stakeholders to inform restoration, adaptation, and conservation decisions around the world. It is intended to be utilized to explore risks (where people, property, and natural resources are vulnerable); potential for restoration (ecological and socio-economic factors that determine the success of restoring coastal habitats); and help inform communities about their options, identify adaptation solutions, and track their success. The CRT is available through an online mapping portal.

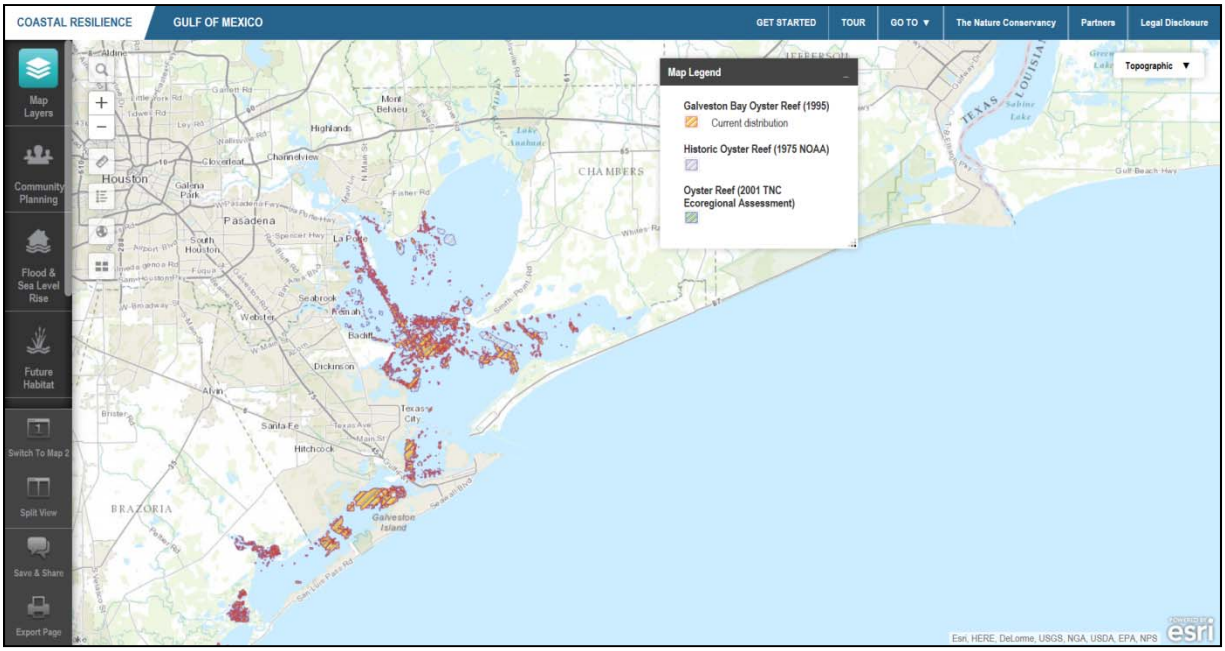

Figure 5. CRT showing Galveston Bay present-day and historical oyster reefs

2. **Sea Level Rise (SLR) Viewer** – National Oceanographic and Atmospheric Administration (NOAA) - http://coast.noaa.gov/slr/ (Figure 6).

    a. Summary: The SLR viewer utilizes a bathtub-type forecasting of a range of sea levels from present-day mean higher high water up to 6-feet SLR. Confidence ranges for these estimates, locations of marshes, vulnerability ratings, and flooding frequency are also forecasted.

