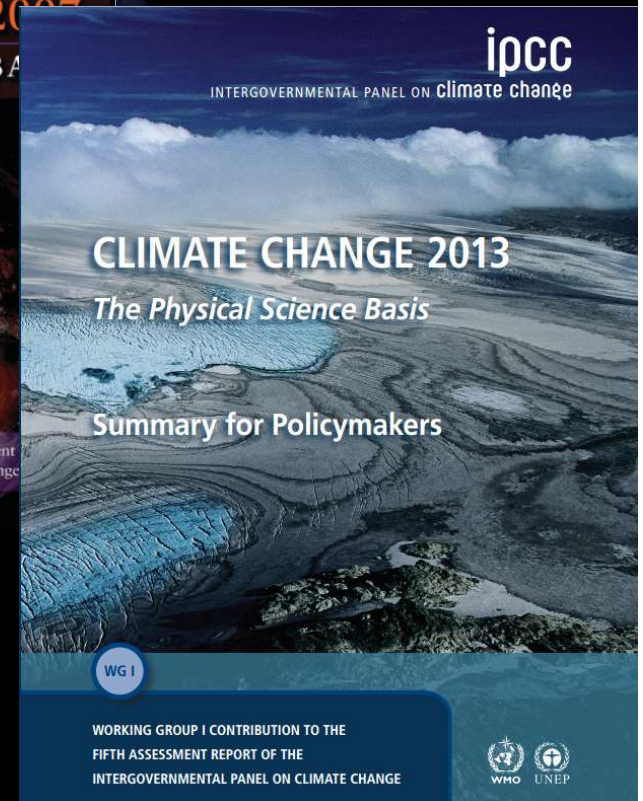
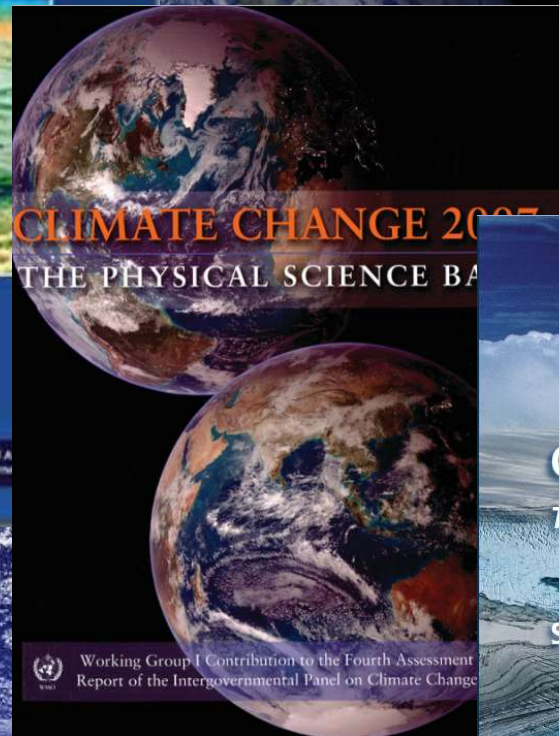
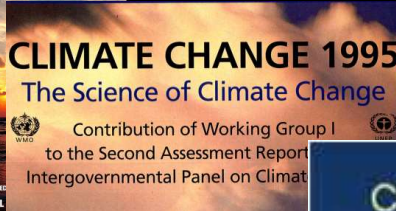


A MAINE PERSPECTIVE ON CLIMATE CHANGE



Ivan J. Fernandez

School of Forest Resources
Climate Change Institute
School of Food and Agriculture



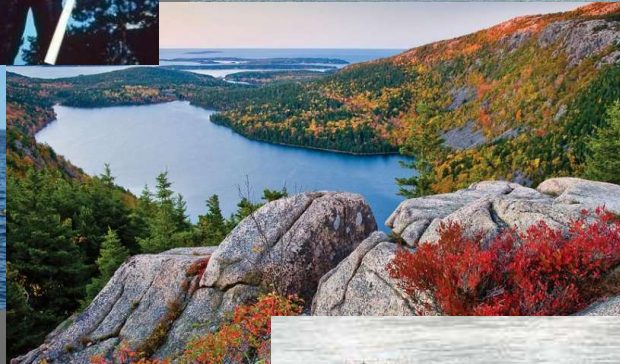
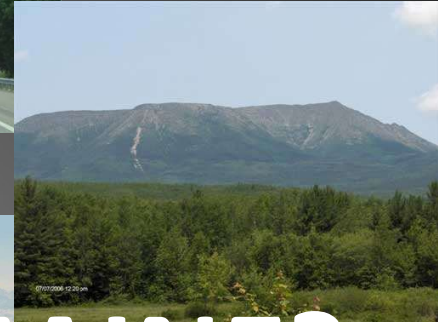
E&ENEWS
ENVIRONMENT

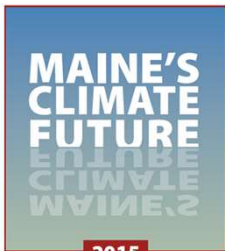
CO₂ Emissions Reached an All-Time High in 2018

The uptick follows several years of relatively flat emissions, underscoring the urgency of climate action

By Chelsea Harvey. E&E News on December 6, 2018

BUT WHAT ABOUT MAINE?





Maine's Climate Future Dashboard

Last 100 years

By ~2050

Air Temperatures

+3°F

+1-3°F

Warm Season

+2 wks

+2 wks

High Heat Index Days/Yr

0-5

1-15
(more coastal)

Precipitation

+13%

+5-10%

Snow

-7%

-20 to -40%

Ocean Temperature

+0.01°F/Yr

+0.41°F/Yr
(>99% world)

Sea Level Rise

+0.62 ft.

+0.5 to 2 ft.
(3 ft. or >>!)

Maine's Average Annual Temperature

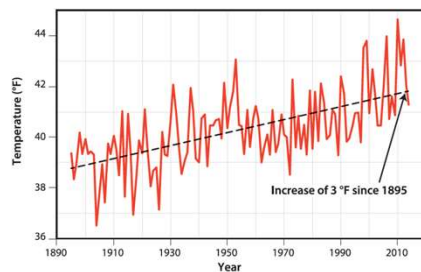


Figure 1. Mean annual temperature, 1895–2014, averaged across Maine from gridded monthly station records from the U.S. Climate Divisional Dataset (ncl.noaa.gov/monitoring-references/meps/us-climate-divisions.php). A simplified linear trend (black line) indicates that temperature increased 3 °F over the record period.

Maine's Total Annual Precipitation

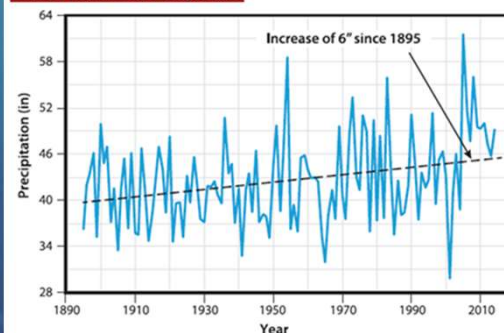


Figure 6. Total annual precipitation, 1895–2014, averaged across Maine from gridded monthly station records from the U.S. Climate Divisional Dataset (ncl.noaa.gov/monitoring-references/meps/us-climate-divisions.php). A simplified linear trend (black line) indicates that precipitation increased six inches, or about 13%, during the recording interval.

Gulf of Maine Sea Surface Temperature

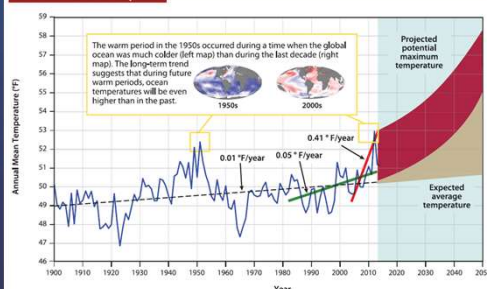
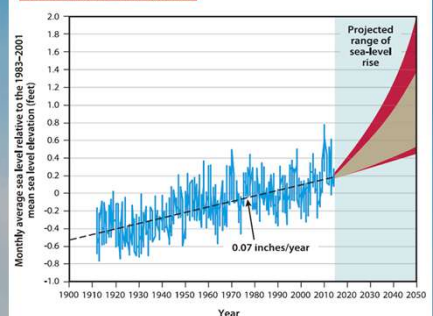


Figure 12. Mean sea surface temperature in the Gulf of Maine from 1900 to 2014 (blue), based on Extended Reconstructed Sea Surface Temperature (ERSST) version 3b data provided by the NOAA/Earth System Research Laboratory Physical Sciences Division, Boulder, CO (psl.noaa.gov/). The temperature trend over the entire record is 0.01 °F per year (black line). The rate accelerated to 0.07 °F per year after 1980 (green line) and accelerated to 0.41 °F per year from 2000–2013 (red line). Based on NOAA's System Integration 4-degree daily sea surface temperature analysis (ncl.noaa.gov/sst/). Climate models provide a range of estimates of future mean temperatures (red and tan area), with the range driven by the uncertainty in how much carbon dioxide and methane will be added to the atmosphere.

