NCA Education Resources for the Coasts

"Coastal lifelines, such as water and energy infrastructure, and nationally important assets, such as ports, tourism, and fishing sites, are increasingly vulnerable to sea level rise, storm surge, erosion, flooding, and related hazards. Socioeconomic disparities create uneven vulnerabilities." --National Climate Assessment, 2014

The National Climate Assessment (NCA) summarizes the impacts of climate change on the United States, now and in the future. This report collects, integrates, and assesses observations and research from around the country, helping us to see what is actually happening and understand what it means for our lives, our livelihoods, and our future. It is important that these findings and response options be shared broadly to inform citizens and communities across our nation. Climate change presents a major challenge for society. This report advances our understanding of that challenge and the need for the American people to prepare for and respond to its far-reaching implications.

understanding of climate science. This content will support the integration of the Next Generation Science Standards (NGSS) into science education. The NGSS also asks educators to raise the teaching of engineering design [http://www.apple.com] to the same level as scientific inquiry. In the Adaptation

Disclaimer:
The National Climate Assessment regional resources for educators is written, edited, and moderated by each team of contributors. Posts reflect the views of the team themselves and not necessarily Climate.gov, NOAA, or USGCRP.

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This webpage features key figures, related resources, and lesson plans, videos and visualizations reviewed by CLEAN [http://cleanet.org] for all the NCA key messages for the region. The page contains information that will help educators and students gain a deeper understanding of climate science and the implications of climate variability and climate change for coastal region.

NCA Coasts Report and Highlights


NCA Coasts Key Message 1: Coastal Lifelines at Risk

Coastal lifelines, such as water supplies, energy infrastructure, and evacuation routes, are increasingly vulnerable to higher sea levels, storm surges, inland flooding, erosion, and other climate-related changes.

1. Guiding Questions
Can you think of a few ways in which your region’s coast is crucial to your community?
Why is coastal infrastructure particularly vulnerable to climate change?
How can communities protect energy infrastructure from events such as flooding and storm surges?
Which coastal lifelines are at risk in your community? Are there any groups currently working to protect your coast from these issues? How can engineering projects account for climate change impacts in the design of coastal roads, private homes and public infrastructure?
2. Key Figures

Adapting Coastal Infrastructure to Sea Level Rise and Land Loss

This “mock-up” shows the existing Highway LA-1 and Leeville Bridge in coastal Louisiana (on the right) with a planned new, elevated bridge that would retain functionality under future, higher sea level conditions (center left). (Current sea level and sinking bridge are shown here.) A 7-mile portion of the planned bridge has been completed and opened to traffic in December 2011. (Figure source: Greater Lafourche Port Commission, reprinted with permission.)

Ecosystem Restoration

The image shows a coastal ecosystem restoration project in New York City that integrates revegetation (a form of green infrastructure) with bulkheads and riprap (gray or built infrastructure). Investments in coastal ecosystem conservation and restoration can protect coastal waterfarts and infrastructure, while providing additional benefits, such as habitat for commercial and recreational fish, birds, and other animal and plant species, that are not offered by built infrastructure. (Photo credit: Department of City Planning, New York City, reprinted with permission.)

Possible Future Flood Depths in Mobile, Alabama, with Rising Sea Level

This map shows that many parts of Mobile, Alabama, including critical roads, rail lines, and pipelines, would be exposed to storm surge under a scenario of a 30-inch sea level rise combined with a storm similar to Hurricane Katrina. Many coastal areas in the United States, including Alabama and other states along the Gulf Coast, are especially vulnerable to sea level rise impacts on transportation systems. This is particularly true when one considers the interaction among sea level rise, wave action, and local geology. Not all roads would be flooded if they merely run through low areas since some are built above flood levels. A 30-inch sea level rise scenario is within the range projected for global sea level rise (Ch. 2: Our Changing Climate, Key Message 10.) (Figure source: U.S. Department of Transportation 2012.)

Airports Vulnerable to Storm Surge

This map shows that thirteen of the nation’s 47 largest airports have at least one runway with an elevation within the reach of moderate to high storm surge. Sea level rise will pose a threat to low-lying infrastructure, such as airports. (Data from Federal Aviation Administration 2012.)

