



## PRESENTATION NOTES



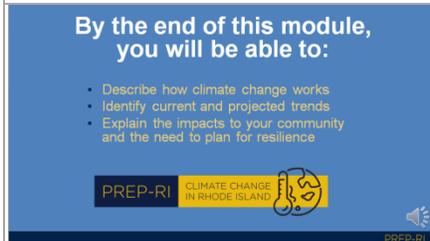
1. Welcome to Climate Change in Rhode Island, part of the online series called, Providing Resilience Education for Planning in Rhode Island (or “PREP-RI”). Climate change impacts Rhode Island’s economy, infrastructure, public health, and environment. By better understanding climate change and recognizing the connection between human practices and their impacts, we can better protect our communities for current and future generations.

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**Image Source:**  
Narragansett Beach, K. O’Kula



2. As Mayor of Warwick, I am pleased to introduce this module and the experts you will hear from today: David Vallee from the National Weather Service, and Janet Freedman from the Coastal Resources Management Council.



3. The PREP RI series is designed to enhance decision-making and resilience to both current and future climate related impacts, which will benefit the health, safety and welfare of our communities. This module helps communities better understand climate change and its impacts. By the end of this module you will be able to:

- Describe how climate change works,
- Identify current and projected trends, and
- Explain the impacts to your community and the need to plan for resilience.



4. So, why should we care about climate change and its impacts?



5. We live, work, and play in areas that we value. Historic neighborhoods, productive fishing grounds, favorite beaches and vibrant marshes are a few of the many areas we want to protect as the Ocean State experiences changes from a warming climate. Now I'm going to hand it off to David.

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**Image Sources:**

**Left top:** Point Neighborhood, Newport, P. Rubinoff, CRC/RISG

**Left Bottom:** Quahog fishermen (Jeff Grant) working in Narragansett Bay, RI Sea Grant

**Right top:** Sapowet Marsh, Tiverton, R. Hancock

**Right bottom:** Narragansett Beach, P. Rubinoff, CRC/RISG



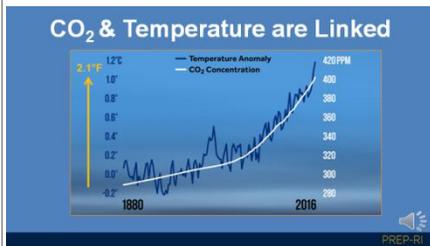
6. You've heard the term "climate change," but have you thought about the mechanism behind it? Simply put, when we burn fossil fuels such as coal, oil, and natural gas for energy, we add rampant amounts of carbon dioxide to the atmosphere, far beyond regular levels created by normal life processes. When sunlight passes through the earth's atmosphere and is transformed into heat, some heat is absorbed by the Earth's surface and some is reflected back to space. However, some of the heat is trapped by carbon dioxide and other gases that act like a blanket around the earth. This blanket is thickening over time, trapping more and more heat, warming our air and oceans.\* This warming leads to a variety of impacts which you'll hear about during the rest of this module.

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**Image Source:**

URI Coastal Resources Center.

\*National Network for Ocean and Climate Change Interpretation  
<http://climateinterpreter.org/resource-topic/heat-trapping-blanket>



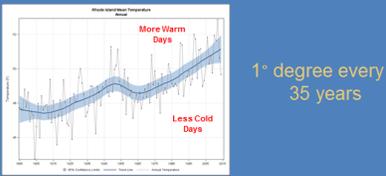
7. Observations show that there is a direct correlation between increasing carbon dioxide and rising temperature. Since 1880, the global annual average temperature has increased by more than 2.1°F. Two-thirds of the warming has occurred since 1975. The white line shows atmospheric carbon dioxide concentration rising at a similar rate as the temperature. The graph shows that some years are higher than others, which is a result of different global patterns. However, the trend is clear.

