



No where is climate change more evident than in our oceans and coasts. Nature won't wait for our politics to sort themselves out. The changes in our oceans are real, and they are measurable. They follow the laws of biology, of chemistry, and of physics. Our steady flood of carbon pollution has real consequences, and they are already being felt in Rhode Island.

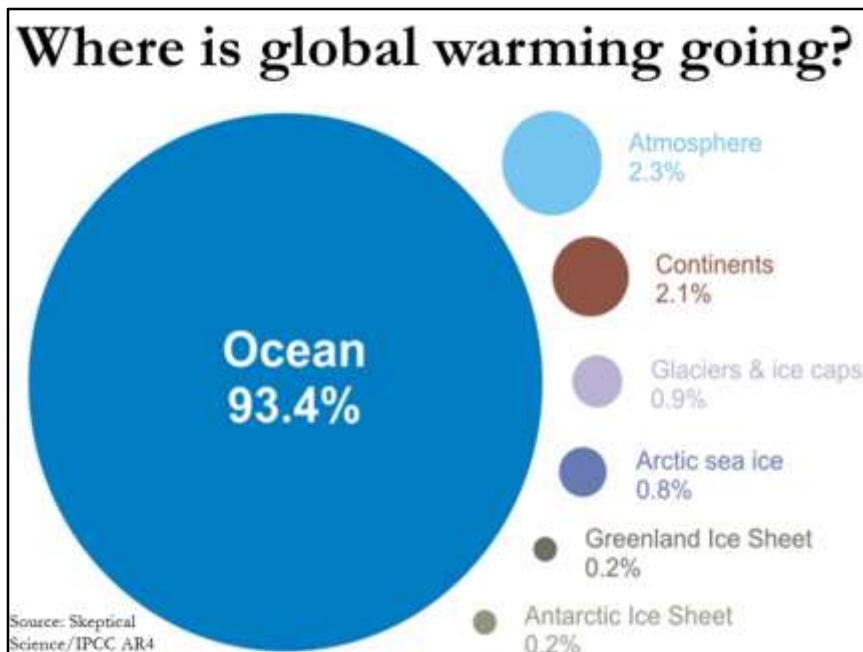
Photo Credit: Ray Collins



Great Gale of 1815

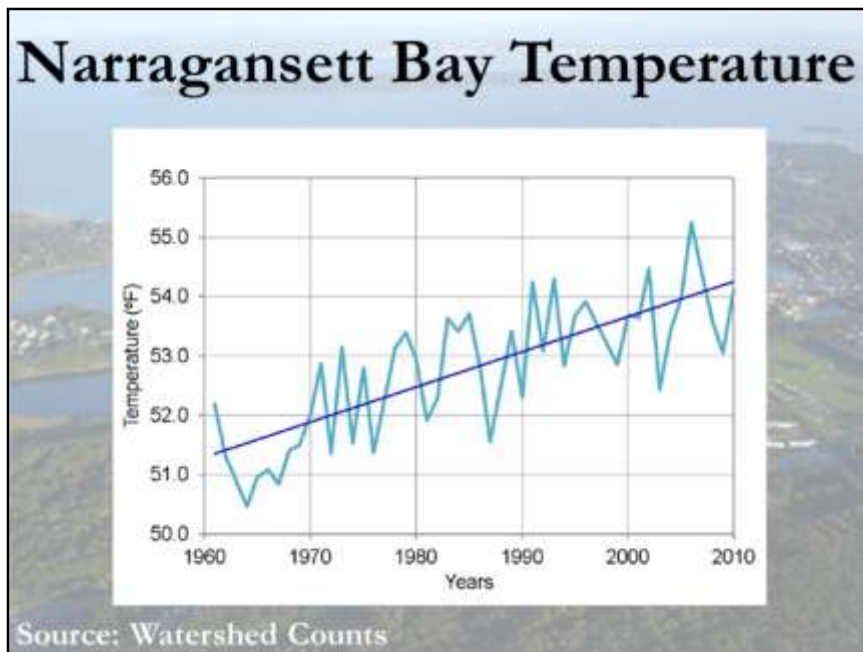
Painting by John Russell Bartlett, part of the RI Historical Society Collection, featured in a ProJo article marking the storm (<http://www.providencejournal.com/article/20150920/ENTERTAINMENTLIFE/150929983>)

The storm tore the Washington Bridge from its supporting columns when it hit New England on September 23, 1815. Water reached 13 feet, 9 inches above mean high tide in downtown Providence on Sept. 21.