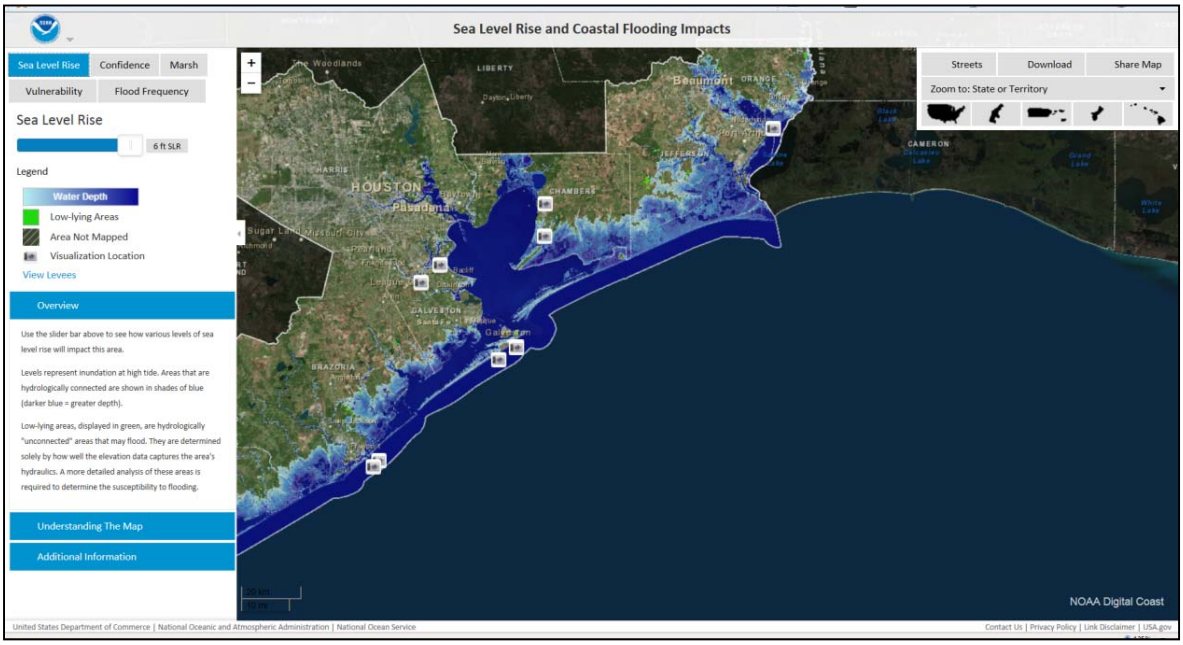

Figure 6. SLR viewer for Houston-Galveston, TX region, showing 6-feet sea level above present-day mean higher high water

3. **Coastal Vulnerability Index (CVI)** – US Geological Survey (USGS) - http://woodshole.er.usgs.gov/project-pages/cvi/images/largenat.jpg (Figure 7).
    a. Summary: The CVI quantifies the relative risk that physical changes will occur as sea level rises based on the these criteria: tidal range, wave height, coastal slope, shoreline change, geomorphology, and historical rate of relative sea level rise. The CVI is calculated as the root-mean-square of the ranked variables (see http://pubs.usgs.gov/of/1999/of99-593/pages/cvi.html).

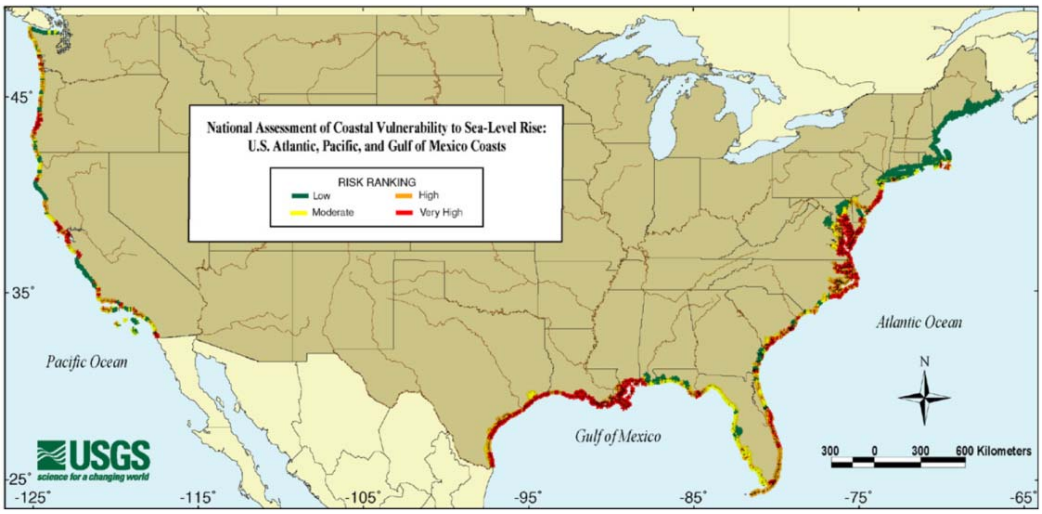

Figure 7. CVI for the US.