3. Other Resources

Coping with Climate Change: Louisiana's Vanishing Coast

This is a slideshow without audio about the effects of sea level rise on the Isle de Jean Charles, a Louisiana coastal community, and how disappearing land impacts humans. Direct Link

Level: Middle, High School, College Lower

4. Lesson Plans

Sea Level Rise Visualization for Alabama, Mississippi, and Florida

This is an interactive map that illustrates the scale of potential flooding in Alabama, Mississippi, and Florida due to projected sea level rise. It is a collaborative project of the NOAA Sea Grant Consortium and the U.S.
Geological Survey. It is a pilot project, so there is some possibility that the resource may not be maintained over time. Direct Link (http://gom.usgs.gov/slr/slr.html)

**Level:** Middle, High School, College Lower

5. Videos

Sea Level Viewer (http://www.climate.gov/teaching/resources/sea-level-viewer)

Video and animations of sea level from NASA's Climate website. Since 1992, NASA and CNES have studied sea surface topography as a proxy for ocean temperatures. NASA Missions TOPEX/Poseidon, Jason 1, and Jason 2 have been useful in predicting major climate, weather, and geologic events including El Niño, La Niña, Hurricane Katrina, and the Indian Ocean Tsunami. Direct link (http://climate.nasa.gov/interactives/sea_level_viewer)

**Level:** Middle, High School, College, Informal, General Public

**NCA Coasts Key Message 2: Economic Disruption**


Nationally important assets, such as ports, tourism, and fishing sites, in already vulnerable coastal locations are increasingly exposed to sea level rise and related hazards. This threatens to disrupt economic activity within coastal areas and the regions they serve, and results in significant costs from protecting or moving these assets.

1. Guiding Questions

What are the potential short- and long-term negative economic effects of coastal climate hazards?

What industries will these occurrences disrupt the most? For each one, list an example of an adaptation effort that can be taken to mitigate these impacts.

What are a few important products supplied by the ports in your region?

Can you think of a nearby community with a large tourism sector? What steps have been taken so far to mitigate climate change effects on these coastal areas?

Can you think of job opportunities that may arise in order to protect the economy of your region from these types of disruption?

2. Key Figures

Coast-to-Inland Economic Connections (http://nca2014.globalchange.gov/sites/report/files/images/web-large/Figure-25.7-hi.jpg)

These maps show the exports and imports in 2010 (in tons/year) and freight flows (in trucks per day) from four major U.S. ports to other U.S. areas designated in the U.S. Department of Transportation’s Freight Analysis Framework (FAF): Los Angeles, Houston, New York/New Jersey, and Seattle. Ports are deeply interconnected with inland areas through the goods imported and exported each year. Climate change impacts on ports can thus have far-reaching implications for the nation’s economy. Note: Highway Link Flow less than 5 FAF Trucks/Day are not shown. (Figure source: U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Freight Analysis Framework, version 3.4, 2012.)


The graph shows estimated, observed, and possible future amounts of global sea level rise from 1800 to 2100, relative to the year 2000. Estimates from proxy data (for example, based on sediment records) are shown in red (1800-1890, pink band shows uncertainty), tide gauge data are shown in blue for 1880-2009, and satellite
observations are shown in green from 1993 to 2012. The future scenarios range from 0.66 feet to 6.6 feet in 2100. These scenarios are not based on climate model simulations, but rather reflect the range of possible scenarios based on other scientific studies. The orange line at right shows the currently projected range of sea level rise of 1 to 4 feet by 2100, which falls within the larger risk-based scenario range. The large projected range reflects uncertainty about how glaciers and ice sheets will react to the warming ocean, the warming atmosphere, and changing winds and currents. As seen in the observations, there are year-to-year variations in the trend. (Figure source: NASA Jet Propulsion Laboratory).

3. Other Resources

NOAA’s State of the Coast (http://stateofthecoast.noaa.gov/coastal_economy/welcome.html)

Case Studies
The Ocean and Great Lakes Economy- Dependent on a Healthy Coastal Ecosystem (http://stateofthecoast.noaa.gov/coastal_economy/ocean_economy.html)
Non-Market Value of the Coast – Benefits Regularly Taken for Granted (http://stateofthecoast.noaa.gov/coastal_economy/nonmarket.html)
A Closed Beach Affects Local Economics (http://stateofthecoast.noaa.gov/coastal_economy/beacheconomics.html)

4. Lesson Plans

Surging Seas (http://www.climate.gov/teaching/resources/surging-seas)
This interactive map allows the user to explore projected alterations of land surfaces in coastal communities, based on different scenarios of sea level changes over time. Direct Link (http://sealevel.climatecentral.org/)