Sea Level Trend at Portland, Maine



Projected Snowfall Decline

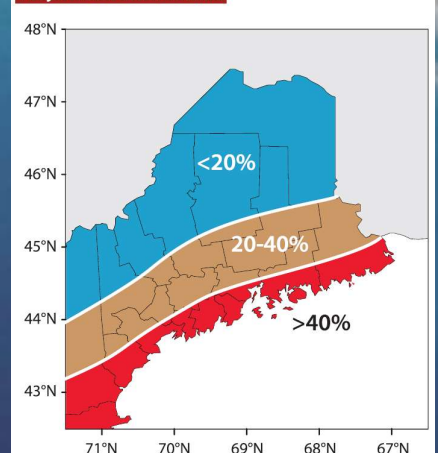
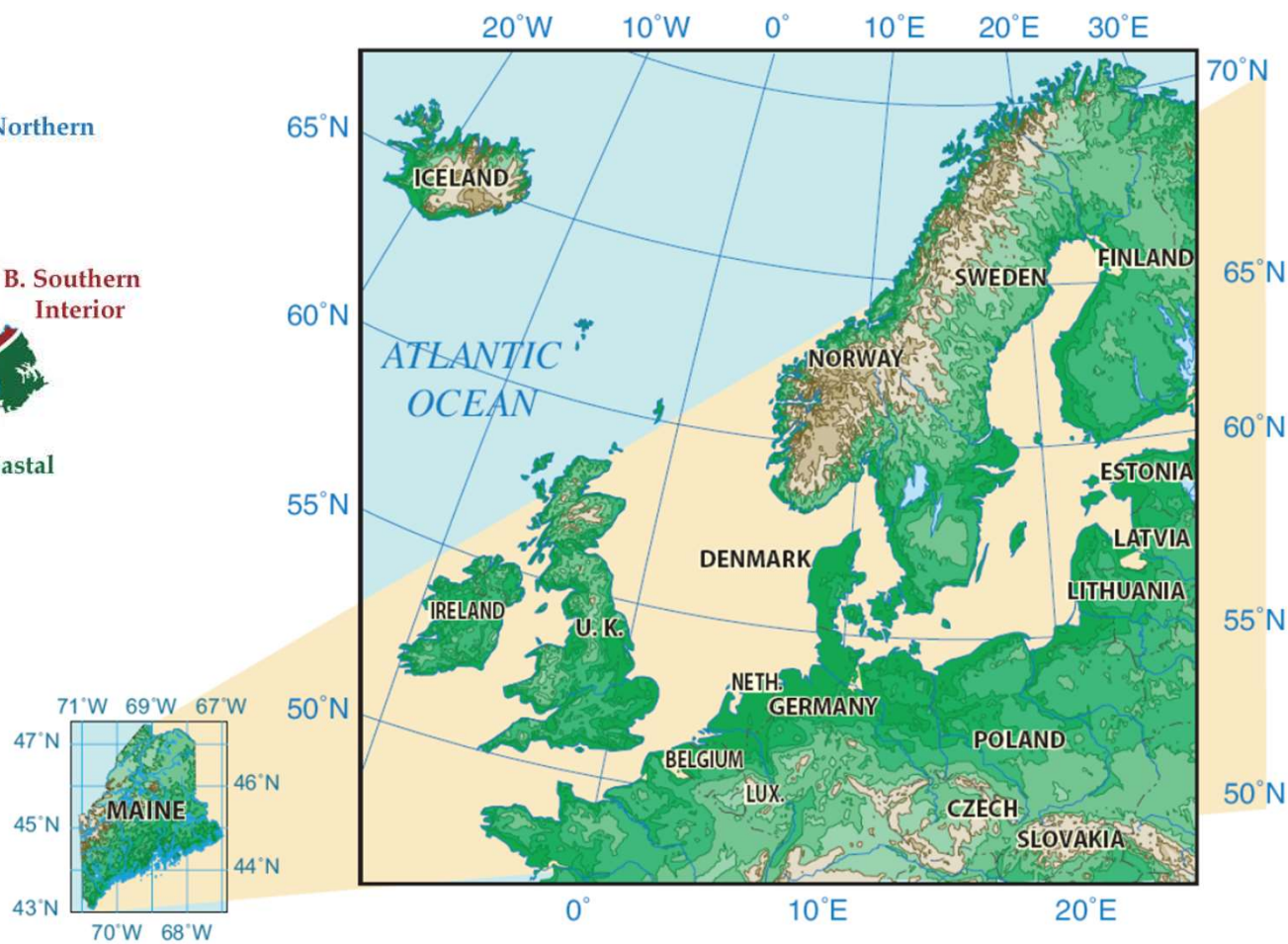
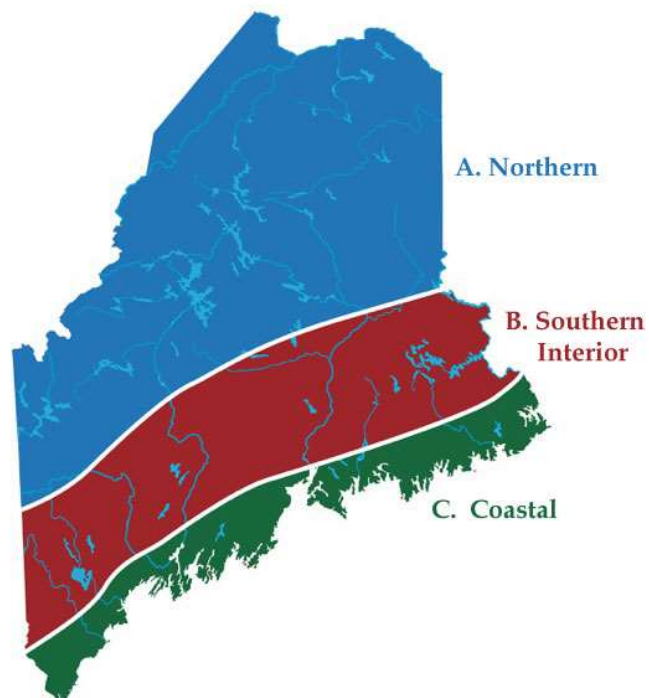


Figure 10. Map showing the predicted change or difference in total accumulated winter snow by climate zone from 1995–2014 to 2035–2054. The greatest changes are predicted to be along the coast, where many winters of the future will bring rain instead of snow. Map derived from an ensemble simulation of the IPCC A2 emissions scenario.

Temporal *and* Spatial Variability in Maine's Climate

Maine Climate Divisions



Does this affect Maine?



Agriculture

An oval-shaped image showing a rural landscape with a large barn and a body of water under a cloudy sky.



Forestry

An oval-shaped image showing a logging truck in a snowy, forested area.



Human Health

An oval-shaped image showing a close-up of a tick on human skin.



Marine Fisheries

An oval-shaped image showing a person in a red jacket holding a large lobster.



Communities

An oval-shaped image showing a flooded residential area with houses and cars partially submerged in water.



Businesses

An oval-shaped image showing a man in a red Coca-Cola shirt working in a warehouse, handling boxes of Coca-Cola bottles.



Security

An oval-shaped image showing an aerial view of a large, modern building complex, possibly a government or military installation.

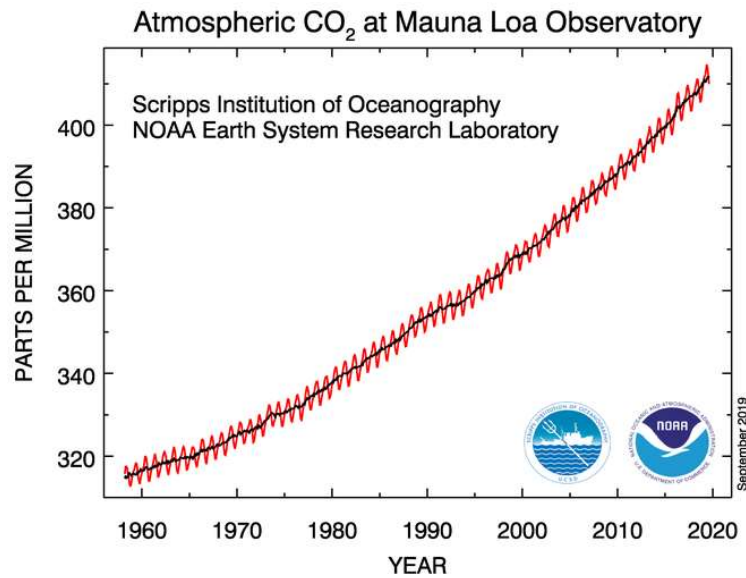


Recreation
+ Tourism

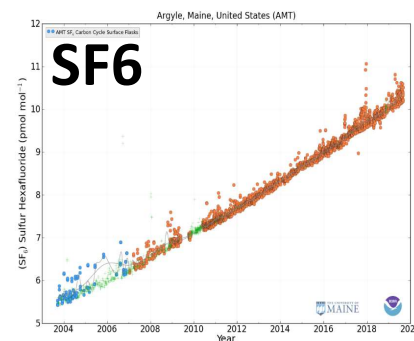
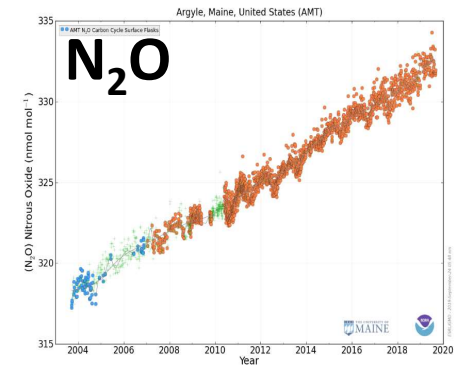
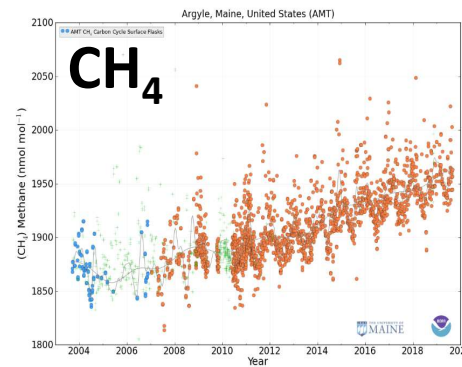
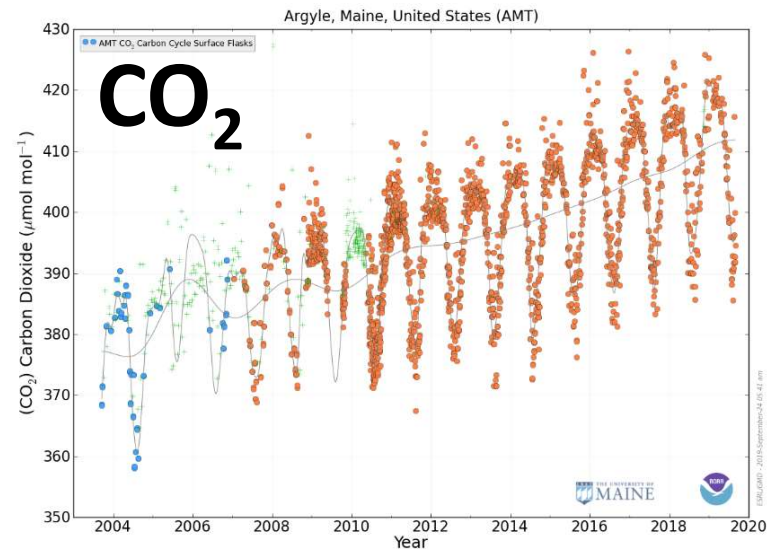
An oval-shaped image showing two people on snowmobiles in a snowy, mountainous landscape.

ADAPTATION
and
MITIGATION

GREENHOUSE GASES



“The Keeling Curve”



ESRL GMD Tall Towers Site
Argyle, Maine (AMT)

TAKE-HOME MESSAGES

Climate Change...

1. ...is accelerating in Maine,
2. ...is rarely the only factor,
3. ...“from away” affects Maine,
4. ...brings both risks and opportunities,
5. ...demands science-informed cost-effective policy,
6. ...means business as usual is not an option.

Thank you





Melissa Law

**Co-Owner and Flower Manager,
Bumbleroot Organic Farm, Windham**



Effects of Climate Change on Maine's Wildlife

Nathan Webb, Wildlife Division Director

Amanda Shearin Cross, Beginning with Habitat and Wildlife Action Plan Coordinator

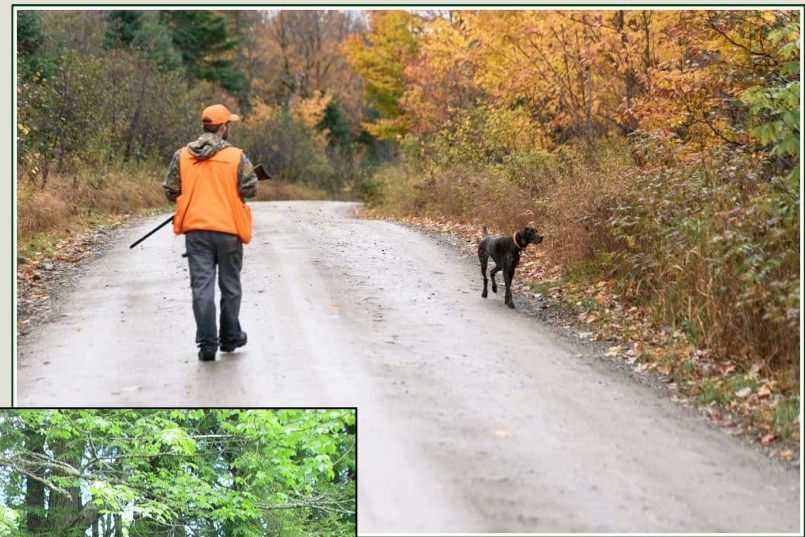
Phillip DeMaynadier, Reptile, Amphibian, and Invertebrate Group Leader