4. **Historical Maps Explorer** – USGS - http://historicalmaps.arcgis.com/usgs/ (Figures 8,9)
    a. Summary: This tool allows exploration, visualization, and downloading of historical bathymetric/topographic maps.

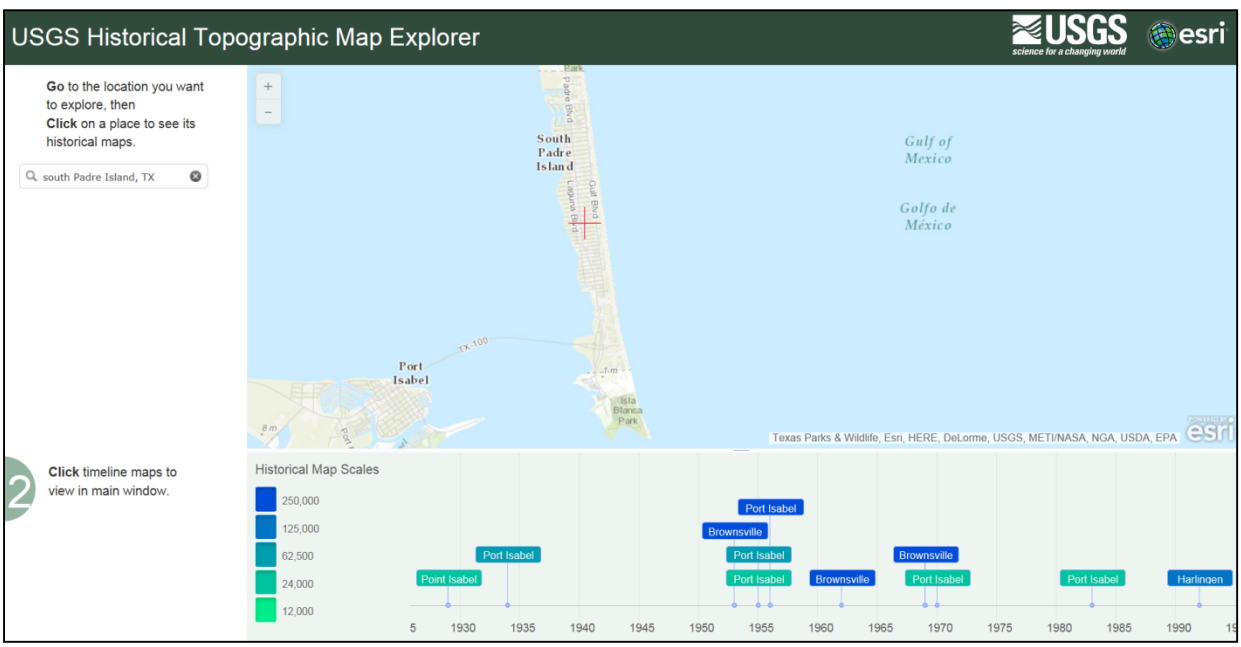

Figure 8. Historical Maps Explorer showing data for South Padre Island, TX

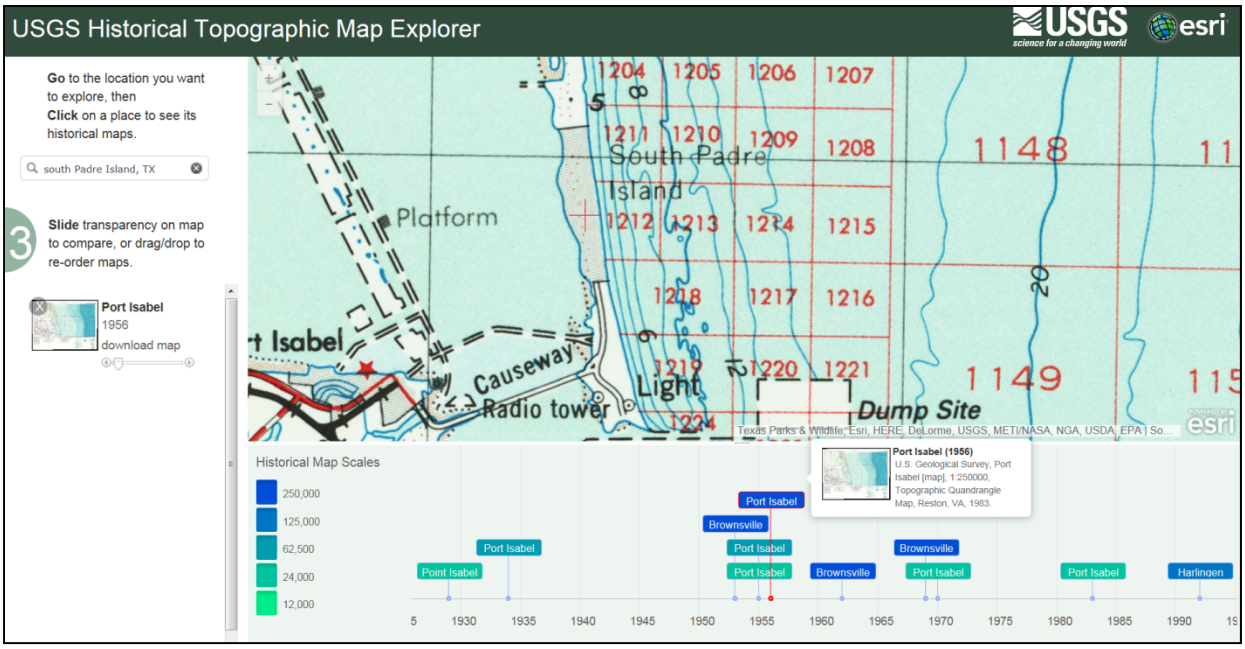

Figure 9. Historical Map Explorer showing 1956 Port Isabel map for the South Padre Island area

5. **State of the Coast** – NOAA - http://stateofthecoast.noaa.gov/vulnerability/welcome.html (Figure 10)
    a. Summary: Using the USGS's CVI data (discussed previously), provides national and state-level assessments for overall vulnerability index rankings, and vulnerability to: erosion rate, geomorphology, historic sea level rise, regional coastal slope, wave height, and tidal range. Selecting a state will provide individual state rankings.