**Grade Level:** Middle, High School, College

5. Videos

This video discusses the social and economic impacts (worldwide and in the US) of sea level rise caused by global warming (aired April 1, 2011). Direct link (http://www.nbclearn.com/changingplanet/cuecard/53460)

**Level:** Middle, High School, College lower

Salmon Move to Deeper Waters (http://www.climate.gov/teaching/resources/salmon-move-deeper-waters)
This video segment features subsistence fishing and harvesting in the Northwest US. Segment was adapted from a student video produced at Northwest Indian College in Bellingham, Washington. Direct link (http://www.pbslearningmedia.org/resource/nasa09.sci.ess.watcyc.saldeep/salmon-move-into-deeper-waters/)

**Level:** Middle, High School

**NCA Coasts Key Message 3: Uneven Social Vulnerability**

Visit the full Uneven Social Vulnerability page (http://nca2014.globalchange.gov/report/regions/coasts#statement-16837)

Socioeconomic disparities create uneven exposures and sensitivities to growing coastal risks and limit adaptation options for some coastal communities, resulting in the displacement of the most vulnerable people from coastal areas.

1. Guiding Questions

What are the important factors to consider when determining the risks posed by climate change to any particular coastal community?
Can you think of any nearby communities that may be particularly vulnerable to coastal climate change?
Are there policies, organizations, or community groups that are working to reduce the negative impacts on these areas? What
opportunities are there for you and your peers to get involved?

2. Key Figures

Social Vulnerability, Probability of Shoreline Erosion

The top map shows the Social Vulnerability Index (SoVI) at the Census tract level for counties along the coast. The Social Vulnerability Index provides a quantitative, integrative measure for comparing the degree of vulnerability of human populations across the nation. A high SoVI (dark pink) typically indicates some combination of high exposure and high sensitivity to the effects of climate change and low capacity to deal with them. Specific index components and weighting are unique to each region (North Atlantic, South Atlantic, Gulf, Pacific, Great Lakes, Alaska, and Hawai‘i). All index components are constructed from readily available Census data and include measures of poverty, age, family structure, location (rural versus urban), foreign-born status, wealth, gender, Native American status, and occupation.

The bottom map shows the probability of shoreline erosion greater than 3.3 feet per year for counties along the coast. Probability is based on historical conditions only and does not reflect the possibility of acceleration due to increasing rates of sea level rise. Regional threats from climate change are compiled from technical input reports, the regional chapters in this report, and from scientific literature. For related information, see data.globalchange.gov.

3. Other Resources

Coastal Community Vulnerability & Resilience Assessment Pilot, Greenwich Township, Cumberland County, NJ

Includes a section and map on social vulnerability.

4. Lesson Plans/Videos/Visualizations

Impact of Climate Change on Human Populations

This visualization is a map showing the global Climate Demography Vulnerability Index (CDVI)–areas of human population with the highest vulnerability to the impacts of climate change. Direct link

Level: High School, College

AAAS - Global Climate Change Video

This video features residents of Shishmaref, Alaska, plus environmental journalist Elizabeth Kolbert and scientist John Holdren, exploring the human impacts of global climate change. The roles of teachers, scientists, policymakers, and concerned citizens in mitigating the changes are highlighted. Direct Link

Level: Middle, High School

NCA Coasts Key Message 4: Vulnerable Ecosystems
Visit the full Vulnerable Ecosystems page (http://nca2014.globalchange.gov/report/regions/coasts#statement-16839)

Coastal ecosystems are particularly vulnerable to climate change because many have already been dramatically altered by human stresses; climate change will result in further reduction or loss of the services that these ecosystems provide, including potentially irreversible impacts.

1. Guiding Questions
What are the most important ecosystem services provided by the coast in your community? And by coastal ecosystems in general?
What are several ways in which climate change will negatively affect coastal ecosystems? Give three specific examples of each way.
Does your community have a plan in place to protect these services? What job opportunities may result from mitigation plans?
Have any significant coastal ecosystem damages already occurred in your area? How has your community responded?

2. Key Figures

Coastal Ecosystem Services (http://nca2014.globalchange.gov/sites/report/files/images/web-small/Figure-25.8-small.jpg)
This schematic illustrates many of the ecosystem services provided in a Pacific or Caribbean island setting, but many of them can also be found along mainland coastlines. Coastal ecosystems provide a suite of valuable benefits (ecosystem services) on which humans depend for food, economic activities, inspiration, and enjoyment.