Maine Department of Inland Fisheries and Wildlife

Maine Department of Inland Fisheries and Wildlife



Species

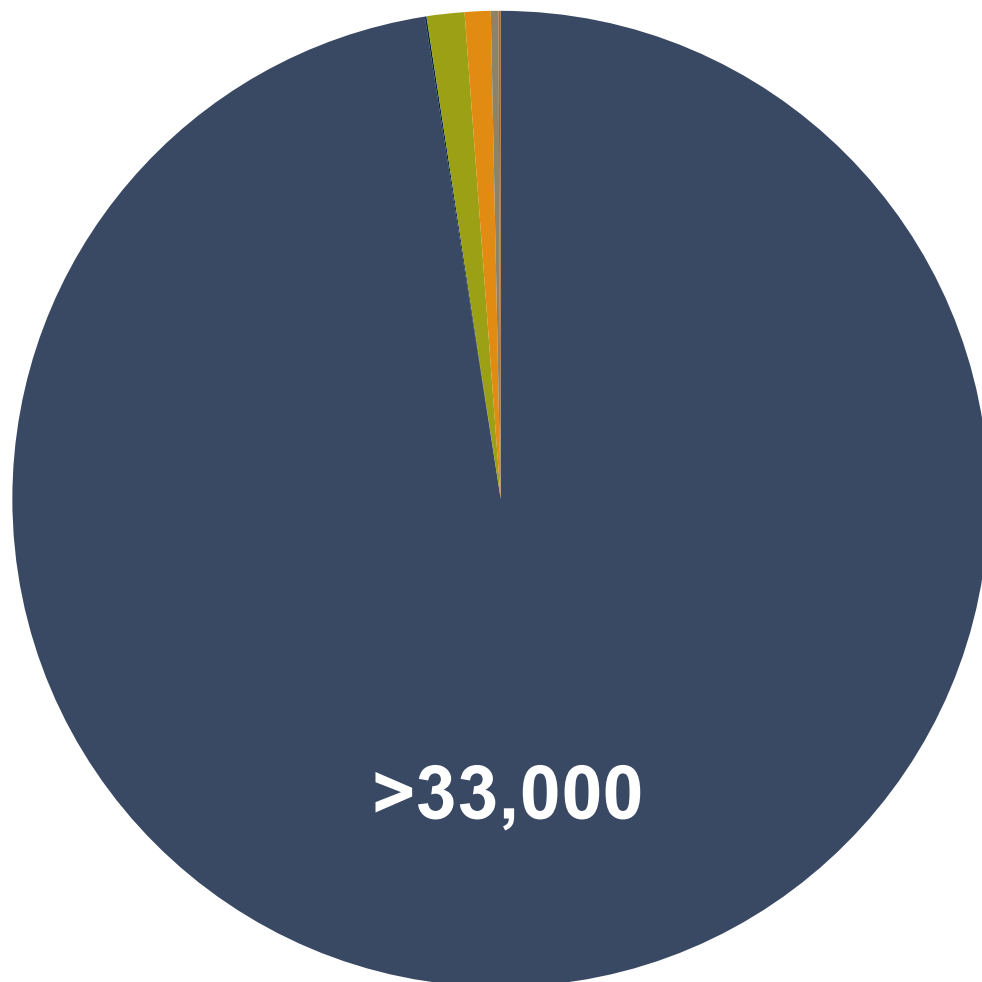


People



Habitats

Maine's Wildlife



■ Invertebrates (33,000)

■ Amphibians (18)

■ Birds (423)

■ Fish (291)

■ Mammals (85)

■ Reptiles (23)

Maine's 2015–2025 Wildlife Action Plan



<http://www.maine.gov/ifw/wildlife/reports/MWAP2015>



Action Plan: 378 At-Risk Species



**One-third affected by
climate change**



Images by USFWS, Audubon, NH Fish and Game

Habitats with High Vulnerability to Climate Change



Coastal

Montane Forests

Peatlands

Cold Water

Alpine

Boreal Forest



Spruce-Fir



Maple-Beech-Birch

Wildlife with High Vulnerability to Climate Change



Mammals

Northern Bog Lemming
Moose
Snowshoe Hare
Canada Lynx
American Marten

Amphibians & Reptiles

Blanding's Turtle
Mink Frog

Fish

Lake Whitefish
Rainbow Smelt
Round Whitefish
Landlocked Salmon
Arctic Charr
Atlantic Salmon

Select Seabirds & Shorebirds

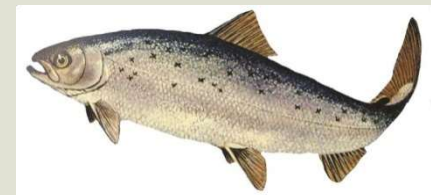
Atlantic Puffin
Arctic Tern
Red Knot
Piping Plover

Select Waterbirds

Yellow Rail
Black Tern
Common Loon
Least Bittern

Select Passerines & Woodpeckers

Saltmarsh Sharp-tailed Sparrow
American Pipit (breeding)
Bicknell's Thrush
White-winged Crossbill
Cape May Warbler
Boreal Chickadee
Black-backed Woodpecker



Moose & Parasites



Bicknell's Thrush & High Elevation Forests



Brook Trout & Water Temperature



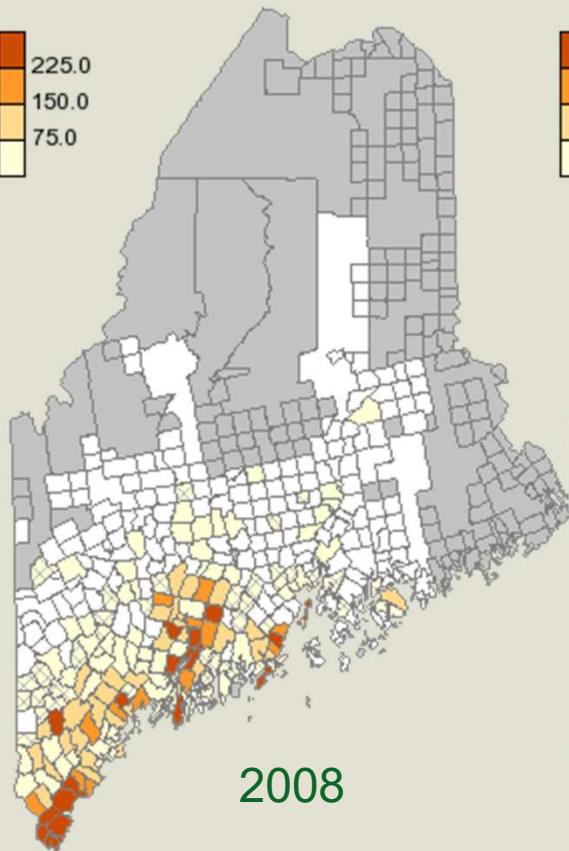
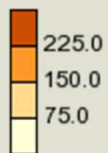
Invasive Species



Ticks & Human Health

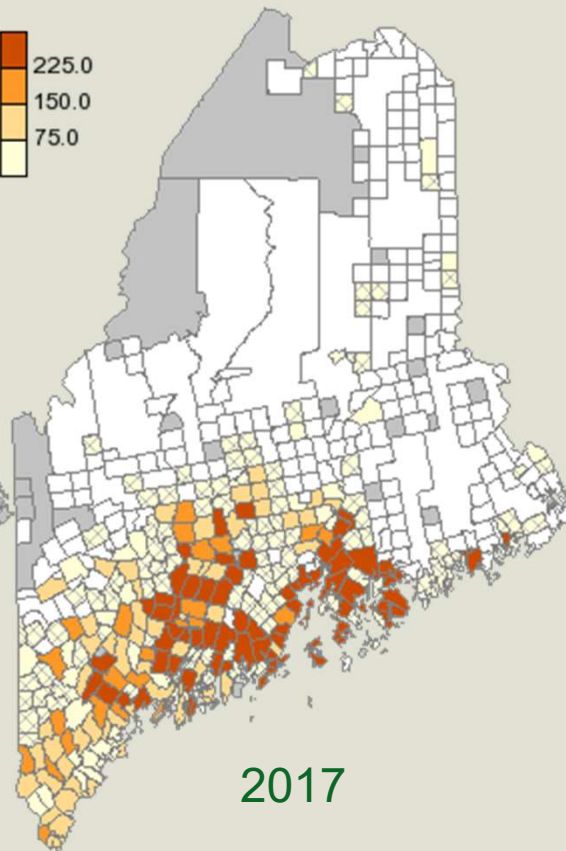
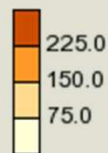


Rate (per 100,000)



2008

Rate (per 100,000)



2017



Griffin Dill

What Does Climate Change Mean for Maine's Wildlife?



- Climate plays key role in distribution & abundance
- Large shifts in geographic distribution
- 'Winners' and 'Losers'
- Many winners will be weedy or invasive spp.
- Some species at southern edge of range will be lost
- Highest risk: species reliant on climate – vulnerable ecosystems