The oceans have soaked up more than 90 percent of the excess heat trapped in the atmosphere by greenhouse gases. It's a lot of heat: the Associated Press has compared the ocean heat we've added in just the last 20 years to setting off nearly four Hiroshima-style atomic bombs in the sea per second for that 20 years.

Source: Skeptical Science, *shows components of global warming for the period 1993 to 2003 calculated from [IPCC AR4 5.2.2.3](#)*.



New England is being hit particularly hard. The Gulf of Maine is warming faster than almost any other part of the ocean in the world.

Data from Narragansett Bay shows that winter ocean temperatures have increased 3-4 degrees Fahrenheit since the 1960's.

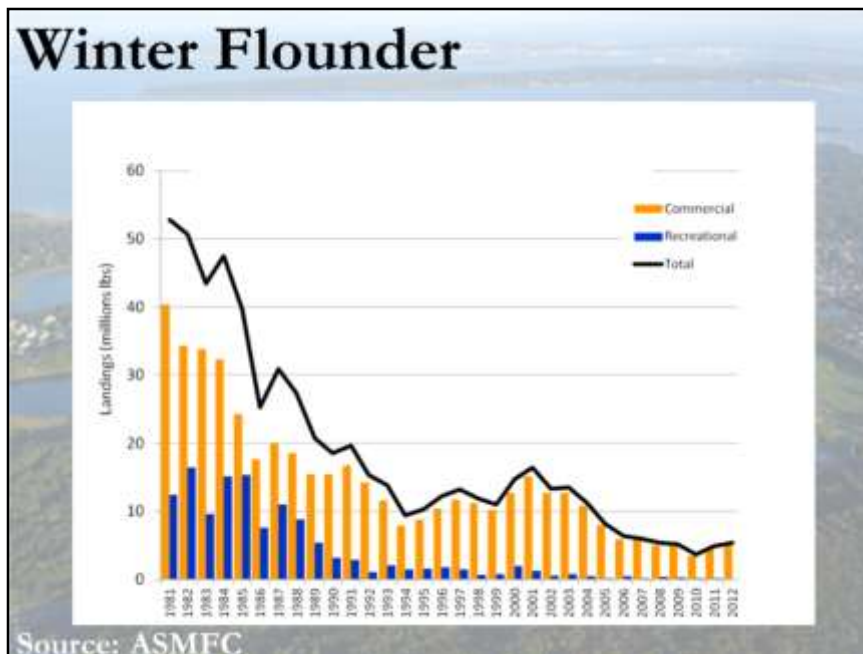
This chart shows the average winter temperature as collected by the University of Rhode Island Graduate School of Oceanography weekly Phytoplankton survey. This temperature record shows a 50 year increase of 1.9 degrees Centigrade, or 3.4 degrees Fahrenheit.

Data Source: Robert Fulweiler, <http://dx.doi.org/10.1016/j.ecss.2015.01.021>; graphic from <http://www.watershedcounts.org/climate.html>

Background photo: Aerial view of Narragansett Bay

Posted by Jessica Phillips

<http://www.visitrhodeisland.com/gallery/view/52/narragansett-bay/>



Here's another example important to Rhode Island: winter flounder. Warming temperatures are inhibiting spawning, but also assisting in spawning of winter flounder predators. So, when spawning does occur, there are more predators at the ready.

Chart is from ASMFC -

http://www.asmf.org/files/Meetings/Winter2014/WinterFlounderBoard_Supplemental.pdf

From RI DEM - <http://www.dem.ri.gov/programs/bnatres/fishwild/pdf/localwfl.pdf>

“The species was the most abundant finfish in trawl samples (Oviatt and Nixon 1973) and was a major component of bay ichthyoplankton in 1972 (Bourne and Govoni 1988). A long-term trawl survey conducted by the University of Rhode Island Graduate School of Oceanography (URIGSO) shows that winter flounder abundance in Rhode Island has fluctuated considerably over time (Jeffries and Terceiro 1985, Jeffries et al. 1989, Collie et al. 2008). The early 1970's were actually a period of medium

abundance for winter flounder. Recent survey results show abundance well below the long-term average. “ (RIDEM Report)

Bmsy – biomass that allows for maximum sustainable yield; population size at the point of maximum growth

(http://www.pewtrusts.org/~media/assets/2015/03/turning_the_tide_msy_explained.pdf)



That excess energy is warming our oceans at alarming rates, and by the law of thermal expansion, coupled with the melting of ice sheets as our planet warms, is causing sea levels to rise. At Naval Station Newport, the tide gauge already measures nearly ten inches of sea level rise since 1930, just before our Great Hurricane of 1938. If that storm were to hit again today, it would ride to shore on ten more inches of sea, plus any added storm surge effects. And we could probably expect a stronger storm, fueled by those warmer seas.