Projected Land Loss from Sea Level Rise in Coastal Louisiana (http://nca2014.globalchange.gov/sites/report/files/images/web-large/Figure-25.9-hi.jpg)
These maps show expected future land change in coastal Louisiana under two different sea level rise scenarios without protection or restoration actions. Red indicates a transition from land (either wetlands or barrier islands) to open water. Green indicates new land built over previously open water. Land loss is influenced by factors other than sea level rise, including subsidence, river discharge and sediment load, and precipitation patterns. However, all these factors except sea level rise were held constant for this analysis. The panel on the left shows land change with a sea level rise of 10.6 inches between 2010 and 2060, while the one on the right assumes 31.5 inches of sea level rise for the same period. These amounts of sea level rise are within the projected ranges for this time period (Ch. 2: Our Changing Climate (http://nca2014.globalchange.gov/report/our-changing-climate/introduction).) (Figure source: State of Louisiana, reprinted with permission 53 (http://nca2014.globalchange.gov/report/regions/coasts#fn:f1d65fb3-933a-4bbf-b6ac-25ea4d0409d5).)

3. Other Resources

Economic Value of Reefs (http://coralreef.noaa.gov/aboutcorals/values/resources/cr_econ_value Chattanooga.jpg)
The chart above depicts the breakdown of component values that contribute the the global annual value of coral ecosystems. From the National Oceanic and Atmospheric Administration (NOAA) Coral Reef Conservation Program (http://coralreef.noaa.gov/aboutcorals/values/) website. Direct Link (http://coralreef.noaa.gov/aboutcorals/values/resources/cr_econ_value Chattanooga.jpg)

4. Lesson Plans

Keeping Watch on Coral Reefs (http://www.climate.gov/teaching/resources/keeping-watch-coral-reefs)
This activity identifies and explains the benefits of and threats to coral reef systems. Students read tutorials, describe the role of satellites, analyze oceanographic data and identify actions that can be undertaken to reduce or eliminate threats to coral reefs. As a culminating activity, students prepare a public education program. Direct Link (http://oceanservice.noaa.gov/education/kits/corals/lessons/keep_watch.html)
Level: High School

5. Videos


This video provides a comprehensive introduction to the role of coral reefs, the physiology of corals, and the impacts of both ocean warming and acidification on coral survival. It highlights experts from the Bermuda Institute of Ocean Sciences and the University of Miami. Direct link ([http://www.windows2universe.org/earth/changing_planet/fading_corals_intro.html](http://www.windows2universe.org/earth/changing_planet/fading_corals_intro.html))

Level: Middle, High School

NCA Coasts Key Message 5: The State of Coastal Adaptation


Leaders and residents of coastal regions are increasingly aware of the high vulnerability of coasts to climate change and are developing plans to prepare for potential impacts on citizens, businesses, and environmental assets. Significant institutional, political, social, and economic obstacles to implementing adaptation actions remain.

1. Guiding Questions

What is the current status of coastal adaptation? What approaches are being utilized, and what are the potential barriers to implementation?

What actions has your local government taken thus far to mitigate these impending impacts?

What are two main barriers to accelerating coastal adaptation actions? How could these challenges be reduced?

2. Key Figures

Ecosystem Restoration ([http://nca2014.globalchange.gov/sites/report/files/images/web-large/Figure-25.6-hi.jpg](http://nca2014.globalchange.gov/sites/report/files/images/web-large/Figure-25.6-hi.jpg))- also listed under Key Message 1

The image shows a coastal ecosystem restoration project in New York City integrating revegetation (a form of green infrastructure) with bulkheads and riprap (gray or built infrastructure). Investments in coastal ecosystem conservation and restoration can protect coastal waterfronts and infrastructure, while providing additional benefits, such as habitat for commercial and recreational fish, birds, and other animal and plant species, that are not offered by built infrastructure. (Photo credit: Department of City Planning, New York City, reprinted with permission.)

Role of Adaptive Strategies and Tactics in Reducing Impacts and Consequences ([http://nca2014.globalchange.gov/sites/report/files/images/web-large/Figure-5.5-hi_1.jpg](http://nca2014.globalchange.gov/sites/report/files/images/web-large/Figure-5.5-hi_1.jpg))

This graphic shows how many projected climate change impacts and resulting consequences on transportation systems can be reduced through a combination of infrastructure modifications, improved information systems, and policy changes. Note: not specific to coastal adaptations.