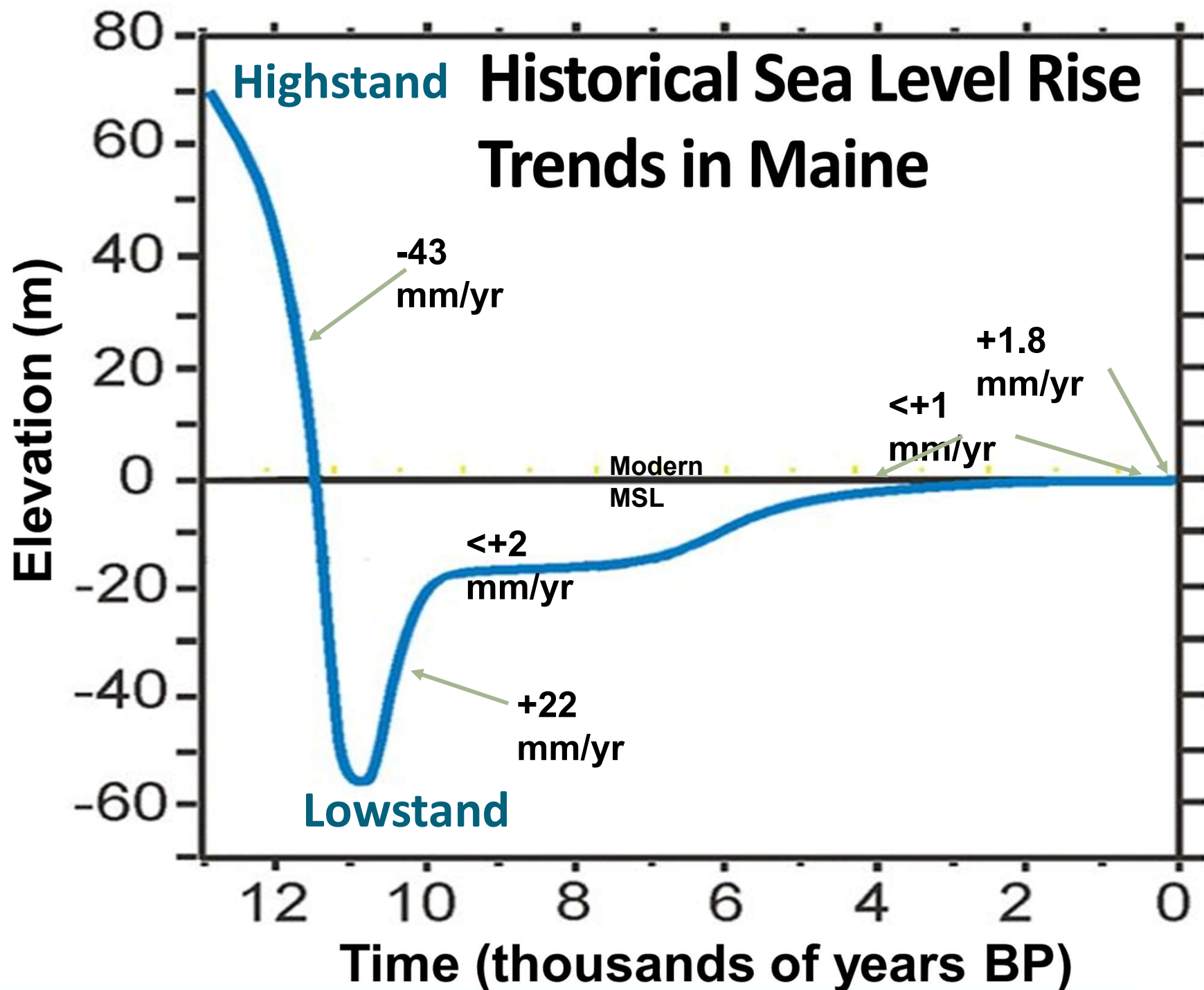


Trends in coastal flooding and sea-level rise in Maine

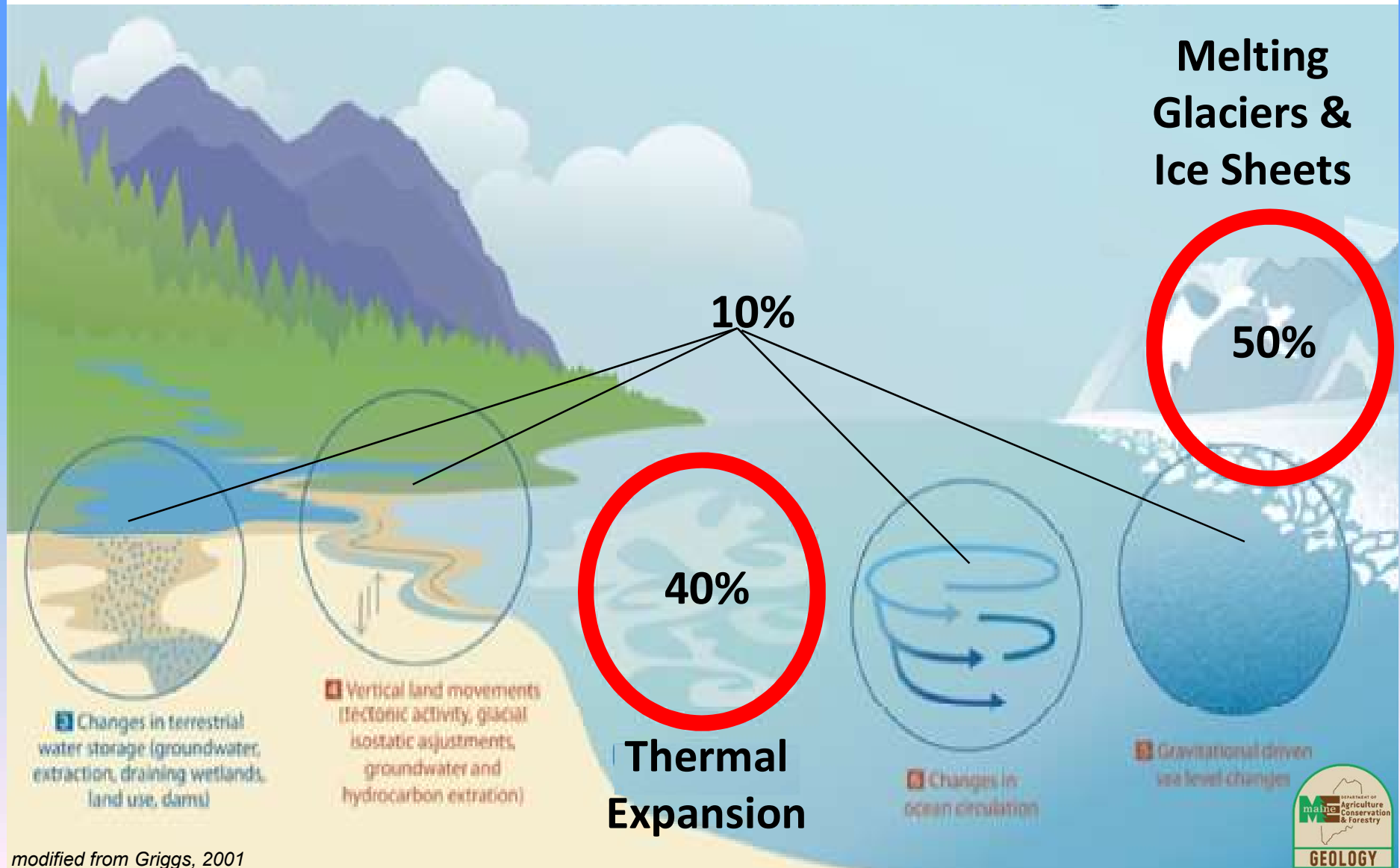


Robert G. Marvinney, State Geologist
Peter A. Slovinsky, Marine Geologist
Maine Geological Survey

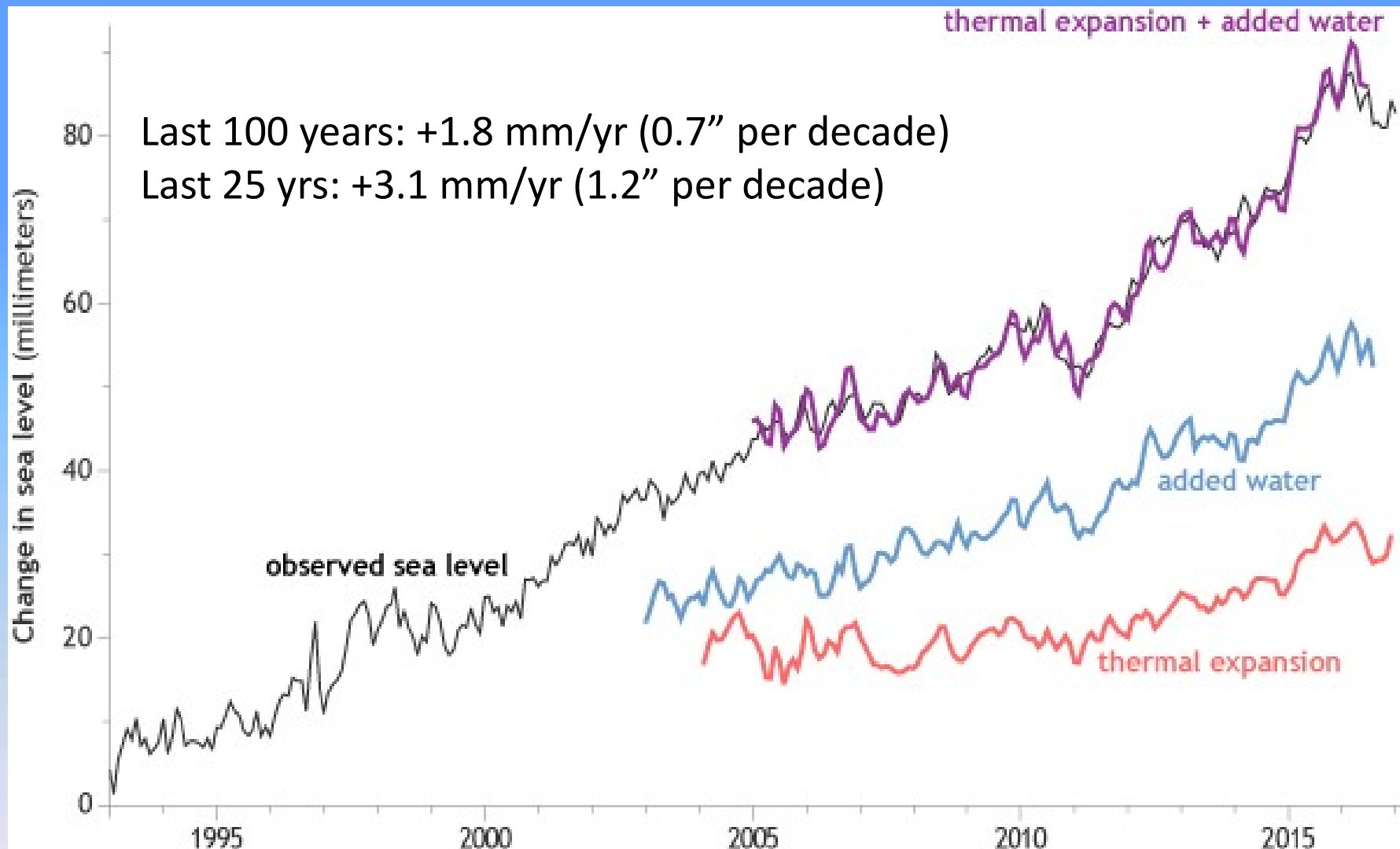
Image from Chebeague.org



What causes the global sea level changes we see today?



Global sea level rise observations



Combined independent totals from **thermal expansion** and **glacier/land-based ice sheet input** match **satellite** measurements

adapted from Figure 3.15a in [State of the Climate in 2016](#)

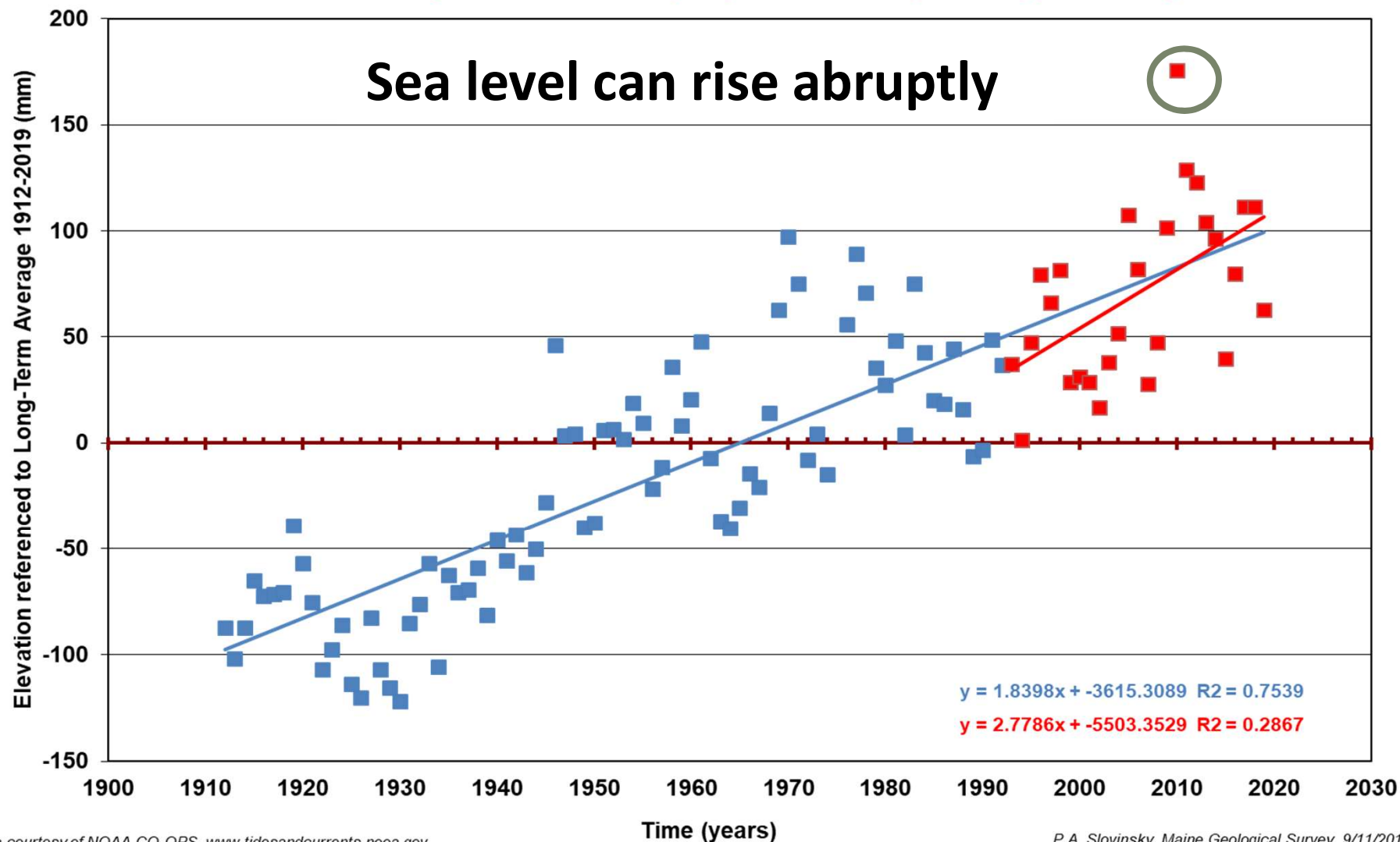


Long- and short- term sea level rise

Annual Sea Levels, NOAA Station 8418150, PORTLAND 1912-2019

1912-2019 average: 1.84 ± 0.1 mm per year or 0.6 ft (7.24 in) per century

1993-2019 average: 2.78 ± 0.88 mm per year or 0.91 ft (10.94 in) per century



**Slightly higher sea levels, combined with storm events,
lead to *much higher levels of erosion* as witnessed in
winter 2010**