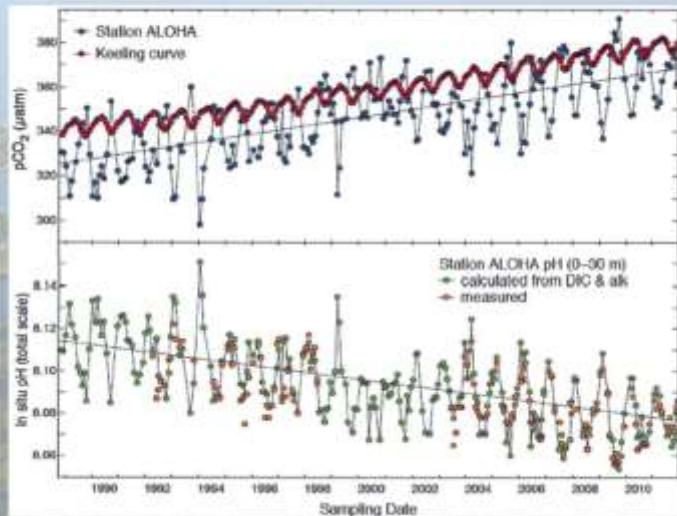
NOAA released a report last week that used the latest peer-reviewed science to update global and regional U.S. sea level rise estimates for 2100. The range for global mean sea level rise was updated to 0.3 to 2.5 meters by 2100; the previous estimate scenarios ranged from from 0.1 to 2 meters. The Northeast will be among the hardest hit in the United States. Under the extreme high scenario (2.5 meters in GMSL by 2100), our region could see over an additional meter of sea level rise. Under even the intermediate scenario (1 m GMSL), we could still see an additional 0.3-0.5 meters above that for a total of nearly 10 feet.



As seas rise, low lying coastal areas, which includes much of Rhode Island's shores, can expect more "sunny day flooding," or flooding that comes with just the change of tides. However, the real danger of sea level rise comes when storms hit the coasts riding on elevated seas. This photo is from Bowen's Wharf in Newport after Superstorm Sandy came through Rhode Island in October 2012.

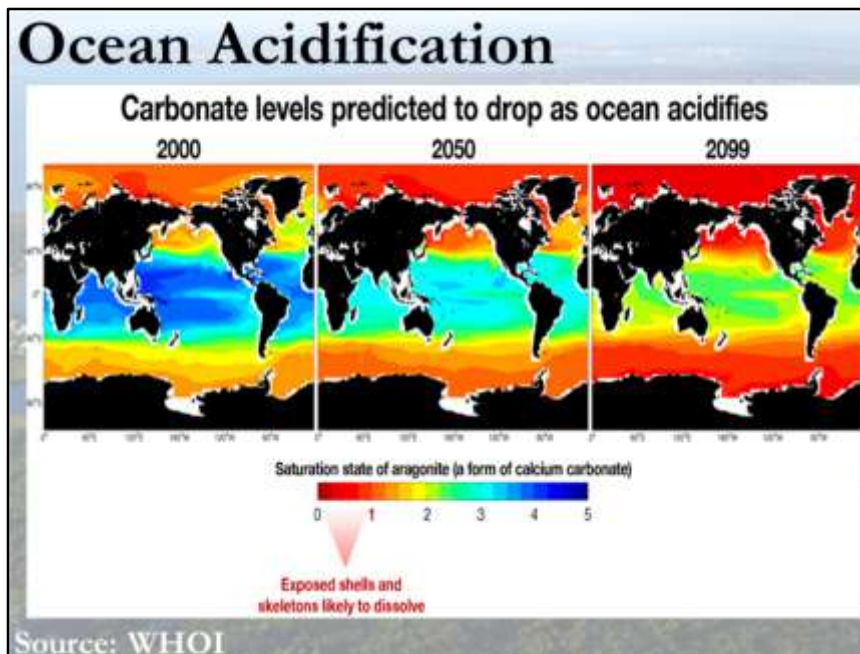
Insurers, mortgage lenders, realtors, business owners, homebuyers, emergency responders, and city planners will all need to understand and incorporate this new reality into their decision-making.

Ocean Acidification



Source: Karl, et al., 2012

This chart shows the steady increase of carbon dioxide in the atmosphere (top chart) and the resulting decrease in pH, or acidification, of the ocean (bottom chart). The oceans are 30% more acidic than in 1850.