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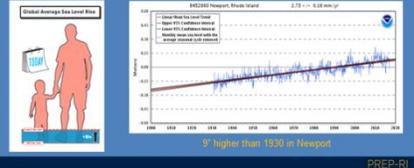
**Image Source:**

Climate Central, 2016

<http://www.climatecentral.org/gallery/graphics/co2-and-rising-global-temperatures>

<p><b>Weather and Climate are Different</b></p> 	<p>8. Remember, weather changes from day to day and even year to year. Climate refers to the long term trends in the weather.</p> <p>***</p> <p><b>Image Source:</b> R. Ferdinandi, URI CRC, 2016</p>
<p><b>A Warming Planet Affects Weather Patterns</b></p> 	<p>9. Warming ocean and air temperatures have caused a marked loss of sea ice in the Arctic Ocean. Over the past 50 years, this loss of sea ice combined with a warming ocean have resulted in changes to the jet stream; the fast flowing rivers of air that carry our storm systems across the hemisphere. In turn, this affects the behavior of our storm systems.</p> <p>***</p> <p><b>Image Source:</b> Arctic Ocean, NASA, 2016 <a href="https://www.nasa.gov/sites/default/files/meltpondshansen.jpg">https://www.nasa.gov/sites/default/files/meltpondshansen.jpg</a></p>
<p><b>What's Happening?</b></p> 	<p>10. Keeping the heat-trapping blanket and the increase in global temperature in mind, let's consider the impacts in Rhode Island.</p>
<p><b>RI Air Temperatures are Warming</b></p> 	<p>11. Rhode Island has experienced a remarkable shift in temperatures over the last century, a trend represented by the blue line in this graph. Our annual temperature was around 49 degrees in the 1930s, while today it averages 51 degrees. Perhaps most striking is that the 10 warmest years have all occurred since 1980.</p> <p>***</p> <p><b>Image Source:</b> National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center <a href="https://www.ncdc.noaa.gov/temp-and-precip/state-temps/">https://www.ncdc.noaa.gov/temp-and-precip/state-temps/</a></p>

<p><b>High Temperatures Impact Quality of Life</b></p>  <p>PREP-RI</p>	<p>12. The warming trend is also reflected in temperature extremes. Prior to 1970, just 8 summers experienced 15 or more days above 90 degrees, compared to 15 summers since 1970. *</p> <p>Increased temperatures mean longer, hotter summers with increased potential for drought and negative effects on human health.</p> <p>***</p> <p><b>Image Sources:</b>  <b>Left:</b> Construction worker <a href="http://www.OSHA.gov">www.OSHA.gov</a>  <b>Middle:</b> Stop sign, Narragansett, P. Rubinoff, CRC/RISG  <b>Right:</b> Child with inhaler, Shutterstock</p>
<p><b>Steady Increase in Precipitation</b></p>  <p>PREP-RI</p>	<p>13. Warmer air temperatures allow the atmosphere to hold more water vapor. Since 1930 annual precipitation has increased by 8". This is dramatic! Looking at the graph, notice the number of years since 1970 with annual rainfall of more than 55 inches.</p> <p>***</p> <p><b>Image Source:</b> National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information <a href="http://www.ncdc.noaa.gov/cag">http://www.ncdc.noaa.gov/cag</a></p>
<p><b>More Heavy Rain Events</b></p>  <p>Observed change in very heavy precipitation (1958-2012)</p> <p>PREP-RI</p>	<p>14. Rhode Island is also experiencing more intense precipitation events. We used to average 8 days per year of rainfall greater than 1". Today we are averaging nearly 15 days per year!*</p> <p>***</p> <p><b>Image Sources:</b>  <b>Left:</b> National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information. <i>Heavy downpours are increasing nationally, especially over the last three to five decades, with the largest increases in the Midwest and Northeast. Increases in extreme precipitation are projected for all U.S. regions</i> <a href="http://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing">http://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing</a>  <b>Right:</b> Flood waters in Newport, J. Coop <a href="http://rightweather.com/2012/08/surprise-t-storms-lead-to-flooding-waterspout/">http://rightweather.com/2012/08/surprise-t-storms-lead-to-flooding-waterspout/</a></p> <p>* Rainfall data analysis by NOAA/NWS/Northeast River Forecast Center.</p>