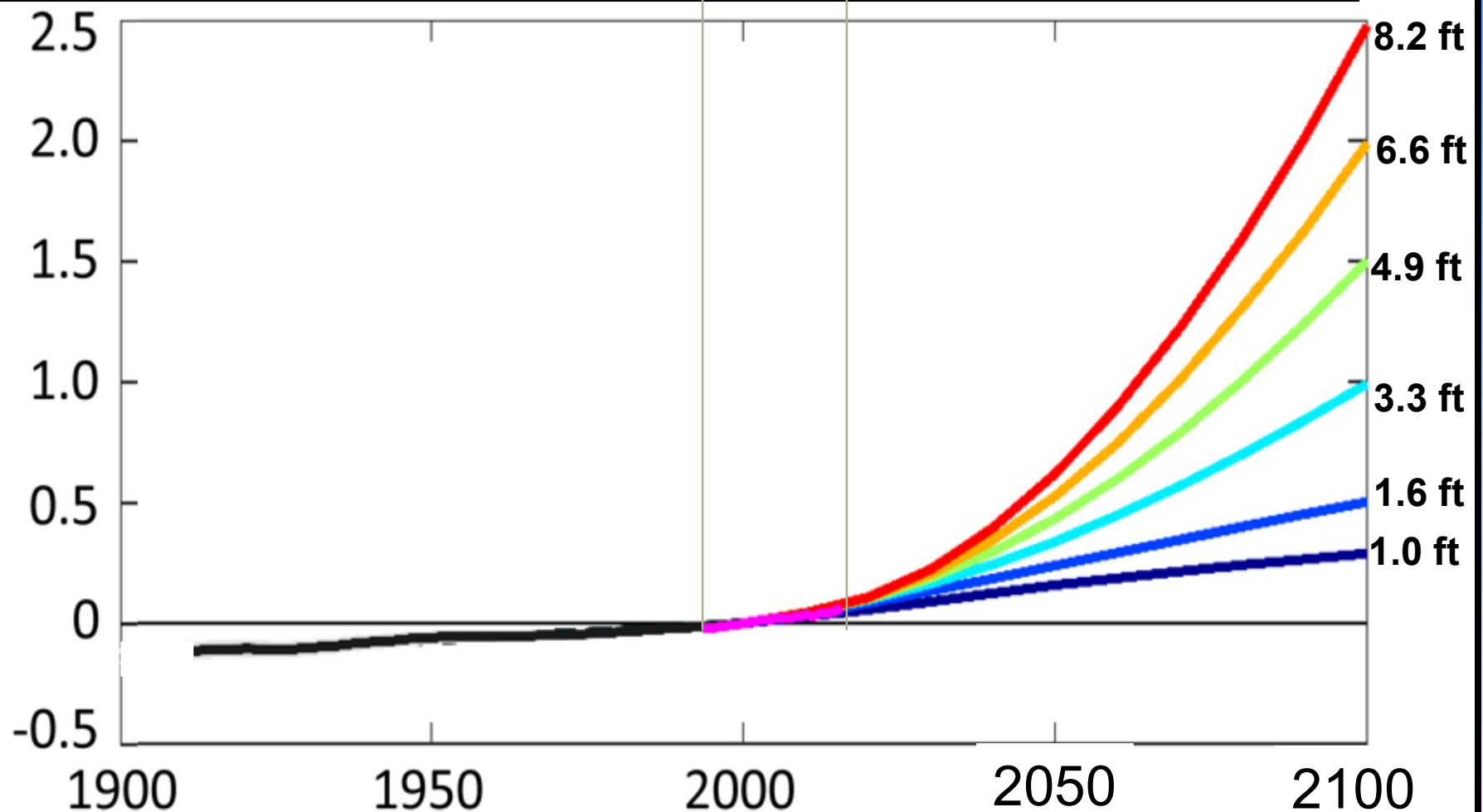
Higgins Beach, Scarborough, April 7, 2010
P.A. Slovinsky



Sea level is expected to *continue to rise...*

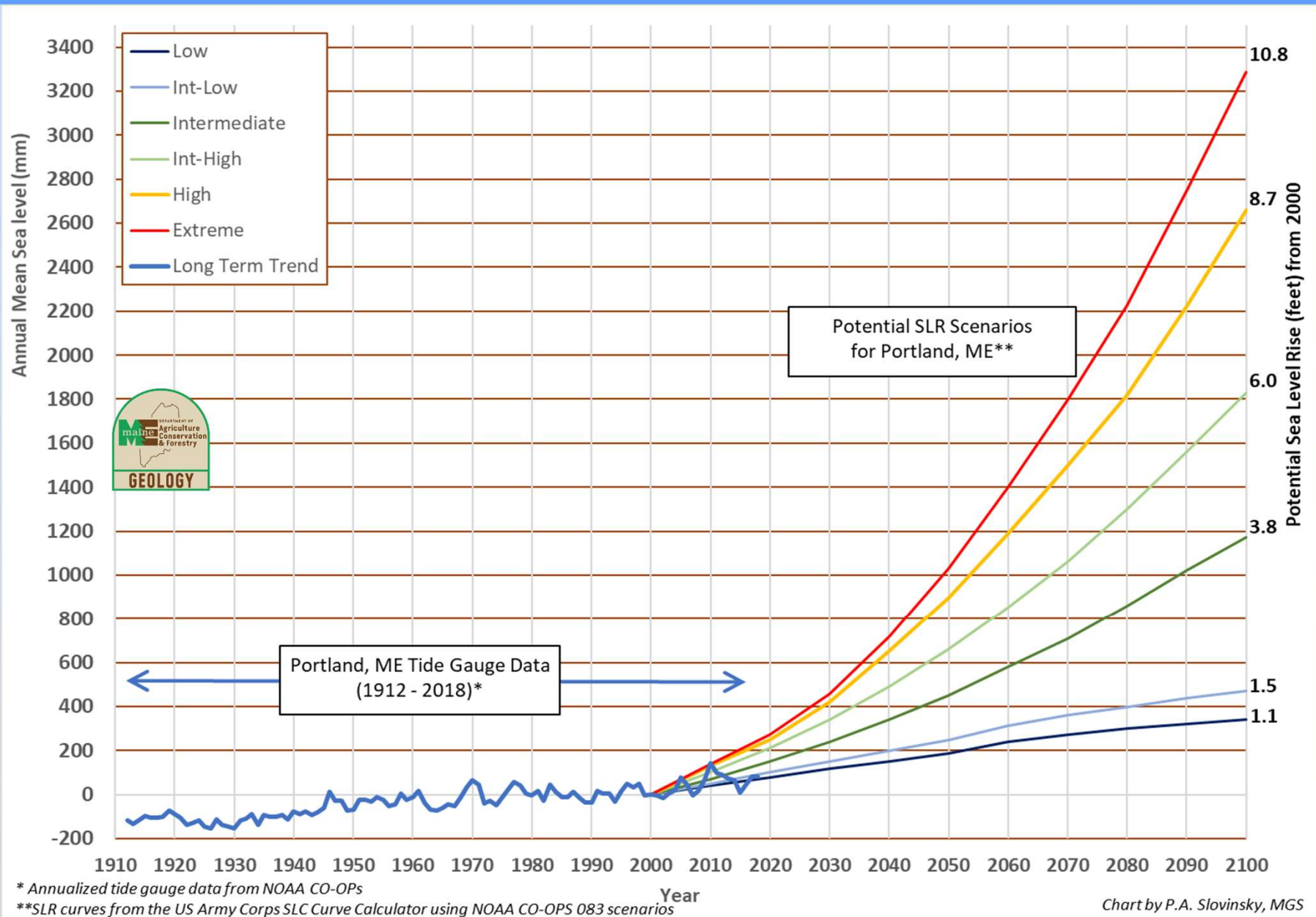


Global Mean Sea Level Scenarios to 2100



Adapted from NOAA Technical Report NOS CO-OPS 083, January, 2017

...and in Maine, could potentially rise *higher than* global averages.

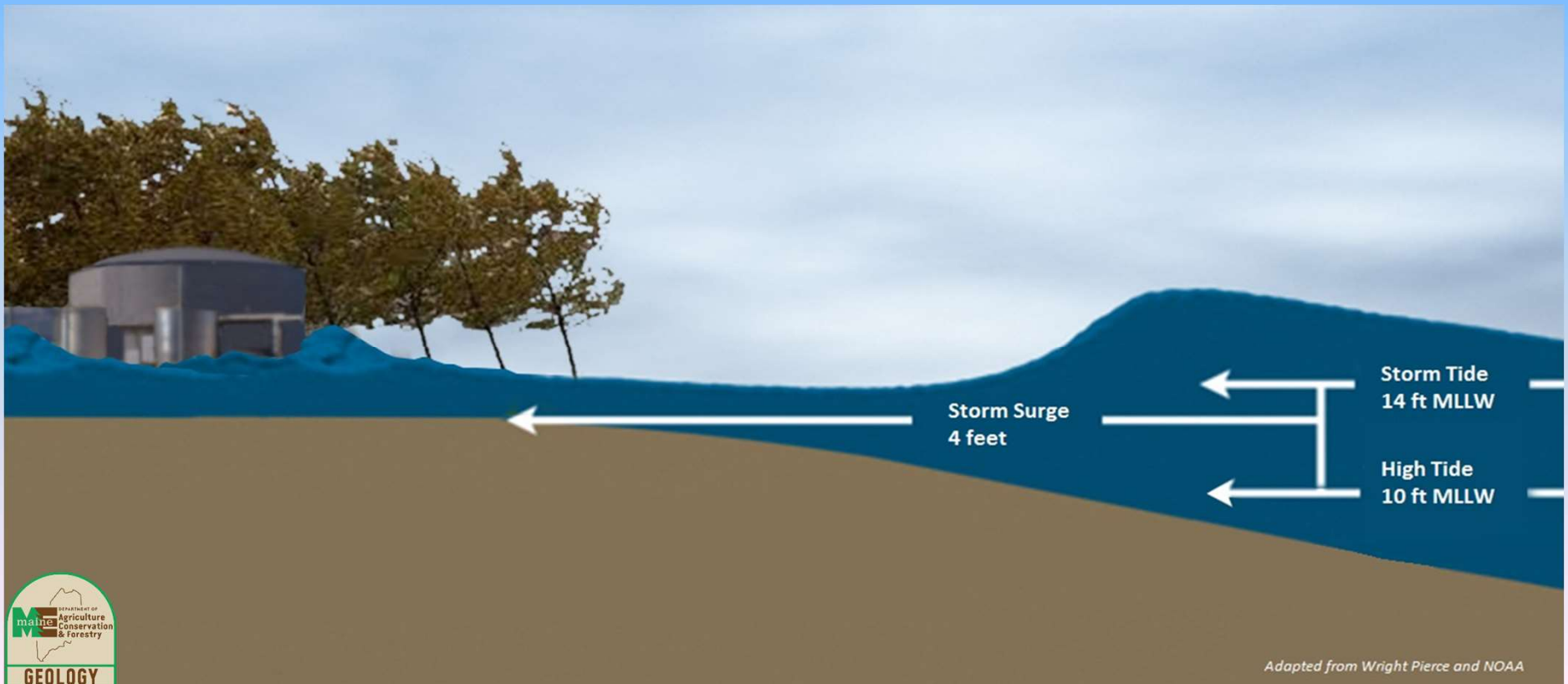


What about storm tides and storm surges?