3. Other Resources


Processes that affect the capacity for climate change mitigation (CO2 sinks) and adaptation (shore line protection from rising sea level) are shown for seagrass meadows (upper panel), salt marshes (middle panel) and mangrove forests (lower panel). Blue arrows indicate transport of atmospheric or dissolved material, red arrows show transport of particulates and purple arrows indicate vegetative growth. (Images reproduced from
Nature with permission: Top, Posidonia meadow, water colour by Miquel Alcaraz; middle, Spartina in Rattekaai salt marsh, photo by Iris Hendriks; bottom, Mangrove Forest, photo by Rohan Arthur.)

Coastal Adaptation Examples (http://data.globalchange.gov/file/2ce8803b-a242-4e07-bcf9-700216e80ca5)
Will need to download.

EPA Coastal Adaptation (http://www.epa.gov/climatechange/impacts-adaptation/coasts-adaptation.html) page

4. Lesson plans/Videos/Visualizations

Floating Architecture- Preparing for a Life on Water (http://www.climate.gov/teaching/resources/floating-architecture-preparing-life-water)
This slideshow lays out a photo story with short descriptions of how city buildings all over the world are taking climate change and rising sea level seriously, designing structures that can react to unforeseen changes. As sea levels continue to rise, architects design ways to live with the rising water. Direct link (http://www.pbs.org/newshour/slideshow/multimedia-floatingarchitecture/)

Level: Middle, High School, College Lower, Informal

General Coast Resources

Key Figures

This map illustrates that U.S. population growth in coastal watershed counties has been most significant over the past 40 years in urban centers such as Puget Sound, San Francisco Bay, southern California, Houston, South Florida and the northeast metropolitan corridor. A coastal watershed county is defined as one where either 1) at a minimum, 15% of the county’s total land area is located within a coastal watershed, or 2) a portion of or an entire county accounts for at least 15% of a coastal USGS 8-digit cataloging unit. Residents in these coastal areas can be considered “the U.S. population that most directly affects the coast.” We use this definition of “coastal” throughout the chapter unless otherwise specified. (Data from U.S. Census Bureau.)

Flooding During High Tides (http://nca2014.globalchange.gov/sites/report/files/images/web-large/Figure-25.2-hi.jpg)
The photos show the impacts of flooding in Charleston, South Carolina (left) and Olympia in South Puget Sound (right) during high tides. Sea level rise is not just a problem of the future, but is already affecting coastal communities. (Photo credits: (left) NOAA Coastal Services Center; (right) Ray Garrido, January 6, 2010, reprinted with permission by the Washington Department of Ecology).

Projected Sea Level Rise and Flooding by 2050 (http://nca2014.globalchange.gov/sites/report/files/images/web-large/Figure-25.3-hi.jpg)
The maps show how the amount of sea level rise (SLR) by 2050 will vary along different stretches of the U.S. coastline and under different SLR scenarios, mostly due to land subsidence or uplift (Ch.2: Our Changing Climate). The panels show feet of sea level above 1992 levels at different tide gauge stations based on a) an 8 inch SLR and b) a 1.24 foot SLR by 2050. The flood level that has a 1% chance of occurring in any given year (“return level”) is similarly projected to differ by region as a result of varying storm surge risk. Panel c) shows return levels for a 1.05 foot SLR above mean high tide by 2050. Finally, panel d) shows how a 1.05 foot SLR by 2050 could cause the level of flooding that occurs during today’s 100-year storm to occur more frequently by mid-century, in some regions as often as once a decade or even annually. (Figure source: replicated Tebaldi et al. 2012 analysis with NCA sea level rise scenarios3 for panels a) and b); data/ensemble
SLR projections used for panels c) and d) from Tebaldi et al. 2012; all estimates include the effect of land subsidence.

Other Resources

Climate Impacts on Coastal Areas (http://www.epa.gov/climatechange/impacts-adaptation/coasts.html)

Coastal Climate Adaptation (http://collaborate.csc.noaa.gov/climateadaptation/default.aspx): NOAA’s website for coastal climate adaptation


National Climate Assessment Resources for Educators

- 2014 National Climate Assessment Resources for Educators
- Alaska Region
- Coasts Region
- Great Plains Region
- Hawaii and Pacific Islands Region
- Midwest Region
- Northeast Region
- Northwest Region
- Ocean Region
- Southeast and Caribbean Region
- Southwest Region

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