<p><b>Heavy Rains and Impervious Surfaces Increase Floods</b></p>  <p>PREP-RI</p>	<p>15. More intense downpours and increasing impervious coverage such as roads, and parking lots, have resulted in an increase in flood frequency and, in some locations, like the Pawtuxet River in Cranston, flood magnitude. While floods were infrequent in the 1940s, 50s and 60s, the basin now often floods multiple times per year.</p> <p>Now I'm going to hand it off to Janet.</p> <p>***</p> <p><b>Image Source:</b> Route 95, Warwick, RI; RIDOT, 2010 <a href="https://www.flickr.com/photos/ridotnews/4497845118/in/album-72157623789359868/">https://www.flickr.com/photos/ridotnews/4497845118/in/album-72157623789359868/</a></p>
<p><b>What are We Seeing on the Coast?</b></p>  <p>PREP-RI</p>	<p>16. Climate change has also resulted in coastal change in Rhode Island.</p>
<p><b>Sea Level is Rising</b></p>  <p>PREP-RI</p>	<p>17. Measurements taken at the Newport Tide Gage show that sea levels today are more than 9 inches higher than in 1930. Seas are rising due to several factors. Warm waters expand and ice sheets melt, adding water to the ocean. Sea levels can also be affected locally by lands sinking, by changes in ocean currents and even by changes to the gravitational attraction of the large ice sheets. As a result, seas are rising faster in Rhode Island than the global average and will continue to do so in the future.</p> <p>***</p> <p><b>Image Sources:</b> <b>Left:</b> Union of Concerned Scientists, 2014 <a href="http://www.ucsusa.org/global_warming/science_and_impacts/impacts/infographic-sea-level-rise-global-warming.html#.WQDtqfn3hS0">http://www.ucsusa.org/global_warming/science_and_impacts/impacts/infographic-sea-level-rise-global-warming.html#.WQDtqfn3hS0</a> <b>Right:</b> NOAA sea level trends at Newport, RI <a href="https://tidesandcurrents.noaa.gov/sltrends/sltrends.html">https://tidesandcurrents.noaa.gov/sltrends/sltrends.html</a></p>



18. In Rhode Island, we can likely expect 1' of sea rise over the next 20 years, 2' by 2050 and 7' by 2100.\* These projections are defined by NOAA, and adopted by the RI Coastal Resources Management Council.

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**Image Source:**

Union of Concerned Scientists, 2014

[http://www.ucsusa.org/global\\_warming/science\\_and\\_impacts/impacts/infographic-sea-level-rise-global-warming.html#.WQDtqfn3hS0](http://www.ucsusa.org/global_warming/science_and_impacts/impacts/infographic-sea-level-rise-global-warming.html#.WQDtqfn3hS0)

\* Projections, as of 2015, within Section 145 of the [RI Coastal Resources Management Plan](#), adopted in 2016 by RI Coastal Resources Management Council

<http://www.crmc.ri.gov/regulations/RICRMP.pdf>



19. Today's extreme tides give us a preview of our future. Over the next 20 years, many low-lying roads and neighborhoods will experience daily tides equal to today's 1' extreme tide. The 2' moon tide gives us a preview of daily tides at mid-century -- approximately one thirty-year mortgage into the future. At that time, we expect 9 square miles of coastal property to be permanently flooded from rising seas.\* Shores that currently flood 3 or 4 times per year during extreme tides will flood about 70 times a year with 1-foot of sea level rise and over 300 times a year with 2' of sea level rise.\*\*

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**Image Sources:**

**Left:** Westerly, Watch Hill, H. Hanka, 2012

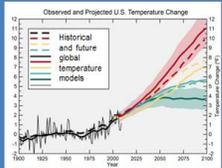
**Right:** Pawtuxet River, Cranston, F. Fullerton, 2011

\* Estimates based on ARCGIS sea level rise layers, as reviewed by J. Freedman, CRMC, 2017

\*\* The NOAA Inundation analysis program shows the frequency and duration of observed high waters (tides). These are based on the Conimicut tide gauge (2011-2016).