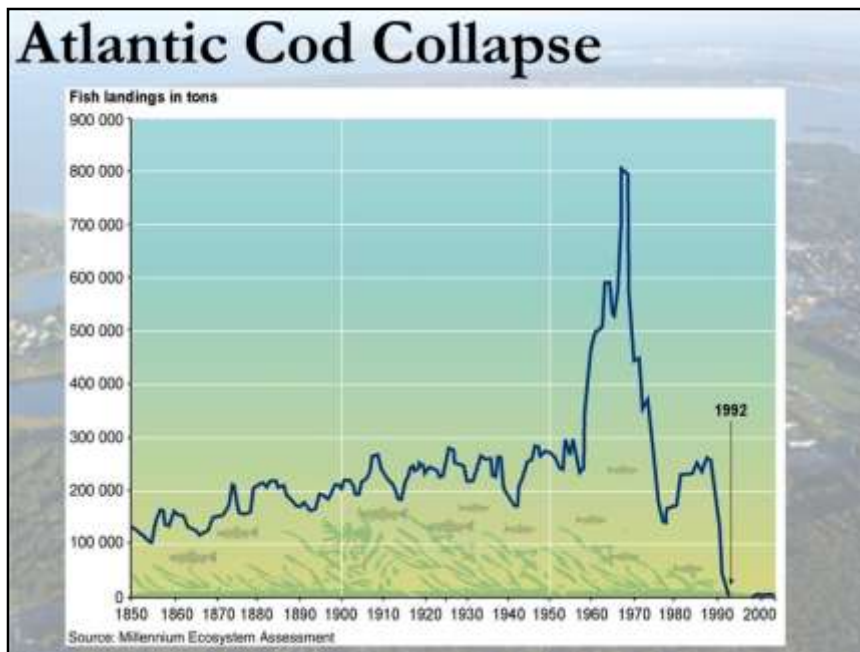
Thirty percent of the excess carbon dioxide that we have added to the atmosphere since the Industrial Revolution has been absorbed by the oceans. Through a chemical reaction in the ocean, this carbon dioxide results in a more acidic sea. The ocean is acidifying at the fastest rate in 50 million years. Rhode Island’s clammers and aquaculture growers are watching with real alarm the damage acidified seas are already doing off American’s Northwest Coast and wondering what’s in store for the Northeast. Oyster hatcheries there experienced significant losses when their new hatches were unable to grow shells in acidified seawater. Off the Pacific coasts of Washington, Oregon, and northern California, 50 percent of ocean pteropods were measured to have “severe shell damage,” mostly from acidified seas. If that species collapses, the bottom falls out of the oceanic food chain, which includes commercially important fish species as well.



These changes—warming, sea level rise, and acidification—carry real consequences for our coastal economies. According to the most recent report from the National Ocean Economics Program, over 134 million people lived in coastal zone counties in the United States in 2014. These counties accounted for nearly half of the total U.S. gross domestic product and 42% of total U.S. employment.

In Rhode Island, the coastal economy accounted for \$55 billion of the state’s GDP and employed over 460,000 people in 2014. Washington County took claim to over \$5 billion in coastal economy earnings.

This productivity is at risk if the businesses and communities in the coastal zone cannot protect themselves from the consequences of our changing environment.



Climate change researchers from the Southwest Fisheries Science Center in Pacific Grove, California found that by the year 2100, some ocean predators could be facing up to a 35 percent loss of habitat as the ocean water with their preferred temperature moves northward. Apex predators are vital to marine ecosystems because they help control and structure food webs in the ocean.

Combined with increased fishing pressure, many apex ocean predators (including sharks, billfish, and tuna), are seeing extensive and rapid population declines. Atlantic cod was one of the first fisheries species in the Northeast to see a major collapse, but it won't be the last.

Graph source - http://www.grida.no/graphicslib/detail/collapse-of-atlantic-cod-stocks-off-the-east-coast-of-newfoundland-in-1992_11e4#

UNEP, Millennium Ecosystem Assessment; "Collapse of Atlantic Cod Stocks off the East Coast of Newfoundland)



Thankfully for Rhode Island, under the leadership of Grover Fugate at the Coastal Resources Management Council and in cooperation with leading experts at the University of Rhode Island, Rhode Island Sea Grant, and the Rhode Island Geological Survey, we are well ahead of the rest of the country in understanding what climate change, sea level rise, and storm surge mean for our coastal communities. It's no surprise that the Ocean State has such a strong legacy in understanding and managing our marine resources.

[End – hand off to Grover]