What is storm surge and storm tide?

Storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tides. Storm surge should not be confused with **storm tide**, which is defined as the water level rise due to the **combination of storm surge and the astronomical tide** (NHC).



Portland Annual “Storm Tide” Statistics 1912-2018

Recurrence Interval	% Annual Chance	Storm Tide (ft, MLLW)
1	100%	11.7
5	20%	12.6
10	10%	12.9
25	4%	13.4
50	2%	13.7
100	1%	14.1

~1 foot difference!



Highest recorded storm tide was 14.1 feet on 2/7/1978

How has “nuisance”
flooding in Portland
increased over the
past 100 years, and
**how might additional
SLR impact it?**

NOAA NWS
“Flood Stage”
For Portland = 12 ft MLLW

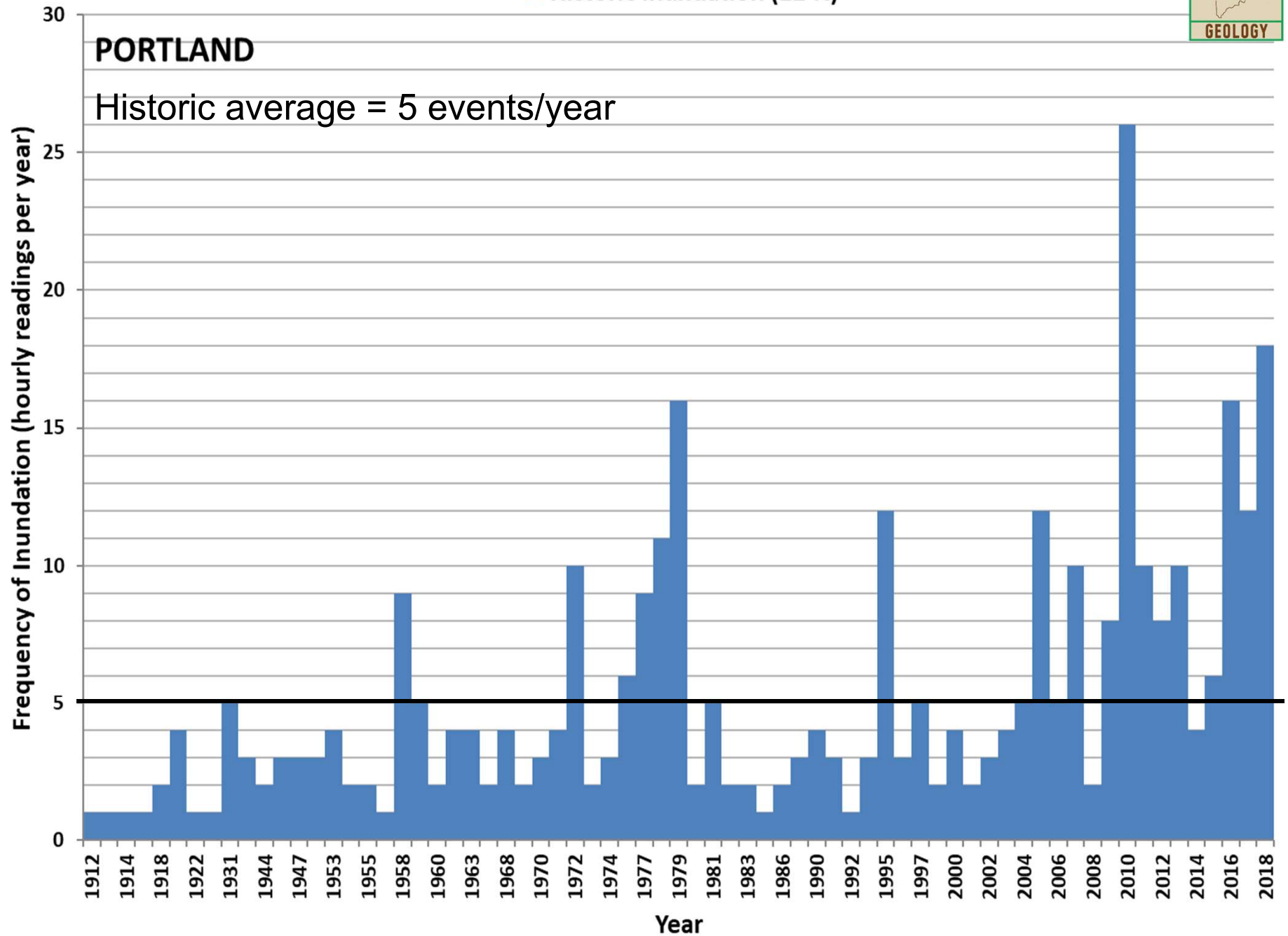
“King Tide” Marginal Way, October 25, 2016
A. Sherwin, MCP



■ Historic Inundation (12 ft)

PORTLAND

Historic average = 5 events/year



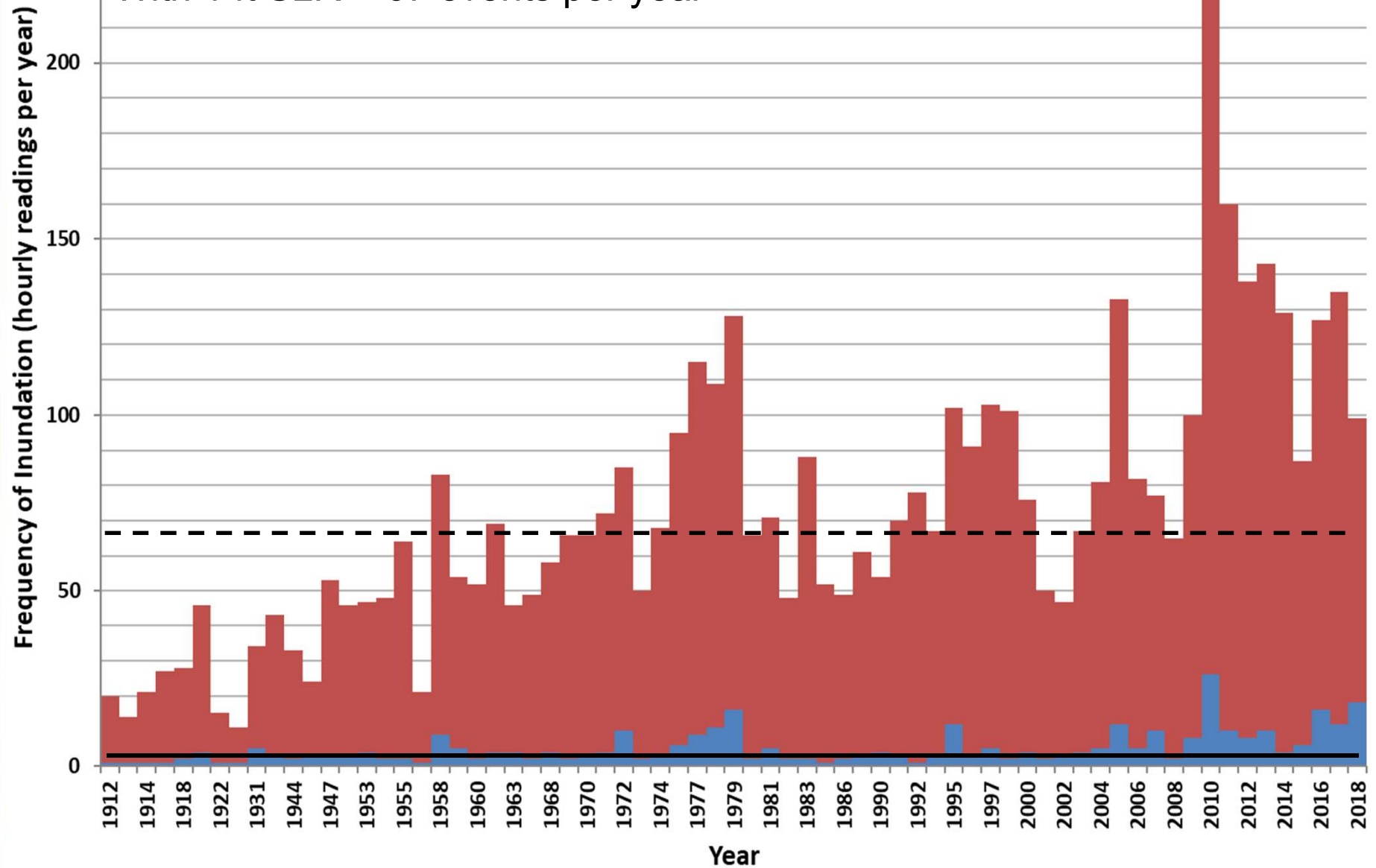
■ Historic Inundation (12 ft)