<https://tidesandcurrents.noaa.gov/inundation/>

<p><b>Sea Level Rise also Affects Marshes</b></p>  <p>PREP-RI</p>	<p>20. Marshes are drowning in place and are moving inland due to rising sea levels. Roads and other coastal development may prevent marshes from migrating upland. Models show that Rhode Island could lose approximately 50% of its salt marshes by mid century.* This loss will reduce ecosystem services such as supporting nurseries for fish, filtering contaminants, and helping to absorb flood waters.</p>
	<p>***</p> <p><b>Image Source:</b> Stillhouse Cove, Cranston, J. Freedman, CRMC</p> <p>*50% is cited in CRMC 2015 report: <a href="http://www.crmc.ri.gov/maps/maps_slamm/20150331_RISLAM_M_Summary.pdf">http://www.crmc.ri.gov/maps/maps_slamm/20150331_RISLAM_M_Summary.pdf</a></p>
<p><b>Storm Surge Impacts our Coasts</b></p>  <p>PREP-RI</p>	<p>21. Storm surge occurs when strong winds push water towards the shore causing a rapid rise in water levels. During Nor'easters surges of 2' or more last through several tide cycles and cause significant shoreline erosion. Hurricanes can generate much higher surges, 10' or more above predicted tide heights.</p>
	<p>***</p> <p><b>Image Source:</b> Browning Cottages, Matunuck Beach, South Kingstown; B. Oakley, Eastern Connecticut State University, 2012.</p>
<p><b>Storm Surge Displaces the Beach and its Activities</b></p>  <p>PREP-RI</p>	<p>22. Storm surge can easily move coastal sediment, causing erosion and disruption to the built environment.</p>
	<p>***</p> <p><b>Image Sources:</b> <b>Left:</b> RIDOT, 2012 <a href="https://www.flickr.com/photos/ridotnews/sets/72157631891636224/">https://www.flickr.com/photos/ridotnews/sets/72157631891636224/</a> <b>Right:</b> Stop sign: Misquamicut Beach, Westerly; C. Walsh, 2012 <a href="https://vimeo.com/52513169">https://vimeo.com/52513169</a></p>
<p><b>Storm Surge Can Move Houses Too!</b></p>  <p>PREP-RI</p>	<p>23. Powerful waves can even move objects such as houses, septic systems, and seawalls.</p>
	<p>***</p> <p><b>Image Source:</b> Misquamicut Beach, Westerly; A. Silva/R. Lucia, CRMC, 2012</p>

<p><b>Damages and Disrupts Low-Lying Bay Communities</b></p>  <p>PREP-RI</p>	<p>24. Storm surge doesn't only impact beaches and beach houses, it also floods communities along the bay.</p> <p>***</p> <p><b>Image Sources:</b>  <b>Left:</b> Newport, Newport Daily News, Oct 29, 2012  <b>Right:</b> Wickford, M. Devine, 2012  <a href="https://www.flickr.com/photos/coastal_resources/8142418302/in/album-72157631897489962/">(https://www.flickr.com/photos/coastal_resources/8142418302/in/album-72157631897489962/)</a></p>
<p><b>Erosion from Storms Moves the Coastline Inland</b></p>  <p>2006 2012</p> <p>PREP-RI</p>	<p>25. Erosion is expected to accelerate due to higher storm surge, resulting in greater damages to buildings and infrastructure</p> <p>***</p> <p><b>Image Sources:</b>  <b>Left:</b> South Kingstown, J. Freedman, CRMC, 2006  <b>Right:</b> South Kingstown, J. Freedman, CRMC, 2012</p>
<p><b>Models Show Sea Level Rise and Storm Surge</b></p>  <p>PREP-RI</p>	<p>26. The effects of storm surge and sea level rise are modeled by an online mapping tool known as STORMTOOLS.</p> <p>Today, this road in Warwick experiences flooding on extreme high tides. The map on the right shows how two to three feet of surge or future sea level rise will flood the neighborhood.</p> <p>***</p> <p><b>Image Sources:</b>  <b>Left:</b> J. Freedman, Spadina Ave, Warwick RI (from <a href="http://mycoast.org">mycoast</a>)  <b>Right:</b> STORMTOOLS; <a href="http://www.beachsamp.org/stormtools/">http://www.beachsamp.org/stormtools/</a></p>
<p><b>Looking to the Future</b></p>  <p>↑ Air Temperature          ↑ Water Temperature          ↑ Intense Rain Events          ↑ Floods          ↑ Sea level          ↑ Erosion</p> <p>PREP-RI</p>	<p>27. Numerous global models show average temperatures continuing to rise in the future. While their magnitudes differ, all the trends continue upward, along with increases in water temperature, annual precipitation, heavy rain events, sea level rise, and erosion.</p> <p>***</p> <p><b>Image Source:</b>          Adapted from  <a href="http://nca2014.globalchange.gov/report/appendices/faqs">http://nca2014.globalchange.gov/report/appendices/faqs</a></p>
<p><b>What Can We Do?</b></p>  <p>PREP-RI</p>	<p>28. As you have just heard, climate change impacts all aspects of Rhode Island's well-being. Let's plan accordingly.</p>