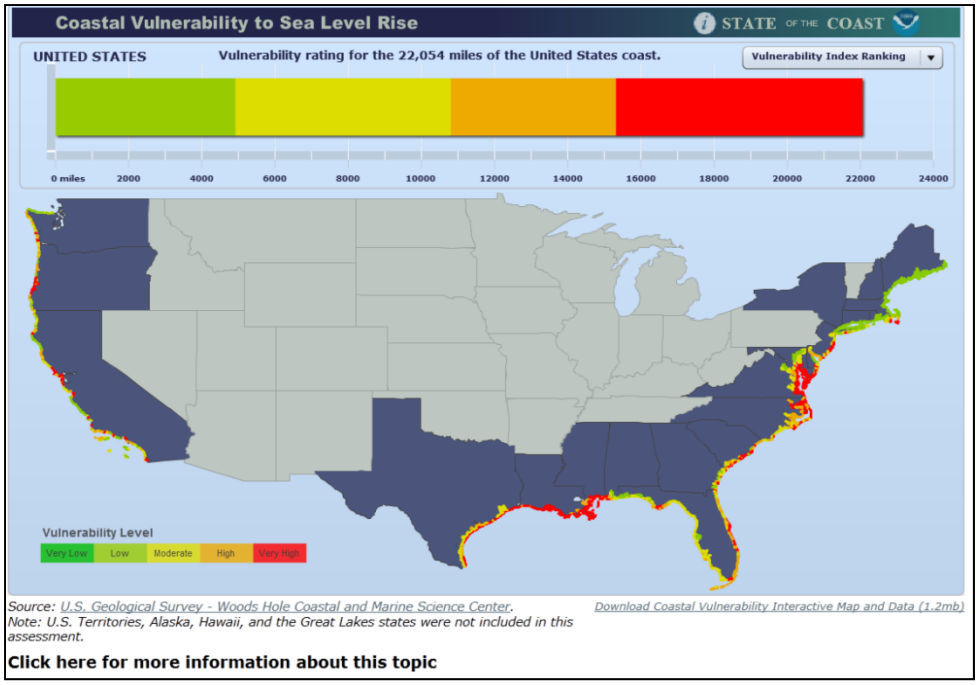

Figure 10. State of the Coast overall vulnerability rating for US coastlines

6. National Ocean Survey (NOS) Digital Coast – hurricane tracks, sea level rise viewer, charts, etc: http://coast.noaa.gov/digitalcoast/tools/hurricanes/ (Figure 11)
    a. Summary: Provides maps and data for historical hurricane tracks, with coastal population and hurricane strike data by county from Maine to Texas.

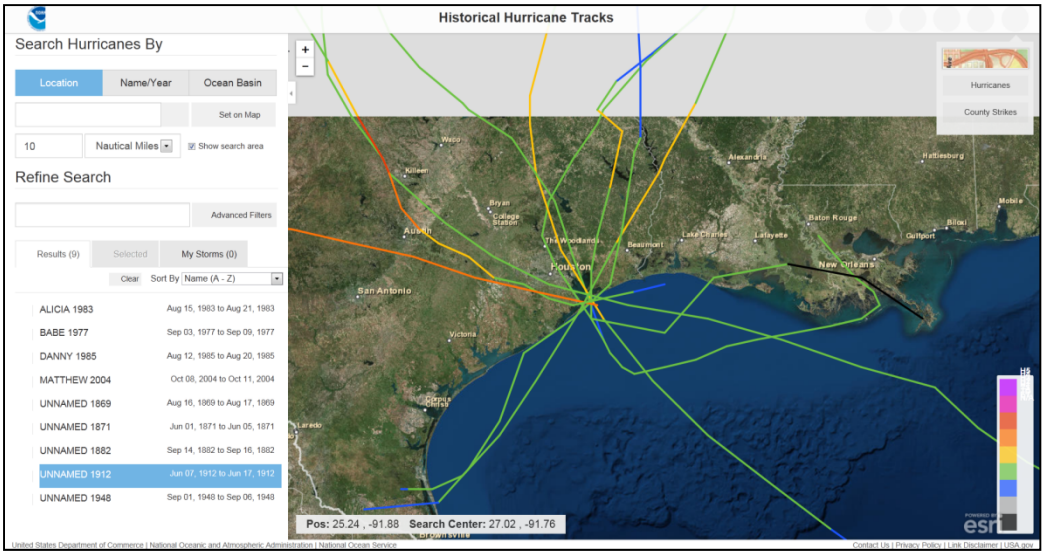

Figure 11. Historical hurricane tracks for the Galveston Bay area, Galveston, TX

7. NOAA, Bureau of Environmental Management (BOEM) Marine Cadastre national viewer of human use of oceans: http://marinecadastre.gov/nationalviewer/

References

Fox-Lent, C., Bates M., Linkov I. 2015. A matrix approach to community resilience assessment: an illustrative case at Rockaway Peninsula. *Environmental Systems and Decisions*, DOI 10.1007/s10669-015-9555-4, http://link.springer.com/article/10.1007/s10669-015-9555-4

Link, L.E., Knight, S.K., Rohner, J., and Miller, L. 2015. "Building Blocks for a National Resilience Assessment." Coastal Hazards Center, Department of Homeland Security Center of Excellence, 59 p. http://civil.umd.edu/sites/default/files/documents/National-Resilience-Assessment.pdf

Sempier T.T., Swan D.L., Emmer R., Sempier S.H., Schneider M. 2010. "Coastal resilience index: a community self assessment." MASGP-08-014. pp 1–194. http://masgc.org/assets/uploads/publications/662/coastal_community_resilience_index.pdf

Other Resources:

Maryland's CoastSmart: http://www.dnr.maryland.gov/CoastSmart/

New Jersey Resilience: http://www.nj.gov/dep/cmp/docs/ccvap-pilot-final.pdf

San Francisco Planning and Urban Research (SPUR) Association Resilient Cities Initiative - Earthquake resiliency: http://www.spur.org/

The Rockefeller Foundation's Structures of Coastal Resilience: http://structuresofcoastalresilience.org/