■ Inundation After +1 ft SLR



PORTLAND

With 1 ft SLR = 67 events per year

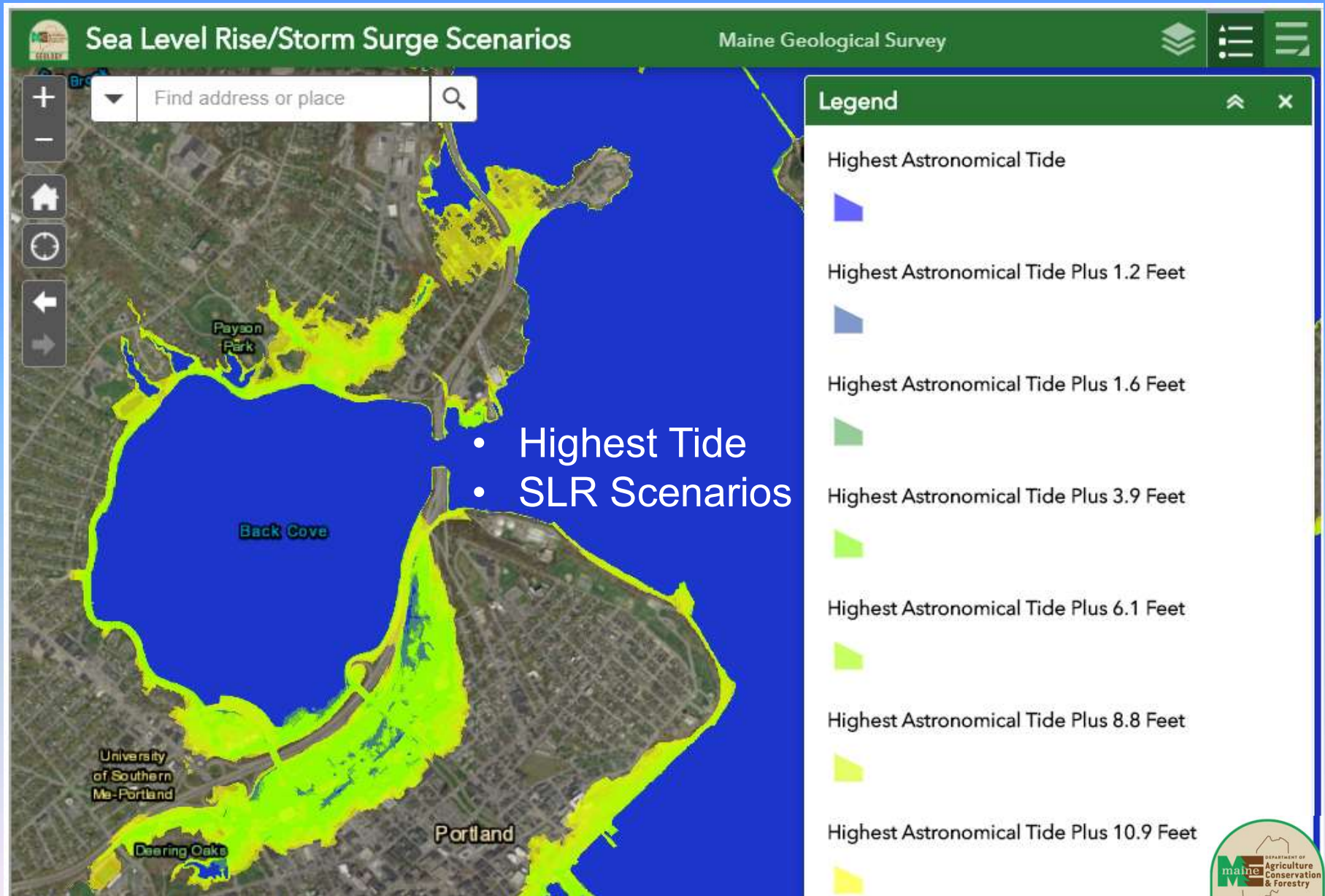


Sea-level rise inundation scenarios for Maine



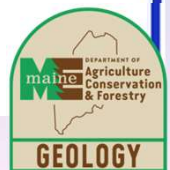
Hurricane Bill 2009, Kennebunk, ME, David R. Jones

Sea Level Rise Mapping



- Highest Tide
- SLR Scenarios

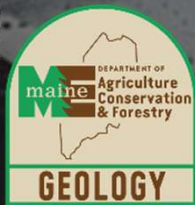
http://www.maine.gov/dacf/mgs/hazards/slr_ss/index.shtml



A photograph of a flooded street. In the foreground, a chalkboard sign on a stand reads "DO NOT use this EXIT!". In the middle ground, a red octagonal stop sign is partially submerged in the floodwater. A yellow sign below it is also partially submerged. In the background, several cars are parked or driving in the flooded area. A utility pole is visible on the left side of the street. The sky is overcast.

Thank you!

Robert G. Marvinney, State Geologist
Maine Geological Survey
robert.g.marvinney@maine.gov
(207) 287-2804



Judy Cooper East

Executive Director, Washington Council of Governments

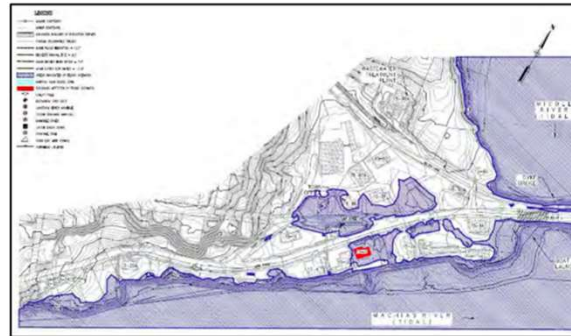


Figure 5 – Effective Base Flood Elevation;

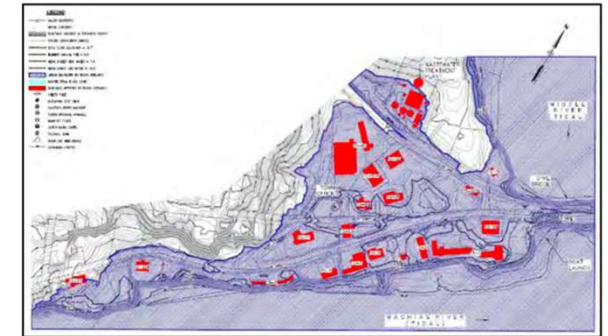


Figure 7 – Base Flood Elevation plus 4-FT

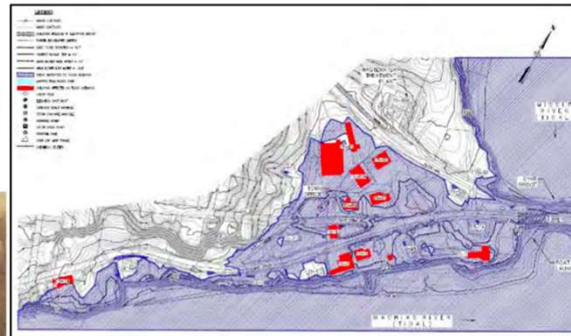


Figure 6 –Base Flood Elevation plus 2-FT

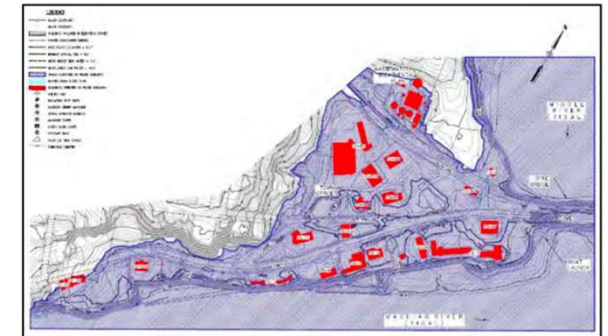


Figure 8 – Base Flood Elevation plus 6-FT



Figure 2 –Historical Development on Machias River looking downstream. Downtown Area is on left of River

If: FEMA Pre-Disaster Mitigation Advance Assistance Planning Grant:
Then: geotechnical analyses, living shoreline opportunities, landowner contact, permitting, final design/engineering
Then: FEMA Pre-Disaster Mitigation: construction (~ \$10M); CDBG, MDOT +

www.wccog.net/machias-resilience.htm

Bill Mook

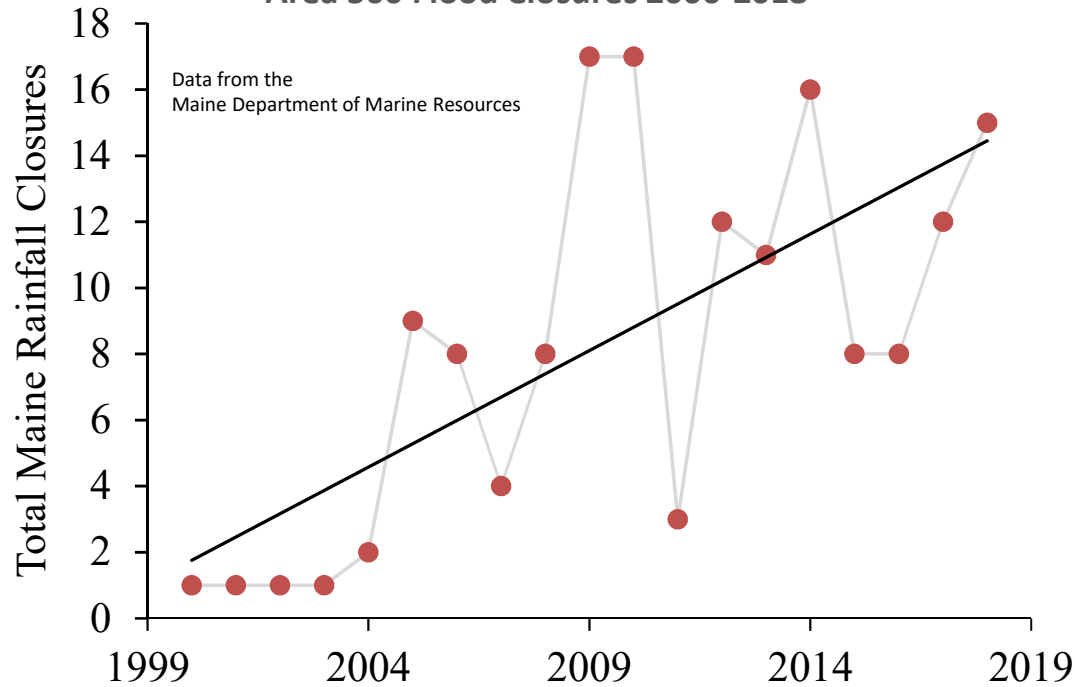
Founder,

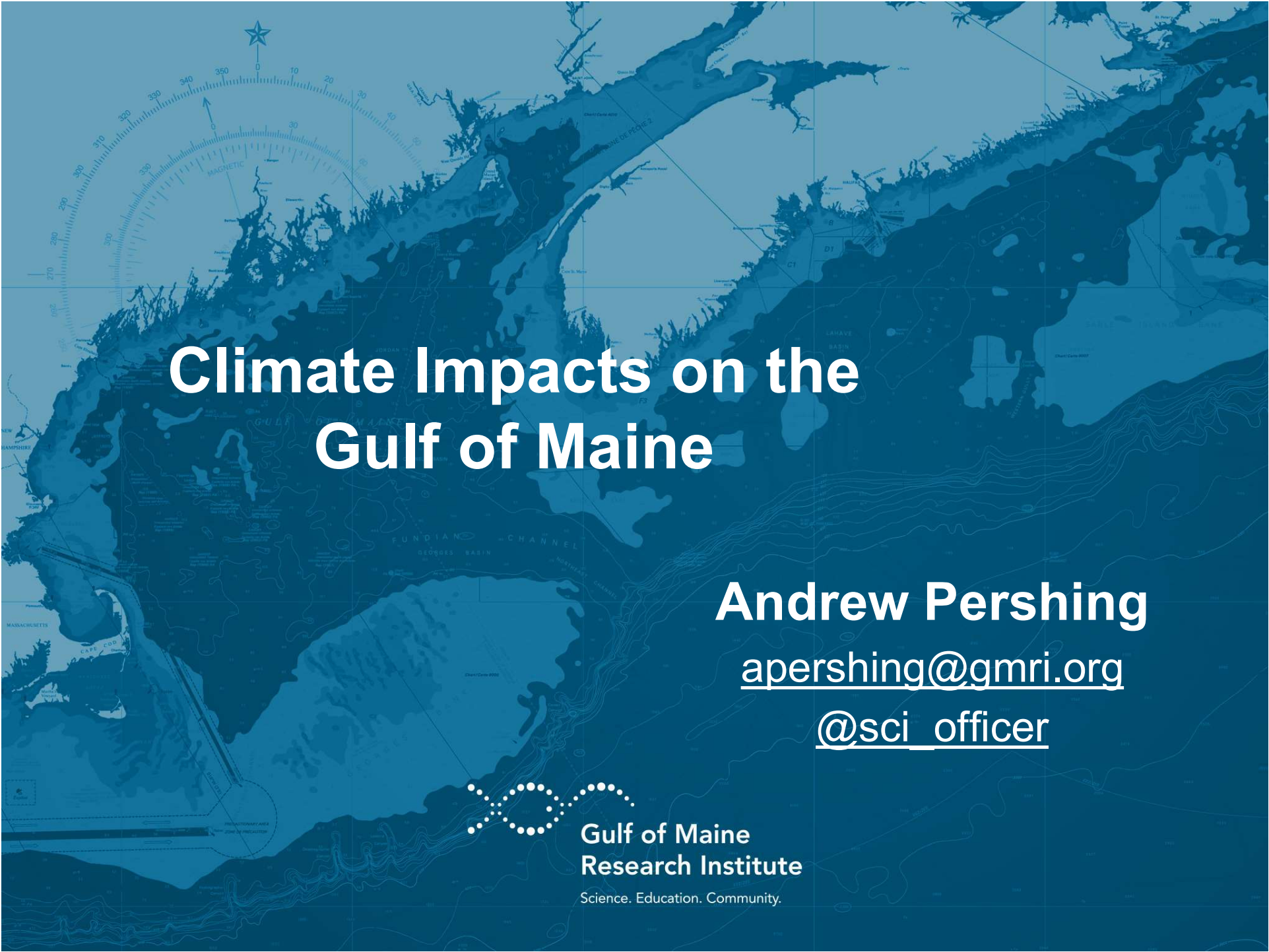


MOOKSEA FARM

Our world is your oyster!