29. This brief module described various implications of climate change and illustrated impacts we are seeing today. Thankfully, Rhode Island’s communities are already tackling the impacts of climate change. Municipalities are taking action to mitigate, or reduce their carbon footprint with programs to advance the state’s renewable energy goals.

When it comes to issues like flooding and erosion, Rhode Island’s municipalities are on the frontline. Some are undertaking vulnerability assessments, others are relocating or elevating critical infrastructure or restoring floodplains. I am proud that Warwick has been a leader in using green infrastructure to reduce stormwater impacts to the Bay and increasing the levee around our wastewater treatment facility. Our communities are now required to include climate change and natural hazards in their Comprehensive Plans. Many are already implementing their strategies that you can learn about in the other PREP-RI modules.\*

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**Image Sources:**

**Left:** Meeting in Warwick, P. Rubinoff, 2016

**Right bottom:** Willow Dell Beach Club, South Kingstown, P. Rubinoff

\* There are many examples of actions taken, which will be discussed in future modules.

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- ❑ Check out the resources document and presentation notes
- ❑ Fill out survey and get your certificate!
- ❑ View other modules

30. Thank you for viewing this module. Go to the PREP-RI website to see the resources document and presentation notes, to fill out the survey, get your certificate, and view the other modules.

**Acknowledgements**

**Support**  
Governor Gina Raimondo, RI Legislature, and the University of Rhode Island

**Oversight Committee**  
Janet Coit, RI Department of Environmental Management  
Grover Fugate, RI Coastal Resources Management Council  
Representative Lauren Carson, District 75, Newport  
Parag Agrawal, RI Division of Planning  
Michelle Burnett, RI Emergency Management Agency (formerly)  
Kelly Mahoney, University of Rhode Island

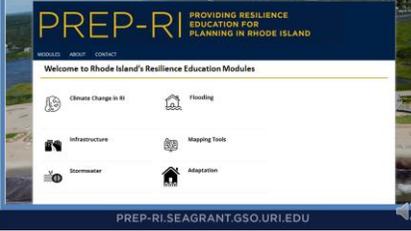
31. The PREP-RI team acknowledges the support of statewide leaders, experts and practitioners who helped to make this module a reality.

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 <p><b>PREP-RI Team</b></p> <p>A partnership of the URI Coastal Resources Center, RI Sea Grant, the Graduate School of Oceanography, and the Narragansett Bay National Estuarine Research Reserve.</p> <p>Pam Rubinoff, Jennifer West, Jennifer McCann, Teresa Crean, Dawn Kotowicz, Mary-Kate Kane, Kevin Proft, Sue Kennedy, Cathy Dwyer, Monica Allard Cox</p>	<p>32. And thanks to the PREP-RI Team for pulling this together!</p> <p>A partnership of the URI Coastal Resources Center, RI Sea Grant, the Graduate School of Oceanography; and the Narragansett Bay National Estuarine Research Reserve.</p> <p>Pam Rubinoff, Jennifer West, Jennifer McCann, Teresa Crean, Dawn Kotowicz, Mary-Kate Kane, Kevin Proft, Sue Kennedy, Cathy Dwyer, Monica Allard Cox</p>
 <p>PROVIDING RESILIENCE EDUCATION FOR PLANNING IN RHODE ISLAND</p> <p>Welcome to Rhode Island's Resilience Education Modules</p> <ul style="list-style-type: none"><li>Climate Change in RI</li><li>Flooding</li><li>Infrastructure</li><li>Mapping Tools</li><li>Stormwater</li><li>Adaptation</li></ul> <p>PREP-RI.SEAGRANT.GSO.URI.EDU</p>	<p>Providing Resilience Education for Planning in Rhode Island <a href="http://PREP-RI.Seagrant.gso.uri.edu">PREP-RI.Seagrant.gso.uri.edu</a></p>