Area 500 Flood Closures 2000-2018





Climate Impacts on the Gulf of Maine

Andrew Pershing

apershing@gmri.org

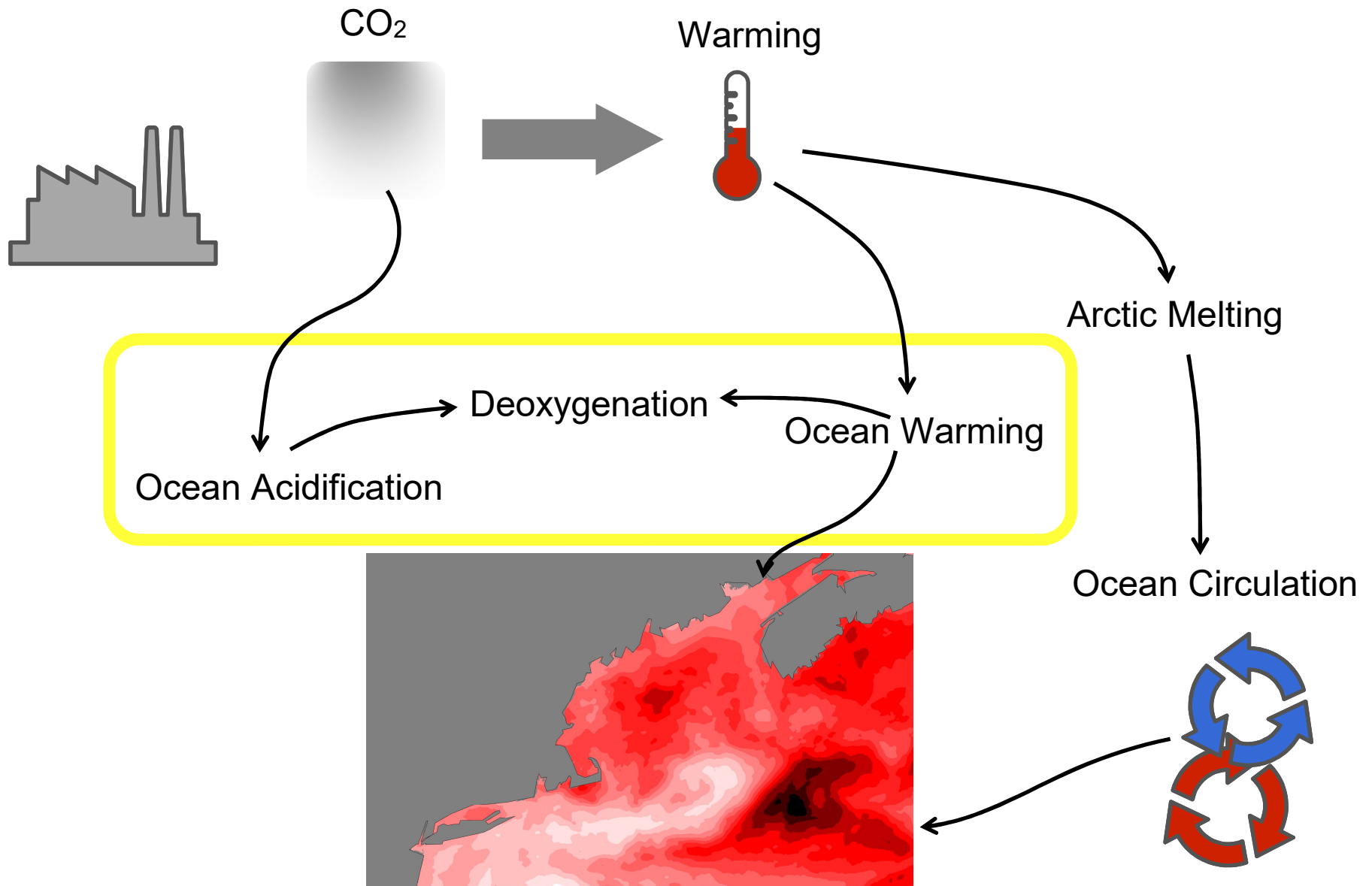
[@sci_officer](#)



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Climate Change & the Ocean



FOURTH NATIONAL CLIMATE ASSESSMENT

Volume II: Impacts, Risks, and Adaptation in the United States

The National Climate Assessment (NCA) assesses the science of climate change and variability and its impacts across the United States, now and throughout this century.

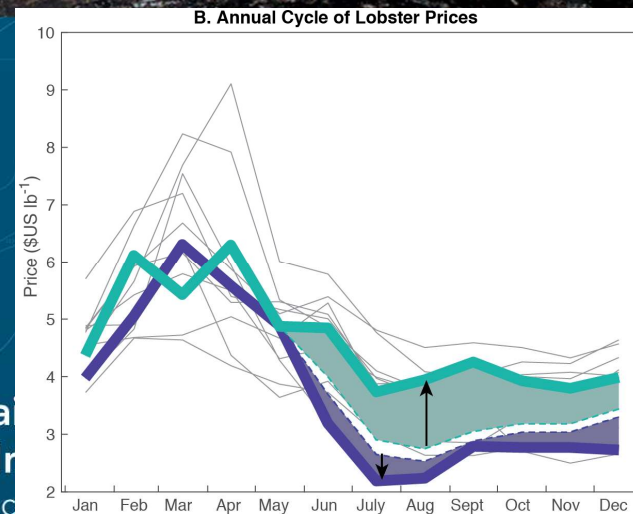
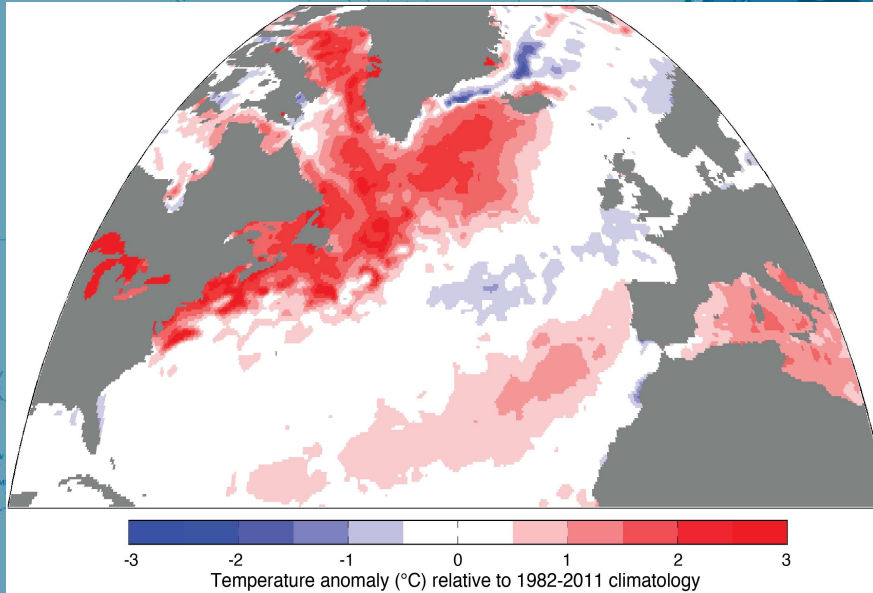
Extreme events

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Extreme Events



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Extreme events

Fisheries

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nca2018.globalchange.gov



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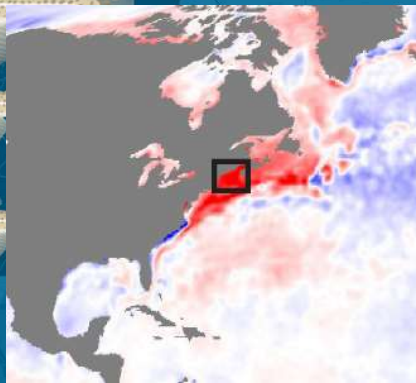
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Fisheries



Fishery
Management

Stock
Assessment



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Extreme events

Fisheries

Ecosystem disruptions

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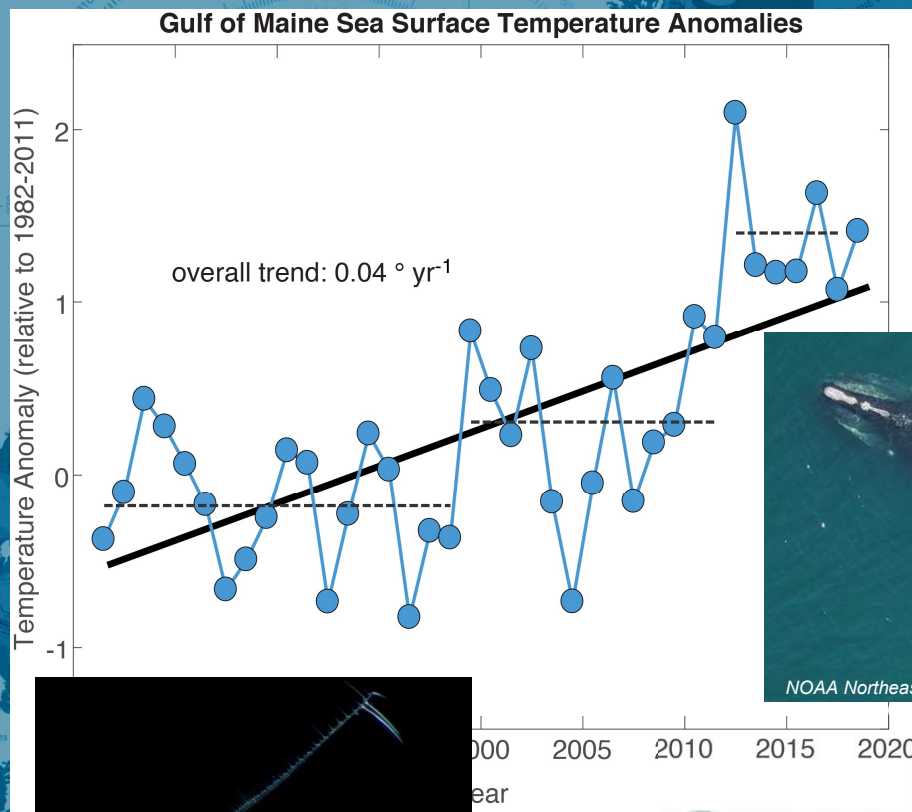
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Ecosystem Disruption



NOAA Northeast Fisheries Science
Center and Elizabeth Josephson.



Hopcroft/UAF/CoML



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The Nation's **valuable** ocean ecosystems are being disrupted by increasing global temperatures through the loss of iconic and highly valued habitats and changes in species composition and food web structure.

F

Ecosystem disruptions



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The Nation's **valuable** ocean ecosystems are being disrupted by increasing global temperatures through the loss of iconic and highly valued habitats and changes in species composition and food web structure.

F Ecosystem disruption will intensify as ocean **warming, acidification, deoxygenation**, and other aspects of climate change increase.

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The Nation's **valuable** ocean ecosystems are being disrupted by increasing global temperatures through the loss of iconic and highly valued habitats and changes in species composition and food web structure.

F Ecosystem disruption will intensify as ocean **warming, acidification, deoxygenation**, and other aspects of climate change increase.

In the absence of significant reductions in **carbon emissions, transformative impacts** on ocean ecosystems cannot be avoided.